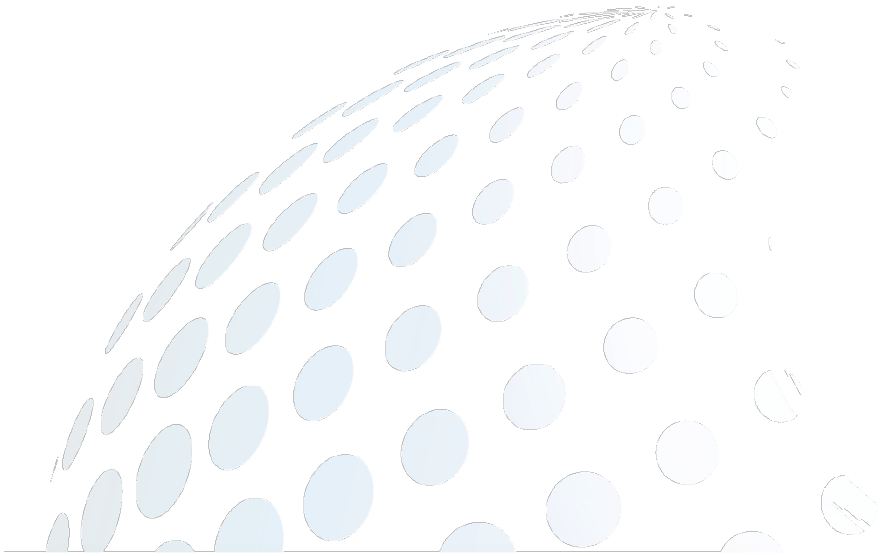
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Abstract Book



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PP-039	Pia Fischer	Luminescence of Sm^{2+} doped perovskites $CsMX_3$ (M = Ca, Sr; X = Cl, Br, I) – a comparative study

PP-040	Lawrence Munguti	High photodegradation performance of ZnO nanoparticles supported on porous zeolite Na-A: effects of ZnO loading
PP-041	Sarah E. P. Silva	Computational modeling of LMCT energies in europium compounds
PP-042	Sarah Morais Bezerra	Study of the amplification of light emission of lanthanide complexes using of copper and copper oxide nanoparticles
PP-043	Kexin Wang	Dual resonance Raman scattering nanoprobe based on ZnO@ZnS nanocomposite for accurate PSA detection
PP-044	Karolina Trejgis	Effect of the nanoparticles size on thermometric properties of SBR luminescent thermometer in $NaYF_4:Nd^{3+}$
PP-045	Huihua Song	Four novel lanthanide coordination compounds based on amino acid derivative ligands: construction, characterization and fluorescence chiral recognition performance
PP-046	Leonardo H. C. Francisco	Luminescence of $Eu(tta)_3(N\text{-picNO})_2$ (N=2, 3 and 4) doped PMMA films under synchrotron radiation.
PP-047	Xue Li	Enhanced glow of ultraviolet phosphor $LuAl_3B_4O_{12}:Bi^{3+},Gd^{3+}$ in ambient light
PP-048	Israel Ferreira da Costa	Structure and charge transport properties of tris (2-acyl-1,3-indandionate) aluminium(III) complexes
PP-049	Junshan Liu	Enhanced red luminescence of Sm^{3+} in structural-modified fluorophlogopite and its potential application
PP-050	Jie Ren	Dominant contribution of photosensitizer monomers to upconversion nanoparticles-based photodynamic therapy
PP-051	Min Ying Tsang	Lanthanide doped vis-to-UV upconversion phosphors for bio-application
PP-052	Yanshuang Li	Large area directional mechanical peeling and twisting angle stacking of TMDs
PP-053	Wei Xin	Anisotropic photoelectric response of graphene oxide film high-speed structurized via femtosecond laser
PP-054	Dorah Kawira Muthee	Modification of anatase-rutile mixed-phase properties using Sn^{4+} doping for photocatalytic brilliant green degradation
PP-055	Jorge Coelho	Adaptation and application of the intramolecular energy transfer to complexes containing transition metals and lanthanides
PP-056	Weiheng Zhong	GaS: a superior optoelectric material
PP-057	Qiushi Feng	High photoluminescence quantum yield achieved in monolayer MoS_2 and WS_2 via trifluoromethanesulfonic-acid assisted sulfur vacancy repairation and P-type doping

PP-058	Yuanzheng Li	Slow cooling of high-energy C exciton limited by intervalley-transfer in monolayer MoS_2
PP-059	Wenjuan Han	Ultraviolet photoluminescence from Ti_3C_2Tx MXene quantum dots by controlling the oxidation degree
PP-060	Julian Weiss	$M(AlCl_4)_2:Eu^{2+}$ (M = Ca, Sr, Ba) – a promising new class of Eu^{2+} containing phosphors
PP-061	Federico González García	Insight into the luminescent properties of Yb^{3+}/Bi^{3+}-doped $La_2Zr_2O_7$: charge transfer state and sensitization
PP-062	Tingxing Shi	Up-converted persistent energy transfer in $Gd_3Ga_5O_{12}:Pr^{3+},Tb^{3+}$
PP-063	Małgorzata Sójka	Exploiting bandgap engineering to finely control dual-mode $Lu_2(Ge,Si)O_5:Pr^{3+}$ luminescent thermometers
PP-064	Baiqi Shao	Engineered anisotropic fluids of rare-earth nanomaterials
PP-065	Shikao Shi	Enhancedred luminescence of Sm^{3+} in structural-modified fluorophlogopite and its potential application
PP-066	Yanling Wei	Two optical methods of temperature sensing behaviour of upconversion: Yb^{3+}/Ho^{3+} co-doped $KY(MoO_4)_2$ phosphor
PP-067	Yao Jin	Highly fluorescent PDI/SiO_2 nanospheres for in situ and real-time latent fingerprint development
PP-068	Hairegu tuxun	Probing and controlling photothermal heat generation in thermoplasmonic heating system
PP-069	Tamires Maira Oliveira	Au-decorated $REVO_4$ particles as potential nanoplatforms to study plasmonic catalysis
PP-070	Sofia Zanella	Reprogrammable and reconfigurable photonic molecular logic gates based on Ln^{3+} ions
PP-071	Alexander Verevkin	Formalization of adaptive management methods by training based on cognitive models
PP-072	Feng Chen	Upconverting phosphor-based ultraviolet light source
PP-073	Bruno Viana	Upconversion inducing persistent luminescence in $NaGdF_4:Yb^{3+},Er^{3+}$/ZGSO:Cr^{3+} nanoparticles
PP-074	Daniel Kujawa	Effect of graphene addition on the thermal and persistent luminescence properties of the $Gd_{2.994}Ce_{0.006}Ga_3Al_2O_{12}$ and $Gd_{2.964}Ce_{0.006}Dy_{0.03}Ga_3Al_2O_{12}$ ceramics
PP-075	Maria Claudia Felinto	Synthesis and luminescent properties of three new and bright Eu-tta compounds modified on α-carbon for use as biological markers
PP-076	Hongbo Zhu	Near-infrared photoelectric efficiency study of PbS solar cells enhanced by bimetallic electrode resonance

PP-077	Chunxiang Xu	In-situ, quantitative and gradient of perovskite composition regulation and trap state-mediated carrier dynamics
PP-078	Zhipeng Li	Photoacoustic/magnetic resonance imaging-guided photothermal theranostic nanoagent for glioma
PP-079	Yuwen Jia	High-performance electron-transport-layer-free quantum junction solar cells with improved efficiency exceeding 10%
PP-080	Zengchao Yu	Up-conversion charging $MgGeO_3:Mn^{2+}$ persistent phosphor upon illumination with white flashlight

The Shape of Water

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Water is the most important liquid for the existence of all life on Earth. Though it is the most common liquid, it is also the most uncommon in its behavior's, exhibiting a range of anomalous properties such as increased density upon melting, density maximum at 277 K (4 °C), reduced viscosity under pressure at below 306 K (33 °C), high surface tension, and decreased isothermal compressibility and heat capacity with temperature at ambient conditions (minimum values at 319 K (46 °C) and 308 K (35 °C), respectively).[1] To explain these anomalous behaviour, the hypothesis of two organizations of hydrogen bonds competing at thermal equilibrium has been proposed.[2] These two hydrogen-bond organizations manifest as two phases, namely the low-density liquid (LDL) and the high-density liquid (HDL), in the supercooled regime.[3] However, at ambient conditions, the existence of two distinct structural organizations and their implications remain elusive and controversial.

In this lecture, we will show how experimental measurements of the instantaneous Brownian velocity of $NaYF_4$:Yb/Er upconversion nanoparticles dispersed in water can prove the transition between low- and high-density phases in liquid water at the minimum of the isothermal compressibility.[4] Since the long-range hydrogen-bond network in LDL motif is the key to decipher the behavior of water, we will also emphasize why understanding the temperature dependence of its length scale will provide insight into the liquid water properties.

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Progress in phosphor materials and future perspectives

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Light-emitting diodes (LEDs) have attracted a great deal of attention around the world. Phosphor materials, as crucial color-converted components, play pivotal roles in the development of LEDs.[1–3] The demands for phosphor materials have become increasingly stringent for the past decades, from high brightness to function-dependent spectrum engineering. Although substantial progress in currently developed phosphor materials, it is still challenging to simultaneously satisfy all the requirements for high-level applications. To comprehensively fulfill these aspects, one should possess an extensive understanding of the progress in phosphor materials and the developed spectra control mechanism. Here, we summarize different generations of phosphor materials through the classification of demands for high luminescence, high thermal stability, narrowband emission for high color gamut, and broadband emission for near-infrared. Their key control mechanisms are revealed. Furthermore, future perspectives about the micro-LED applications as well as quantum dot materials are provided. This study opens up an avenue for designing luminescent materials for the future.

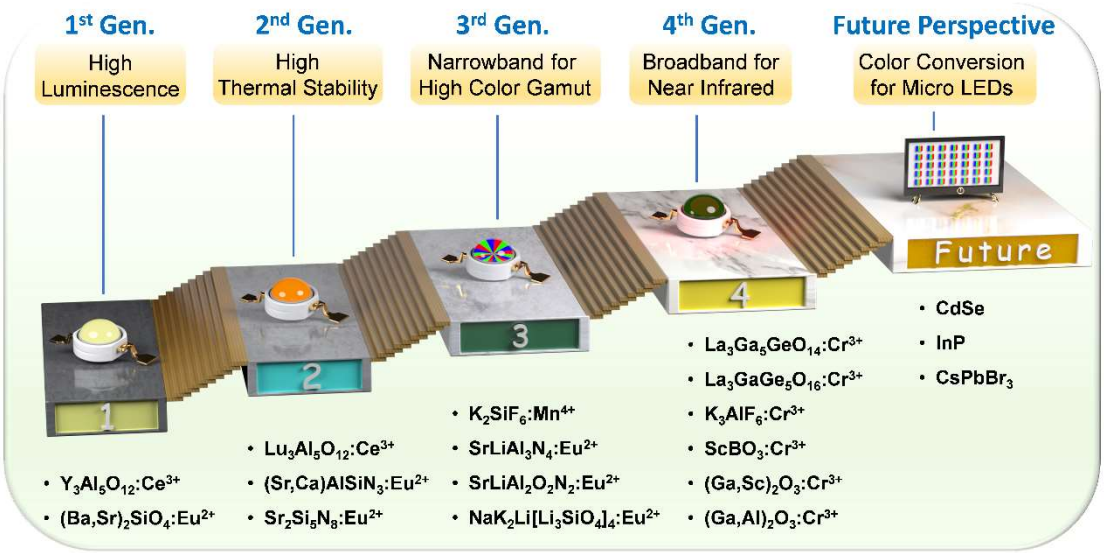


Figure 1. Progress in phosphor materials and future perspectives.

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Recent Advances in Flexible Electronics

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In the past decades, organic optoelectronics has made great progress both in fundamental studies and commercial applications because of their excellent properties, such as solution processable, flexible, low-cost and able to be made at large area. Our recent work is devoted to the development of high-performance organic semiconductors for flexible electronics and optoelectronics. I will present our recent advancement on rational molecular design of organic semiconductors for light-emitting diodes, lasers, memories, chemo-/biosensors, and latest research results about ultralong organic phosphorescence, light-emitting perovskites and color display technologies.

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Mixed-anion compounds giving unique luminescence characteristics in rare-earths

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While many of natural minerals, functional ceramic and glass materials are either oxides, chalcogenides or halides, the mixed-anion compounds, which contain several different anions, have now drawn attention as new types of inorganic material. Because of unique coordination, crystal structures and tunability of valence band in such mixed-anion compounds, it is possible that fundamentally different, innovative functions may be created. Materials with such innovative functions are expected to be created by using several different anions with differing electronegativity and polarizability, and exploiting the exceptional ability of such anions to control chemical bonding and electronic structures. In addition, many elements that become anions have a high Clarke number, and mixed-anion compounds have the possibility of becoming materials that act as a driving force for element strategies.

In this talk, some examples of development of new luminescent materials will be introduced by giving asymmetric ligand field to the active center and achieving lower excitation energy of charge transfer band by the valence band engineering in oxynitride and oxyhydride systems. Also examples of oxyfluoride glass ceramics will be presented, which have both formability of silicate glasses and high luminescent efficiency because of low phonon energy environment around the active ions.

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Photon-assisted up-conversion emission in semiconductor nanocrystals

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Colloidal Semiconductor nanocrystals as emissive materials are being widely explored in both academic research and industrial applications. Similar to other types of emissive materials, these activites are centered around down-conversion excitations. For instance, in the liquid-crystal displays, green- and red-emitting semiconductor nanocrystals partially convert the blue photons from GaN LEDs and yield displays with outstanding performance. This talk shall discuss a different class of emission, namely, single-photon up-conversion light emission. High optical quality nanocrystals are synthesized, which are with near unity photoluminescence quantum yield, mono-exponential decay dynamics, nearly identical single-dot and ensemble photoluminescence peak width, and outstanding photo-chemical stability. The single-photon up-conversion mechanism is confirmed to be phonon-assisted, implying near unity quantum yield and over 100% power conversion efficiency. Optical cooling of the nanocrystals in solution is observed relative to the blank solution. High-quality white-light source is demonstrated by this new type of highly efficient up-conversion (Figure 1).

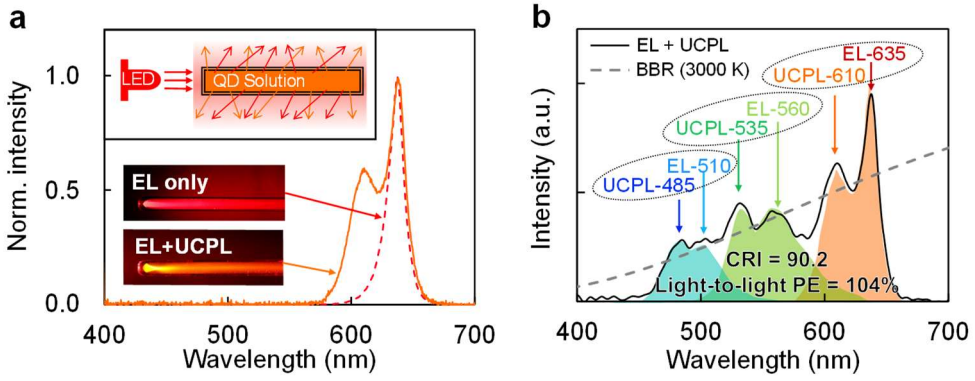


Figure 1. (a) Schematic illustration of up-conversion photoluminescence (UCPL) by excitation of electroluminescence (EL) from a red-emitting LED and spectra of orange-emitting UCPL nanocrystals and the red-emitting LED. (**b**) Spectrum of high-quality white-light based on nanocrystal UCPL and LED EL.

Lanthanide-Doped Upconversion Nanoparticles: Energy Transfer Modulation and Optical Imaging

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The rich spectroscopic terms of lanthanide ions confer unique optical characteristics to lanthanide-doped upconversion nanocrystals (UCNPs), including excellent photostability, large Stokes/anti-Stokes shifts, long luminescent lifetimes, sharp-band emissions, *etc*.[1] These attractive optical properties endow UCNPs with great prospects in biomedicine and nanophotonics.[2] Here, we developed a general thermal decomposition protocol to synthesize monodispersed UCNPs with controllable composition, size, morphology and structure.[3] The local structure and core/shell architecture of UCNPs were rationally designed to modulate the upconversion emission selectivity, efficiency, lifetime as well as excitation characteristics.[4,5] The as-developed UCNPs have been implemented in optical storage and bioimaging applications in both wavelength and lifetime dimensions.[6,7] In addition, our proposed UCNPs can be integrated with other imaging and therapetutic modalities, namely magnetic resonance imaging, photodynamic therapy, *etc*.[8,9] Moreover, with the highly sensitive and resolved optical microscopy, our upconversion investigations have been achieved in single-particle level, including barcoding, lasing, light polarization, *etc*.[10]

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Progress of hetero-epitaxy of AlN on sapphire substrates and the fabrication of deep ultraviolet light emitting diodes

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AlN, AlGaN with high Al fraction and their low dimensional quntum structures are the important materials for deep ultraviolet (DUV) optoelectronic devices. However, due to the lack of high-quality and low-cost homogeneous AlN substrates, AlN are mainly prepared by hetero-epitaxy on sapphire with large lattice mismatch. The resulting high defect density and residual stress in AlN films become a bottleneck to enhance the performance of AlGaN-based DUV light-emitting diodes (DUV-LEDs). In this talk, the recent research advances in the epitaxial growth of AlN films and AlGaN-based quantum wells of high quality on nano-patterned sapphire substrates (NPSS), the p-type doping of AlGaN with high hole concentration, and the fabrication of high-efficiency DUV-LEDs in Peking University are demonstrated.

Advances in highly doped upconversion nanoparticles

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My labs have developed a new family of nanophotonic "Super Dots" that can up-convert infrared photons into intense visible light at the nanoscale. A single Dot can be highly doped with more than 10^4 ions for high brightness. Several fascinating properties have been discovered since to allow high-throughput bio-discoveries, data storage, single nanoparticle lasing and high-security-level anti-counterfeiting applications, setting records for the tracking of single-molecule transport, super-resolution microscopy, nanoscale thermometry, and recently super-capacity single molecule digital assays and optical tweezers. In my talk, I will present the recent new developments of super-resolution microscopy imaging and single molecule tracking techniques, including direct microscopic inspection and tracking of single upconversion nanoparticles in living cells, multi-photon near-infrared emission saturation nanoscopy using single beam scanning, Bessel beam scanning to map single nanoparticles inside tumor spheroids, nonlinear structured illumination microscopy, Fourier domain heterochromatic fusion for single beam scanning super-resolution microscopy, axial localization and tracking of self-interference nanoparticles by lateral point spread functions, and recently optical tweezers.

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Luminescent properties of uncommon divalent lanthanides – fascinating spectroscopic features lead to promising candidates for future applications

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In contrast to the 4f-4f transitions in general observed for trivalent lanthanides, the intense emissions of the parity-allowed 4f ↔ 5d transitions of divalent rare earth ions depend strongly on the surrounding. The luminescence of the most stable one, Eu^{2+}, has been described in numerous host lattices [1], while other divalent lanthanides are rather sparsely investigated due their lower stability [2]. In fact, the number of publications correlates on the reduction potential Ln^{3+}/Ln^{2+}. While some works of Yb^{2+} and Sm^{2+} doped materials are available, the number of publications concerning Tm^{2+} are rare [3-5]. Materials containing more unstable divalent lanthanides, like Dy^{2+} and Ho^{2+}, are very scarcely described. The general procedure is doping with trivalent lanthanides, the reduction was achieved afterwards by γ-rays or alkaline earth vapor. This procedure is by far not suitable for the preparation of high quality samples, because it leads to numerous defects which influences the optical properties, and, moreover, the stability of the samples is very poor.

In this talk, I present the investigation of the luminescence properties of Yb^{2+}, Tm^{2+}, Sm^{2+} doped in different hosts. Above all, samples of good quality was achieved by direct doping with LnX (Ln = Yb, Tm, Sm, X = Halid, O, S), which is proved by the measurement of their optical properties. Yb^{2+} doped materials depicts T- dependent high- and low-spin emission, therefore it is a promising candidate for nano-thermometry. In this context we were successful to synthesis Yb^{2+} doped nanoparticles for the first time using ionic liquid as solvents. Additionally, Tm^{2+} doped materials are presented, which show extremely efficient up-conversion compared to trivalent lanthanide ions.

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Upconversion emission from Lanthanide nanoparticles: challenges and opportunities

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Luminescence from lanthanide nanocrystals, ranged from ultraviolet to visible and even the near-infrared, is attractive for a broad field of photon conversion applications. Efficient tailoring of the luminescence of lanthanide nanocrystals, i.e., intensity, f-f intra-configurational transition selectivity, and lifetime, are of great importance for extended applications. Lanthanide nanoparticles provide versatile possibilities in confining the energy transfer and recombination in nanoscale, make them a good platform of luminescence toolbox. Besides excitation and emission concerns, there is still plenty of room to investigate the intrinsic optical behaviors for polarization studies, lasing actions, and multiphoton conversion. Recent progress on these fields will be discussed.

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Luminescent All-Inorganic Perovskite Nanocrystals: Electronic Structure and Optical Properties

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All-inorganic perovskite nanocrystals (PeNCs) have shown great promise in optoelectronics and photovoltaics owing to their outstanding photophysical properties. In this talk, we shall focus on our recent efforts in the development of luminescent PeNCs from the controlled synthesis and electronic structure to their optoelectronic applications, with an emphasis on optical property tuning through cation incorporation and hetero-nanostructure design. For instance, we have devised a photoinduced method to synthesize $CsPbX_3$ (X = Cl, Br, I) PeNCs and nanocomposites with a high degree of control based on the light-triggered breakage of the covalent carbon-halogen bond of haloalkanes.[1] We have proposed a strategy via Mn^{2+} substitution to stabilize the lattice of $CsPbX_3$ PeNCs with improved thermal stability and optical properties as well as enhanced device performance in light-emitting diodes.[2] We have also unveiled the drastically distinct photoluminescence properties and excited-state dynamics of Mn^{2+} in spatially-confined 0D Cs_4PbCl_6 PeNCs in comparison with those in their 3D $CsPbCl_3$ counterparts.[3] Through the bandgap and surface structure engineering via Cd^{2+} doping, we have achieved efficient ultraviolet luminescence in $CsPbCl_3$ PeNCs.[4] Specifically, through sensitization by lanthanide-doped nanoparticles, we have realized full-spectrum upconversion and persistent luminescence tuning in $CsPbX_3$ PeNCs with a color gamut over 130% NTSC.[5,6] These findings provide fundamental insights into the structure-property relationship of $CsPbX_3$ PeNCs, thus laying a foundation for future design of luminescent PeNCs toward versatile applications.

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ICL 2020

Printing electroluminescent materials and devices

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The presentation will contribute printing electroluminescent (EL) materials and matrix devices, including polymers, cathode, quantuum dots, and provikete materials. The purpose of the investigation is try to realize full pringting display. The details of printing process, especially for pixel film qulity control, will be discussed. We have realized full printing (including cathode) electroluminescent devices with high EL efficiency, low drive voltage, and matrix red, green, blue EL Devices (Figure 1).



Figure 1 Full color AM-QLED display devices

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Biomaterials to boost cancer photo-immunotherapy

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Cancer immunotherapy has attracted tremendous attention in recent years. In our recent studies, we have tried to combine phototherapy with immunotherapy using nano-agents for cancer treatment. Those nanoparticles not only exhibit strong near-infrared (NIR) absorbance for efficient photothermal conversion, but also could serve as nano-adjuvants to promote the immunological responses. Stimulated by the tumor-associated antigens released after photothermal tumor ablation, the triggered immunological responses if in combination with anti-CTLA4 immune checkpoint blockade (ICB) therapy to suppress the activity of regulatory T cells could result in effective inhibition of tumor cells remaining in the body, promising for treatment of cancer metastasis. A strong immune-memory effect was also observed after such treatment. Such a strategy that works for various tumor types could effectively ablate primary tumors, inhibit metastases, and trigger strong immune-memory effects to prevent tumor relapses. Beyond photo-immunotherapy, we have extended this strategy to effectively treat metastatic tumors by combining radiation therapy with ICB immunotherapy based on rationally designed biomaterial platforms, achieving exciting therapeutic outcomes in different types of animal tumor models.

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Lanthanide-doped upconversion nanomaterials: from design to application of theranostics

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In recent years, lanthanide-doped upconversion nanoparticles (UCNPs) have undergone considerable advances in the design, synthesis and applications. Especially, UCNPs exhibit unique merits in theranostics applications, such as enhancing penetration depths, high resistance to photobleaching, as well as the minimized background auto-fluorescence. We firstly developed a super facile strategy (1 min only at room temperature) to synthesize the novel hexagonal phase of $NaBiF_4$ UCNPs with high yield (above 90%), which provided a new strategy to achieve UCNPs under mild conditions. Then, we further constructed stimuli-responsive nanotheranostic platforms based on UCNPs that imaging and anticancer activities in response to various internal/external stimuli, such as pH, H_2O_2, and light. The ZnO functionalized UCNPs can not only be used as multi-modality bioimaging (upconversion luminescence (UCL), computed tomography (CT), and magnetic resonance imaging (MRI)) contrasts, but also achieve specific pH-triggered ondemand drug release. We further made use of over-expressed H_2O_2 in tumor microenvironments to generate reactive oxygen species (ROS) by constructing “All-In-One” nanotheranotics.

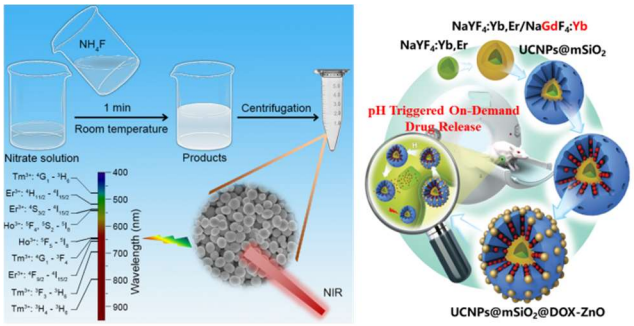


Figure 1. The design and construction of nanotheranotic agents based on UCNPs.

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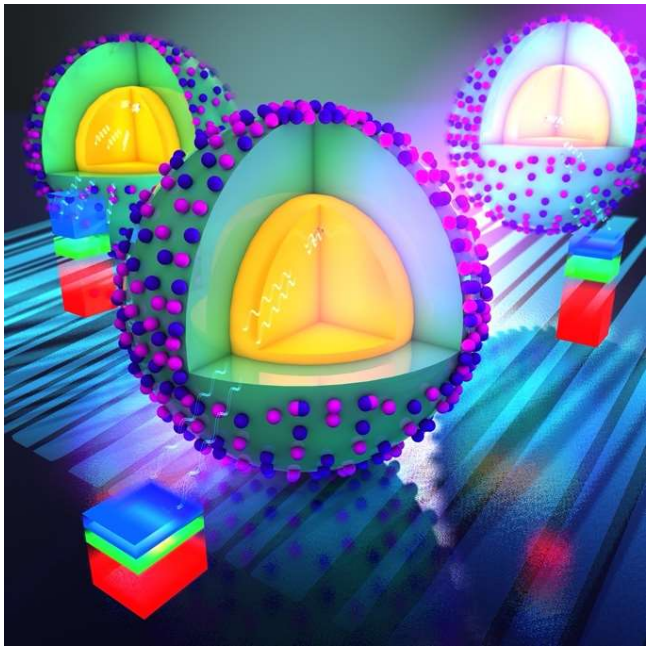
Time-resolved FRET with lanthanides, quantum dots, and dyes for brightness-equalized barcoding and biosensing

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Rapid, sensitive, and multiplexed quantification of biomolecules and biological interactions via Förster Resonance Energy Transfer (FRET) is an important analytical method in many fields of the life sciences. Combining lanthanide complexes, semiconductor quantum dots, and organic dyes as luminescent FRET probes offers many advantages concerning versatility, sensitivity, specificity, simplicity, and multiplexing. Here, we present how this combination can be used for color (luminescence wavelength) and temporal (luminescence lifetime) multiplexing for brightness-equalized optical barcoding [1,2], *in-vitro* diagnostics [3,4], and *in-situ* and *in-vivo* imaging [5,6].



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Perovskite semiconductors for photonics and polaritonics

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Halide perovskite semiconductors exhibit exceptional optical gain properties, large oscillator strength and high external quantum efficiency, thus they have shown tremendous potentials in a wide range of photonic and optoelectronic applications, such as solar cells, light-emitting diodes, photodetectors, and nanophotonics. In 2D hybrid perovskites and some 3D all inorganic perovskite systems, robust exciton formation at room temperature has been recognized, suggesting a bright future for strong light-matter coupling towards room-temperature polaritonics. We will present an exciting journey in the discovery of exciton polariton in perovskite semiconductor microcavities, resulted from a strong light-matter coupling. Particularly we will discuss recently progress in polariton laser and condensate, nonlinear properties and quantum optics control based on artificial potential landscapes, demonstrating the significant promise in future photonics, polaritonics and integrated photonic devices based on those new quasiparticles.

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Measuring 3D orientation in nanoscale with polarized Eu^{3+} emission

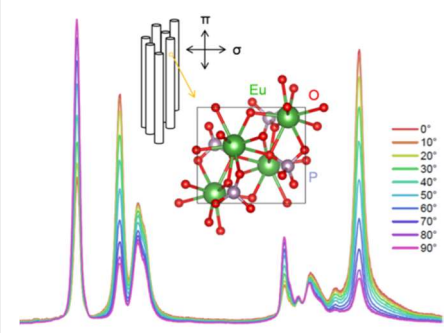
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Luminescent probes are universally used to observe the dynamics of life and matter in small scale. Recent progresses in optical microscopies have achieved nanoscale spatiotemporal resolutions for positional tracking. However, most dynamic processes from molecular to cellular level still remain secret because they involve complex motions such as rotation, twisting, and bending that are difficult to observe.

We design lanthanide nanoprobes emitting light that signals their 3-dimensional (3D) orientation. We utilize the peculiarly polarized luminescence of Eu^{3+} doped in anisotropic nanocrystal hosts. The multiple transition lines of Eu^{3+} exhibit a dramatic spectral line shape change when the probe rotates. The unique nature of lanthanides possessing both electric and magnetic dipole transitions with distinct polarization behaviours delivers rich information on the spatial orientations of individual probes (*spherical angles*: θ, ϕ) and their ensemble (*order parameter*: $S = <3\cos^2\theta - 1>/2$) [1]. We deliberately tune the host nanocrystal structure (e.g. $LaPO_4$, $NaYF_4$) in order to maximize the emission efficiency and the degrees of polarization of Eu^{3+} lines, thereby achieving unprecedented sensitivity to the orientation of nanoscale objects [2].



Polarized emission spectra of Eu^{3+} doped in monazite $LaPO_4$ nanorods [2]

Our approach treats *geometrical* orientation analysis as a simple *spectroscopic* problem. This eliminates various sources of error such as background luminescence, experimental noise, or unstable excitation that are unavoidable with previous methods. It is thus promising to utilize the new probes for unveiling the complex dynamics of biomolecular processes and cellular activities. Furthermore, we present how the orientation analysis of these nanoprobes can be applied to the microfluidic shear stress imaging [3] and the study of colloidal self-assemblies [4].

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Structural engineering of Eu^{2+} doped silicates phosphors for LED Applications

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Owing to the unique 4*f*-5*d* transition, Eu^{2+} is one of the most commonly used activators in luminescent materials for phosphor-converted light-emitting diodes (*pc*-LEDs), and Eu^{2+}-doped silicates phosphors exhibit outstanding luminescence properties, including multi-color emission, adjustable bandwidth, excellent thermal stability as well as high luminescence efficiency. These attributes motivate scientists to find Eu^{2+} doped silicates phosphors that can practically meet the various LED application requirements. In this talk, I will summrize several structural strategies proposed by our group to manipulate Eu^{2+} emission, including (1) modify the chemical composition and crystal structure by various substitutions, (2) choose or change a suitable crystallographic site for Eu^{2+} and (3) control crystalline phase transition by external factors. The state-of-the-art LED application including full spectrum solid-state lighting, wide color gamut display and near infrared night-vision technologies will be also introduced based on these Eu^{2+} doped silicates phosphors. We hope this talk will be helpful for controlling the photoluminescence by theory-structure-property relationships and guide scientists discover the next generation of Eu^{2+} doped phosphors for emerging applications.

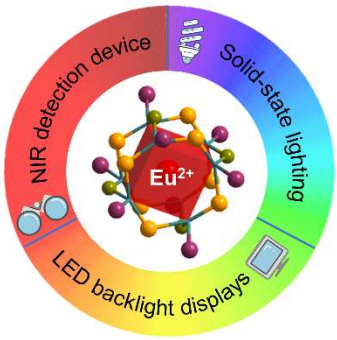


Figure 1. structural engineering diagram of Eu^{2+} for materials design and LED applications.

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First observation of the hyperfine structure and level anticrossings in the luminescence spectra of a crystal

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We investigate high-resolution low-temperature luminescence spectra of $LiYF_4:Ho^{3+}$. Hyperfine and isotope structures were resolved, for the first time in the luminescence spectra of a crystal. The line width of the narrowest spectral lines is as small as 0.0022 cm^{-1}, being the smallest line width ever observed in the luminescence spectra of crystals. An effect of the hyperfine levels' anticrossing was found in magnetic fields 20 – 180 mT directed along the *c* axis. In our previous study, we have reported on this effect in the absorption spectra of $^7LiYF_4:Ho^{3+}$, which was, as we believe, the first direct observation of the hyperfine levels' anticrossings in optical spectra [1]. The present finding opens the way for studying the hyperfine effects in the transitions between the excited crystal-field levels.

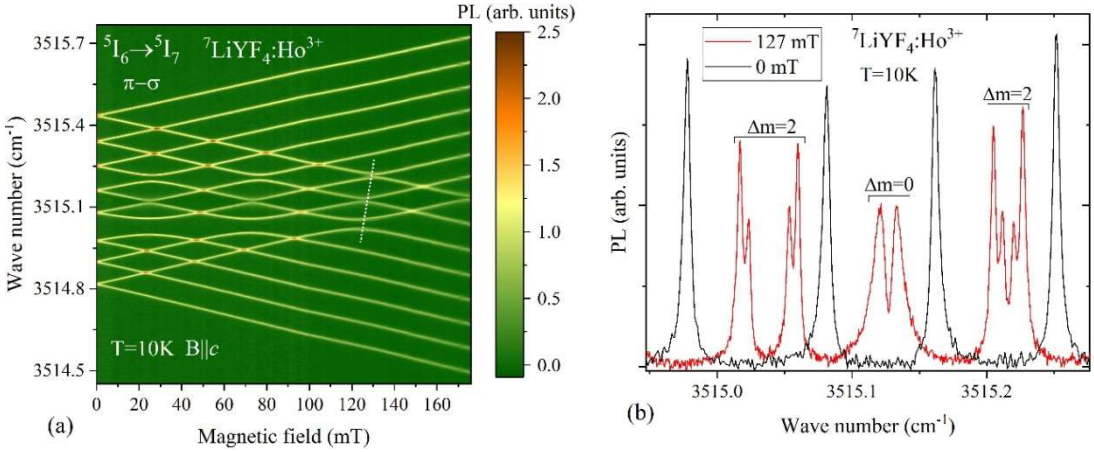


Fig. 1. (a) Luminescence intensity map in the magnetic-field – wavenumber scale for the $^5I_6\,\Gamma_2$ (8670.9) → $^5I_7\,\Gamma_{34}$ (5155.7) transition of Ho^{3+} in $^7LiYF_4:Ho^{3+}$ (0.1%) at 10 K. (b) shows in more detail the 5th anticrossing in (a) (red trace) together with the zero-field spectrum.

The results create preconditions for developing magnetic-field sensors that can be in demand in modern devices of quantum information technologies. Anticrossings observed in the hyperfine spectral pattern in a magnetic field can be used as sensors of random lattice strains in the crystal.

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Advances and challenges in rare earth doped materials for quantum technologies

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Systems with both spin and optical transitions offer a range of functionalities for quantum technologies [1]. They allow storage and entanglement of photonic quantum states for quantum communications, interfacing processing nodes with optical networks for distributed quantum computing, or efficient detection for quantum sensing. Among various solid-state systems currently considered, rare earth doped materials stand out as they combine, at cryogenic temperatures, long-lived optical and spin quantum states [2]. In addition, they offer optical transition in a wide spectral range, including telecom wavelengths, high chemical stability, and easy doping in many hosts, thus enabling using large ensembles of centers with uniform properties.

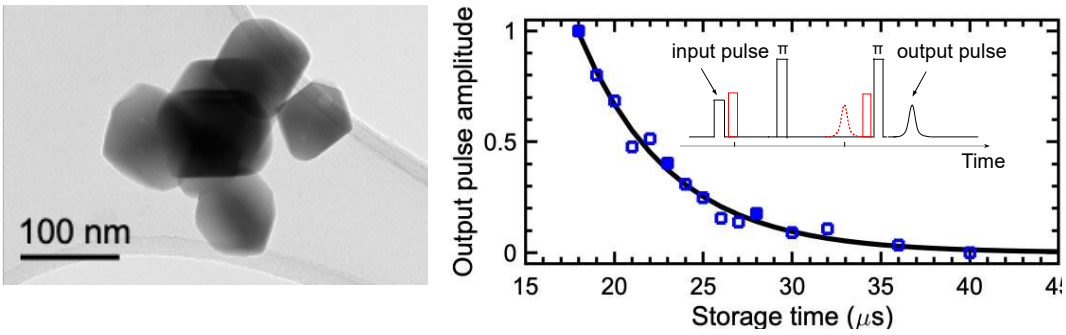


Figure 1: Coherent and frequency multiplexed optical storage in rare earth doped nanoparticles using an electro-optic protocol [3,4].

Quantum-grade rare earth doped materials are developed in different forms. They include bulk crystals, like Y_2SiO_5, in which many early demonstrations were performed, and more recently nanostructured materials such as nanoparticles or thin films, aiming at integration into nanophotonics devices. New platforms and approaches are also studied, taking advantage of ion implantation, molecular chemistry or hybrid structures for example. This fast-expanding field has witnessed impressive progress and hold exciting promises for a broad range of quantum-based applications. In this talk, we will review these advances, as well as the challenges to be addressed to bring rare earth doped materials up to the highly demanding requirements of quantum technologies.

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Research in luminescence inspired by Prof. George Blasse: A tribute

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I will highlight the influence of Prof. George Blasse's publications on my research in solid state luminescence.

In the wake of George Blasse

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In his paper « Classical Phosphors: a Pandora's box » [1], George Blasse discussed some unclear aspects of the optical behaviors of otherwise « classical phosphors » (tungstates, vanadates, …) or « classical activators » (Cu^{+}, Bi^{3+}, Sb^{3+}, Tb^{3+}, …), sharing with us his doubts and intuitions. Through this, he sowed topics to investigate as seeds to grow. Twenty-five years later, we show in this lecture how some of these seeds have developed, with special focus on spectroscopic issues involving metal-to-metal charge transfer processes and their consequences.

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Remembering George Blasse

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The impressive career of George Blasse in the field of luminescence started in 1964. Triggered by the discovery of $YVO_4:Eu^{3+}$ as red phosphor in cathode ray color TVs the management of Philips Research decided to re-establish the luminescence group and George Blasse was asked to lead the group. Very productive years followed in which George discovered many new phosphors, including $YAG:Ce^{3+}$. In 1970 he made an unusual career switch and accepted the position of professor of Solid State Chemistry at Utrecht University. George Blasse led a highly successful research group for over 25 years and became internationally recognized for his research on luminescent materials. He combined groundbreaking fundamental discoveries with societal relevance. George had a deep and also intuitive understanding of luminescence phenomena and often relied on clever chemical variations in host composition and structure to obtain insight in the underlying physics. Simple guidelines and clear design rules based on systematic and careful research of a wide variety of materials were discovered, explaining spectral variations and trends, for example in thermal quenching of luminescence for Eu^{3+}. The constant energy difference between fd states of different lanthanides was pioneered by George Blasse and later became the basis for the now widely used Dorenbos model. Another area where the work of George Blasse was instrumental involved energy transfer and energy migration phenomena. He was able to translate the somewhat complex theoretical papers as those by Förster and Dexter into simple models and equations to understand and quantify energy transfer processes. George Blasse also made important contributions in understanding of the optical properties of s^2 ions like Pb^{2+}, Bi^{3+}, Sb^{3+} and Sn^{2+}. In recent years this work of George receives increasing attention in the light of extensive work on luminescence of these ions in double perovskites. In this presentation I will share memories and highlight the great contributions of George Blasse to our field.



Figure 1 – (left) George Blasse, (middle) Yellow YAG:Ce and other phosphors for white light LEDs and (right) The famous book 'Luminescent Materials' by Blasse and Grabmaier.

Searching for new nitride phosphors for emerging applications

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Eu^{2+} or Ce^{3+}-doped nitride phosphors have played important roles in white light-emitting diodes (wLEDs) due to their significantly redshifted photoluminescence, valuable emissions, high quantum efficiency and small thermal quenching. However, as a new class of luminescent materials, it is necessary to extand their applications except for wLEDs, allowing for a sustainable research and development of nitride phosphors. Thanks to advances in laser-driven solid state lighting and mechanoluminescence-based sensing technologies, nitride phospors are again attracting great attentions. In these emerging applications, there are different requirements for luminescent materials from those used in wLEDs. Therefore, it is urgent to design or find new luminescent materials that can be survived from high-power laser excitation or have desired mechanoluminescence. In this paper, selection rules of phophors for laser lighting will be presented, and some red- or orange -emitting nitride phosphors, such as HP-$CaSiN_2$:Ce^{3+}, $La_3(Si,Al)_6N_{11}$:Ce^{3+} and CALSON:Ce^{3+}, will be reported. In addition, a design principle for mechanoluminecent materials will also be proposed, enabling to discover several nitride phosphors (*i.e.*, β-sialon:Eu^{2+}, $SrSi_2O_2N_2$:Eu^{2+},Dy^{3+}) with interesting mechanoluminescence. Applications of these nitride phosphors in laser lighting and sensing will be demonstrated.

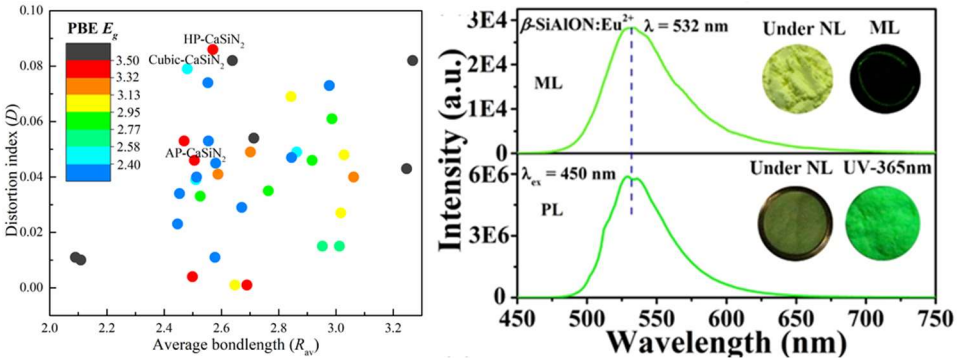


Figure 1 Searching for red-emititng nitride phosprhos for laser liguting (left) and the mechanoluminescnece (ML) of β-sialon:Eu^{2+} (right). PL means photoluminescence.

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The EMP emission in diluted II-VI magnetic semiconductor nanostructures and their application in perovskites

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Optical properties of diluted magnetic semiconductor (DMS) are not well understood so far, especially relationship to their ferromagnetism, which may cause the formation of excitonic magnetic polaron. Here we prepared Mn ion doped ZnO, CdS and ZnSe nanostructures by CVD method, studied their optical properties via microphotoluminescence techniques, found many very interesting properties, which are all related to the exciton magnetic polaron (EMP), itinerant or partially itinerant, their energy levels are agree well with the AB initio calculations.

In ZnO:Mn nanowires, the EMP can show up with free exciton together for very diluted doping(<0.001%), this EMP can form condensate to produce single mode lasing line at fs pulse excitation along with the disappearing of free excitons, which indicate a condensation of EMP. With a little bit large amount of Mn doping, the nanowire show EMP lasing mode with background at fs laser pulse excitation, but at even high power, some electron-hole plasma induced lasing modes could be observed due to the carrier effect. The time-delayed photoluminescence by ns laser pulse are also studied, only free EMP and localized EMP(d-d transition) show up in the emission spectra, we gave the clear assignments for all the d-d transitions of Mn in ZnO,[1] which have been argued for a long time. It is more interesting that these d-d transitions exhibit clear enhanced coherent relaxation behaviors with increasing excitation power, like that by free excitons, even couple with LO phonons, behave a collective spin-dependent coherent radiation, which may be used for quantum modulation applications. We also observed the Mn-O-Mn cluster peak in the long wavelength range, which may be related to the ferromagnetic properties.

In CdS:Mn nanowires,[2] we found many peaks longer than the single Mn ion emission band (575nm) when increasing the Mn concentration, we used a simple Hydrogen-like cloud theoretical model to describe them well, in this model, the Mn-S-Mn-S aggregate with variable Mn ion number and their ferromagnetic coupling are considered. The SQUID detection proved the ferromagnetic behavior of the aggregate, and MFM imaging indicated its cluster nature in a microbelt or nanowire. Ab initio calculation results also support our assignments. The aggregation of Mn ion in II-VI semiconductor microstructures can produce ferromagnetic and PL emission at the same time. If doped with Co(II), clear EMP profile have been observed, which can give single mode lasing at EMP wavelength due to collective EMP condensation;

When over doped with Ni halides, [3] we have found that double –single mode lasing with span over 200nm, due to the EMP effect.

When we used the EMP concept to perovskite preparation,[4] we found that the EMP form when doped Mn ions approach each other in the lattice of mother matrix within about 6.7 Å, which is at the rim between ferromagnetic coupling and paramagnetic coupling. The magnetic polaron formation can give very efficient emission and nonlinear optical responses in these materials.

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Carrier transport in 2D perovskite quantum wells

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Two dimensional (2D) layered hybrid perovskites are naturally formed multiple quantum well (QW) materials, which hold great promise for many optoelectronic devices. In this presentation, I will introduce our recent works on carrier transport dynamics in 2D layered perovskites. By using time-resolved spectroscopic techniques, we found that the carriers within a QW plane performed a trap-enabled transport over a few micrometers, which is a distance comparable with that in 3D perovskites; on the other hand, the electron charges in a QW plane can overcome the energy barrier and transfer to the adjacent QWs trough the Auger-recombination of excitons. These results enlighten the fundamental photophysical properties of 2D perovskites and provide guidelines for designing this class of materials.

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Through-space charge transfer polymers

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Charge transfer (CT) interactions between electron donors (D) and electron acceptors (A) are the basis of optoelectronic functions of many organic and polymer materials, which have enabled important application in organic light-emitting diodes. By finely modulating the CT processes between donor and acceptor, not only the emission color can be tuned to cover the whole visible range, but also the luminescent efficiency can be enhanced by promoting the reverse intersystem crossing process to harness the non-emissive triplet excitons. So far, the majority of luminescent polymers with CT characters are based on conjugated D–A architectures and through-bond charge transfer (TBCT) emissions.

Different from conventional luminescent polymers with through-bond charge transfer emission, our group proposed the new strategy to develop through-space charge transfer (TSCT) polymers which consist of non-conjugated polymer backbone (polystyrene as backbone) and π-stacked donor/acceptor architectures for achieving thermally activated delayed fluorescence (TADF) effect in 2017. This molecular design not only leads to the breakthrough of device efficiency for blue fluorescent polymers, but also allows the realization of full-color and white-emitting polymers, making the TSCT polymer a new paradigm for designing TADF polymers. Meanwhile, by using polynorbornene as non-conjugated polymer backbone, TSCT polymers with fixed and controllable spatial alignment of donor and acceptor in edge-to-face/face-to-face stacking patterns are developed, giving the record-high external quantum efficiency of 18.8% for blue fluorescent polymers. By using hexaphenylbenzene as the skeleton for creating multiple donor/acceptor interaction channels, TSCT dendrimers with both TADF and aggregation-induced emission (AIE) effect are developed.

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Self-assembled organic microcrystal lasers

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Organic solid-state lasers (OSSLs) have been widely investigated during the past decades, owing to their amenability to low-cost and low-temperature processing, compatibility with plastic substrates, and broad spectral tunability. A variety of optical resonators have been applied for optically pumped OSSLs, including planar waveguide Fabry-Pérot (FP) microcavity, distributed feedback (DFB), whispering-gallery mode (WGM) microring microresonator, and photonic band-gap structures. Nevertheless, electrically driven OSSLs remain still a great challenge, partially because the conflicting requirement between large stimulated emission and high charge carrier mobility narrows the range of organic semiconductor gain materials available for electrically driven OSSLs. Recently, we demonstrated that organic microcrystal with well-defined dimensions and different polymorphisms can serve as microresonators for fundamental investigation of optical confinement effect on laser behaviors, such as nanowire FP and microdisk WGM microlasers. Moreover, organic single crystals are ideal for use as laser materials, because their long-range ordered structures minimize traps and are free from grain boundaries. Therefore, organic microcrystals provide a material to combine high carrier transport, efficient optical gain, and microresonator together on the way to develop electrically pumped organic lasers. In this talk, I will present our research on the photonic performance of molecular microcrystal microcavities and the latest breakthroughs toward organic microlaser devices. Overall, organic microcrystals bring tunable optical properties based on molecular design, size-dependent light confinement in low-dimensional structures, and various device geometries for nanophotonic integration.

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LED phosphors

-nitride, trap center, and high pressure-

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Since the discover of blue LED, industrial nitride phosphors such as red $(Ba,Sr)_2Si_5N_8$:Eu, red $(Ca,Sr)AlSiN_3$:Eu, green be-ta Sialon, and yellow or green $La_3Si_6N_{11}$:Ce (LSN) have been discovered. Later, narrow red $SrLiAl_3N_4$:Eu was found. New nitride phosphors have much contributed to the rise of LED lighting and display industry for two decades. At present, the research for advanced LED phosphors is saturated now? Probably, the answer is no.

So far, many new phosphors have been turned down for LED industry due to the bad temperature dependency of emission in spite of relatively narrow emission better for LED display. One of main reason is that these phosphors have 5d band too near conduction band, where nonemissive process happens because the excited electron gets away through conduction band. However, recently, we found that temperature dependency is much improved due to the formation of electron trap center just below conduction band in our new red $(Ba,Sr)_2(Si,Al)_5(N,O)_8$:Eu (Li et al.) [1], which is probably the best in 2-5-8 series. This finding indicates that phosphors have still possibility to be improved by the new strategy.

Another interesting phenomenon for the future is high pressure induced narrow phosphors. We were able to change the narrow green $Ba[Li_2(Al_2Si_2)N_6]$:Eu (Strobel et al.) [2] into the narrow yellow phosphor at 16 GPa (Wang et al.) [3], which has much narrower yellow (FWHM: 70 nm) than LSN (Seto et al.) [4]. It indicates that high pressure can change the emission color to the warmer color with keeping the emission-width, while conventional element's substitution cannot in most cases.

The above phenomena will be explained in detail.

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Recent achievements on multi-color long persistent phosphor (LPP) via doping, solid solution and energy transfer

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Long persistent phosphor (LPP) is a material that could emit light for hours even for days after a period of time excitation, which can be applicated in night-lighting, anti-counterfeiting, artifact, information encryption and bio-imaging etc. LPP has been extensively studied since it discovered due to its attractive property. However, there still are several problems though LPP has been researched and reported a lot, for instance, (i) LPP mechanism, (ii) Diversity of afterglow color and (iii) The demand for new materials. Based on this, our group explored LPP via doping, solid solution and energy transfer, then instructing the new LPP investigation through digging into the mechanism.

We will introduce recent progresses of our lab on LPP in the presentation.

i. Mechanism study of rare earth ions doping

As for $BaSc_2Si_3O_{10}:Eu^{2+}, Nd^{3+}$ presents difference between PL and PersL, indicating the abnormal site occupation of Eu^{2+}, revealing the important role of conduction band in afterglow progress.

For the $BaHf/ZrSi_3O_9:Eu^{2+}, Pr^{3+}$, it is revealed that the trapping and detrapping of electrons into and from the shallow traps through the conduction band leading to a rapid decay while the deeper traps via tunnelling process resulting the much slower and nonexponential decay behavior.

ii. Solid solution

As for the $(Ba,Li)(Si,Ge,P)_2O_5:Eu^{2+},Pr^{3+}$, it is demonstrated that the luminescent intensity and afterglow time of the sample can be regulated by changing Pr3+ doping concentration, as well as solid solution.

As for $CaMgGe_2O_6: Mn^{2+}, Sm^{3+}$ and $Na_2CaGe_5SiO_{14}:Cr^{3+}$, the design and structure analysis of NIR long persistent phosphor materials, as well as the penetration experiment of biological tissues is investigated.

iii. Energy transfer

We utilized the energy transfer between $CaAl_2O_4:Eu^{2+}, Nd^{3+}$ and $Y_3Al_5O_{12}:Ce^{3+}$ to promote the LPP property of the latter in that the emission of former is almost entirely covered with the excitation of latter.

Similarly, the afterglow emission is shifted from blue to green because the energy transfer between Ce^{3+} and Mn^{2+} in $SrAl_2O_4: Ce^{3+}, Mn^{2+}$.

Other works

As for $Ca_6BaP_4O_{17}:Eu^{2+}, Tb^{3+}$, the LPP property in high-pressure condition is studied and discussed the color-shift mechanism in pressure-altering.

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II-VI based organic-inorganic hybrid nanostructures with greatly enhanced optoelectronic properties, perfectly ordered structures, and long-term ambient stability over 15 years

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A family of II-VI based organic-inorganic hybrid materials was discovered in early 2000 [1]. Some of them have been shown to exhibit several unique properties. Here the most studied prototype β-ZnTe(en)$_{0.5}$ (en = $C_2N_2H_8$) is used to illustrate these unique or unusual properties in three aspects: (1) Very high crystallinity in both macroscopic and microscopic scale, manifested as small XRD and Raman linewidths comparable to most binary semiconductors [1, 2] and minimal below bandgap emission and nonradiative recombination in room temperature PL [2]. Furthermore, as a hybrid superlattice, it is the most prefect semiconductor superlattice, of which the concept was proposed by Esaki and Tsu in 1970, that eliminates the commonly existing interfacial diffusion among all the known inorganic superlattices. (2) Exceptionally excellent ambient long-term stability over 15 years [2], which is rare across the hybrid materials. It offers a unique opportunity to investigate the interplay of the intrinsic and extrinsic degradation mechanisms and the development of metrics for assessing the long-term stability of a hybrid material. (3) Greatly enhanced or novel properties, including strongly enhanced excitonic absorption (as high as 10^6 cm^{-1}) and exciton binding energy (over 200 meV), room temperature excitonic emission [3], broad-temperature-range zero-thermal expansion [4], and much reduced density and dielectric constants [3]. These properties suggest a range of potential applications, including room-temperature exciton-polariton condensation, optical switching, transparent p-type conductor, efficient UV emission and detection.

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Spin polarized photon emission from single quantum dots for chiral photonic circuits

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Chiral light–matter interaction between photonic nanostructures with quantum emitters shows great potential to implement spin–photon interfaces for quantum information processing [1]. The tightly confined light field in nanophotonic waveguides carries transverse spin angular momentum, thus a link between spin and the propagation direction of light can be introduced. Consequently, spin-momentum-locked light coupled to quantum emitters with circularly polarized transitions becomes directional-dependent. Self-assembled semiconductor quantum dots are excellent candidates for single photon sources with high purity and indistinguishability, which have much potential to scale up on-chip [2]. Exploiting spin-polarization properties of quantum dots and engineering rational nanophotonic waveguide structures make it possible to transform information from spin encoding to path encoding.

Here, we first demonstrate position-dependent chiral coupling between quantum dots and cross waveguides both numerically and experimentally [3]. Different unidirectional and polarization-deterministic emission into a single waveguide as well as in both two waveguides simultaneously are achieved from the quantum dots embedded in the cross section of the two orthogonal waveguides. Therefore, the cross waveguide can function as a one-way unidirectional waveguide and a circularly polarized beam splitter by placing the quantum dot in a rational position. Furthermore, compact chiral photonic circuits with deterministic circularly polarized chiral routing and beamsplitting are demonstrated using two laterally adjacent waveguides coupled with quantum dots [4]. Chiral routing arises from the electromagnetic field chirality in the waveguide and beamsplitting is obtained via the evanescent field coupling. The spin- and position-dependent directional spontaneous emission are achieved by spatially selective micro-photoluminescence measurements, therefore enabling control of the in-plane transfer direction of the spin states with a high chiral contrast of up to 0.84. The chiral photonic circuits with chiral light-matter interaction provides a base for multi-functional devices, such as quantum spin interference, optical logic circuit, quantum information storage, and muti-photon entanglement, which makes chiral quantum photonic network on-chip feasible in future.

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Disorder engineering of oxide semiconductors for more efficient photoelectric conversion

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Lattice disorder is normally undesirable in semiconductor optoelectronics, since it is well-known that photo-excited electrons and holes tend to recombine at lattice imperfection. In this talk, we will present that certain lattice diordre in nanoscale may result in more efficient photoelectric conversion in oxide semiconductors.

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Three-photon process dominated red upconversion emission in Yb^{3+}-Er^{3+} system

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Since the discovery of infrared (IR) to visible upconversion (UC) through energy transfer between rare earth ions UC luminescence has been extensively studied for its fundamental interest and various potential applications. The UC materials with tunable fluorescence color as a function of IR excitation power density are attractive candidates for fluorescence anti-counterfeiting with high level security. The Yb^{3+}-Er^{3+} combination is the most popular UC system that produces a green and a red emission of Er^{3+} under 980 nm near infrared (NIR) excitation. The green and the red emission both have an obvious two-photon excitation process that a quadratic dependence of their intensity on NIR excitation power density is often observed. Actually, three-photon excitation for the red emission was also observed in a few hosts that showed a super-quadratic dependence of the red intensity on NIR excitation density, leading to an increase of red to green intensity ratio accompanied by color variation. However, the color variation occurred only at high NIR excitation densities, that limits its applications.

Here, we report three-photon process governed UC red emission in YbF_3:Er^{3+}, wherein the green to red color tuning was realized with the excitation power density below 100 $mWcm^{-2}$, which is two orders of magnitudes lower than the power densities required in other UC materials. The three-photon excitation routes and their contributions to the red emission are studied in detail as a function of excitation power density. Our results indicate a promising potential of YbF_3:Er^{3+} in anti-counterfeiting applications.

Defect and interface engineering of two dimensional materials

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Two dimensional (2D) materials have shown great potential in the application of optoelectronic devices, because of their unique optical and electrical properties. The performance of optoelectronic devices based on 2D materials is strongly influenced by defects and the interface. In this talk, we will present our results on the defect and interface engineering of 2D materials to improve the performance of photodetectors. We demonstrate that the trap states in two-dimensional ReS2 could be efficiently modulated by defect engineering through molecule decoration, and both the response time and responsivity of the device are greatly improved. We further elaborate that plasmon-induced hot electron transfer (HET) from tungsten suboxide nanocrystals to graphene is a sufficient fast process (<150 fs) to prevent carrier cooling and trapping processes. A fast near infrared (NIR) detector empowered by HET is demonstrated, and the response time is three-orders of magnitude faster than that based on common band-edge electron transfer. Finally, based on the intefacial gating mechanism, we successfully demonstrate a graphene based position sensitive detector (PSD), which shows excellent position sensitivity, fast response and low degree of non-linearity, and extends the operating wavelength to the near infrared (IR) region. Our results indicate that defect and interface engineering is a new strategy for implementation of efficient and high-speed optoelectronic devices.

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Up-conversion charging and ambient stimulated emission of storage phosphors

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Storage phosphor is a kind of light-emitting material, which can store excitation energy in so-called traps, and then release the energy as light emission upon various stimulus. Further understanding some basic aspects of storage phosphors, involving the excitation (charging) and emission (discharging) performances, is necessary but often underestimated. In this presentation, on one hand, we demonstrate a non-linear excitation approach termed up-conversion charging (UCC), in which the traps are typically filled via a two-step ionization mechanism [1]. Accordingly, we model and experimentally verify the UCC dynamics by taking into account the effect of excitation-light stimulated emptying (Fig. 1a) [2]. On the other hand, we introduce an interesting emission concept termed ambient stimulated emission (ASE), in which the ambient lighting and ambient temperature can simultaneously release the stored energy in the storage phosphors and lead to long-lasting emissions beyond the visible spectrum (Fig. 1b) [3]. As a proof of concept, we focus our discussion on a garnet phosphor, $Y_3Al_2Ga_3O_{12}:Pr^{3+}$, which can be charged by visible-light illumination and subsequently exhibits an interesting glow-in-the-bright emission. We hope this work may bring different point of view to luminescence research, and offers approaches to further learn and utilize the storage phosphors.

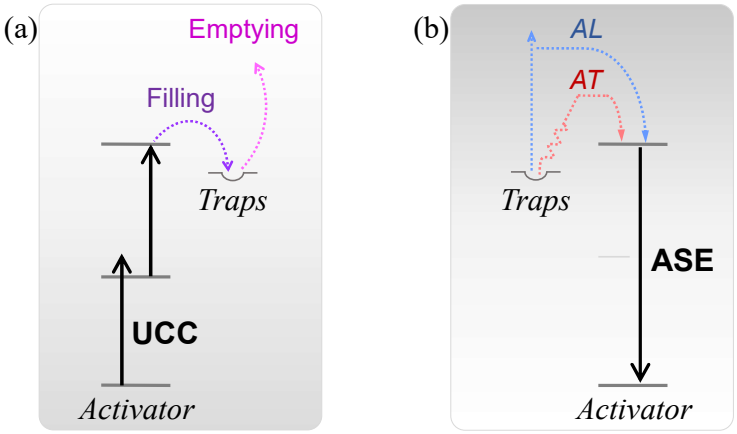


Fig.1 (a) Two-photon UCC process of a storage phosphor. While the trap is being filled under non-linear excitation, the trapped electrons may be simultaneously liberated by the exciation energy. (b) ASE process of a charged phosphor. Stimulation energies from ambient lighting (AL) and ambient temperature (AT) simultaneously liberate the trapped electrons, followed by ASE.

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Remembering Sergey Feofilov

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The unexpected passing of Sergey Feofilov at the age of 62 has shocked our community. Sergey was a driving force in the field of luminescence and contributed not only by innovative discoveries and high quality publications but also by serving the luminescence community as editor of the Journal of Luminescence, chairman of the International Organizing Committee of the DPC and member of the International Program Committee of the ICL. In this presentation I will share some personal memories and focus on two scientific topics where Sergey and I crossed roads: the role of refractive index effects on the radiative decay rates of ions in nanocrystals [1] and discrete 'inhomogeneous' broadening by cation disorder in the second coordination sphere [2]. The pioneering of Sergey on refractive index effects for nanocrystals inspired research by me and many others to better understand local field effects.

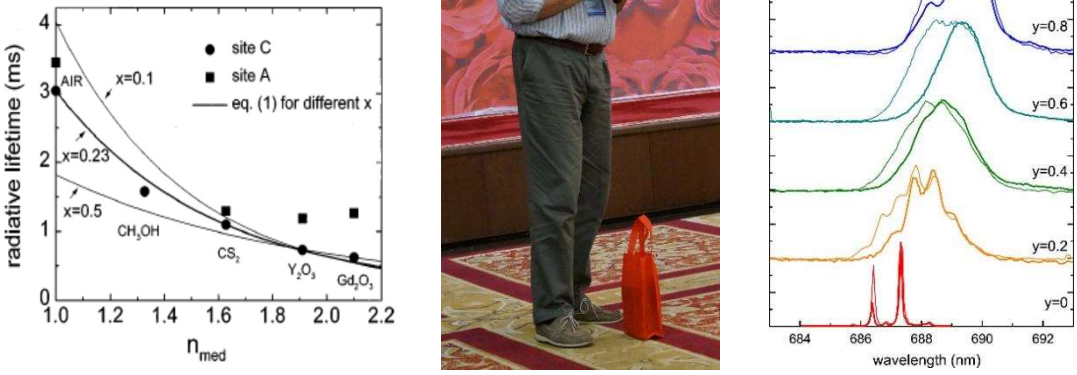


Figure 1 – Sergey Feofilov in his role as chairman of the DPC during the 2013 meeting in Fuzhou in between (left) his work on refractive index effects for the Eu^{3+} decay time in Y_2O_3 nanocrystals and (right) the discrete ^2E emission lines from Cr^{3+} arising from specific (Al.Ga) coordination.

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Remembering Dr. Sergey Feofilov

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When our new cooperation schedule was approved by the Ministry of Education of PRC, I received the very sad news about the unexpected passing of Dr. Sergey Feofilov, which was badly shocked me. Dr. Sergey had been working with Professor Richard Meltzer as a visiting scholar when I was studying for my Ph.D program at USA. He had given me a tremendous help on academic work and others, and a deep friendship was built since then. In this presentation I would like to share some personal memories on Dr. Feofilov， and present some research work fulfilled during the time at USA, especially for the system of rare earth doped nanoparticles embedded in glass matrice.



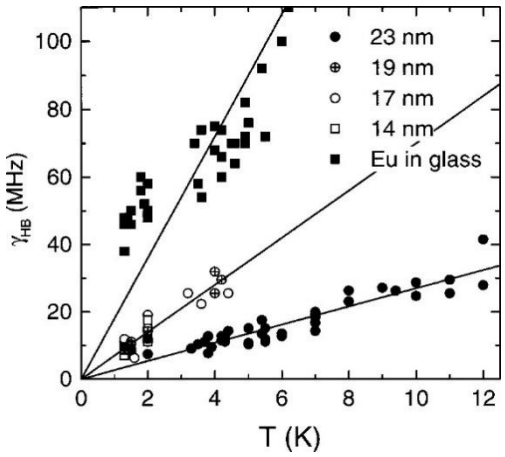


FIG.1 Dr. Sergey Feofilov, Prof. Richard Meltzer (Left) and myself (right) on the ICL 2005 in Beijing. FIG. 2. Temperature dependence of the hole width for $Eu3^{+}$:LaF_3 nanocrystals of different size embedded in oxyfluoride glass ceramics and for Eu^{3+} directly doped into the glass matrix. Solid lines: hole width vs. temperature.

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Performing and disseminating luminescence research with Sergey Feofilov

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The passing of Professor Sergey Feofilov in December 2020 has been a huge loss for the scientific community working on luminescent materials. In this talk I will describe my interaction with Sergey, from the first contact at the DPC'01 in July 2001 in Lyon, France, to our recent collaboration extending to 2020, when it was dramatically stopped by the pandemic.
I will discuss the important impact on my research made by his discoveries about the effect of the refractive index on the radiative transition rates of trivalent lanthanide ions in nanocrystalline materials. I will then move to report on our prolonged joint work as Editors of the Journal of Luminescence, aiming at disseminating research on the optical spectroscopy of solids. I will then conclude describing shortly our recent collaborative work on the luminescence spectroscopy of the Eu^{3+} ion in disordered trigonal pyrochlores, which unfortunately was cut short by Sergey's unexpected demise, just before the research was completed.



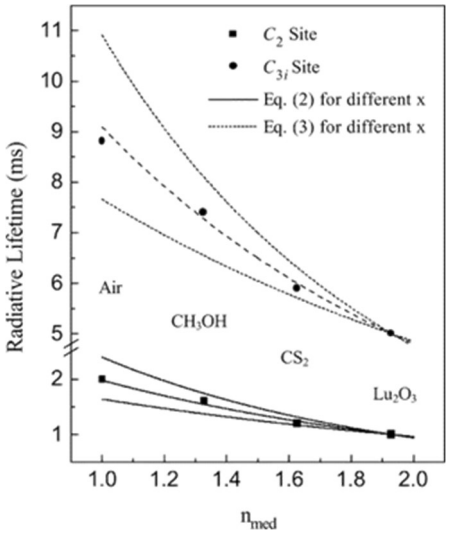


Figure 1. Professor Sergey Feofilov speaking at a conference (left) and dependence of the $^5D_0$ lifetime for the Eu^{3+} C_2 and C_{3i} sites on the index of refraction of the media n_{med} at T = 298 K in nanocrystalline cubic Lu_2O_3 [1] (right).

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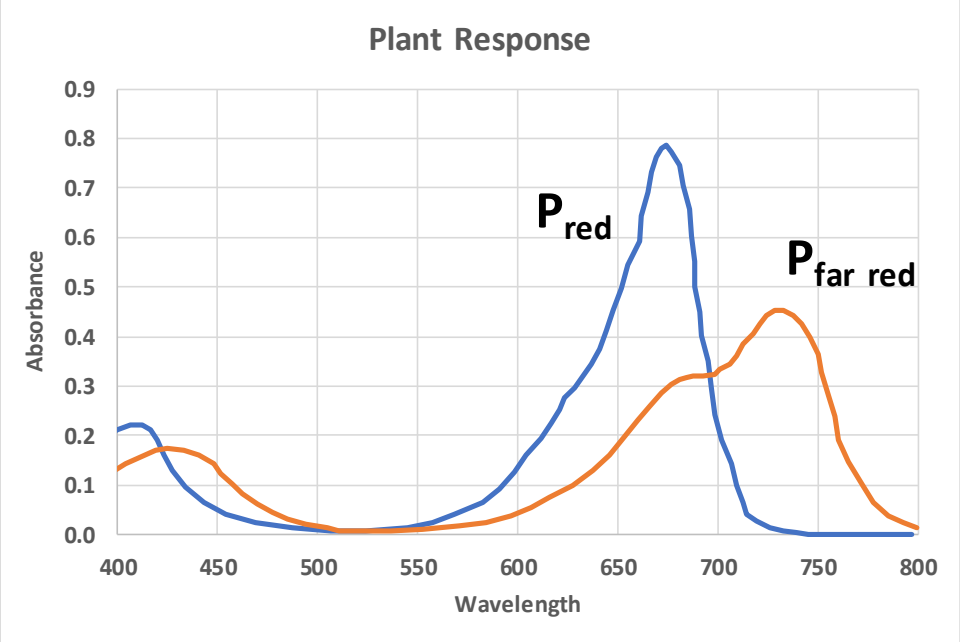
Far Red Phosphors for Horticulture LED Systems

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The far-red (FR) region (700 nm-740 nm) of the electromagnetic spectrum has significant implication for plant growth and development. Exposure to red light regulates processes ranging from seed germination, height, leaf expansion, branching, plant immunity, circadian rhythm, leaf chlorophyll concentration to freezing tolerance. Additionally, FR light plays a role in photosynthesis. In this talk we will discuss research undertaken to develop phosphor converted far-red LEDs for horticultural lighting. In particular, the FR luminescence from transition metal and rare earth ions in oxide and fluoride lattices that are excitable by the blue light from the LED device is emphasized.



Plant Red Wavelength Response Sensitivity

High power deep ultraviolet micro-LEDs

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The explosion of COVID-19 has been greatly impacting the world and intensively activated the technique of ultraviolet-C (wavelength ≤ 280 nm) light-emitting diodes (LEDs) because of its encouragingly perspective for the ultra-fast sterilization towards SARS-CoV-2 in a fraction of a second.[1] One of the most crucial challenges for UVC LED fabrication is the difficulty of acquiring high-crystalline, lattice-matched meanwhile non-UV-absorbed substrate for upper UVC device epitaxy. The propose and verification of the face-to-face high-temperature annealing (HTA) technique obviously relieve the above embarrassment through achieving excellent-crystalline AlN template on sapphire substrate. However, due to native strong compressive strain of HTA AlN, problems of surface roughing and Al composition segregation occur when AlGaN-based UVC epitaxy is performed. Thus to date, HTA AlN has not been generally embraced in the industry.

In this work, based on our high quality HTA AlN template with a dislocation density in the order of 10^8 cm^{-2}, UVC LED epitaxial wafer with a wavelength of 275 nm was grown by MOCVD. By manipulating the strain of epitaxial AlGaN layer and carefully designing the quantum well region, the fabricated 10×20 mil^2 UVC LED chips reach a high output power of 14 mW at operating current of 100 mA, which is comparable to the commercial UVC LED performance based on NPSS substrates. Furthermore, a micro-LED technique in the chip fabrication process is developed, significantly improving the carrier injection efficiency and radiation efficiency in active region and thus nearly 80 mW of output power was achieved at 200 mA (WPE 4.7%). Unambiguously, the present work intensively excavates and highlights the prospect of HTA AlN in large-scale industrial application of UVC LEDs and the UVC micro-LED technology provides a novel post-epitaxy strategy to further improve the device performance.

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Theory for Silicon-based light emitting

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Here, we will first present our recently developed unified theory for explaining why diamond, Si, Ge, and Al-containing group III-V semiconductors have indirect band gap, and the remaining common semiconductors, except GaP, have direct band gaps. We find that the, usually ignored, low-lying occupied d orbitals in cations play the key role in governing the formaiton of direct bandgap in common semiconductors. This theory unravels that it is impossible to make allotropes of Si and compounds consisting by Si mixed together with other elements high efficient direct bandgap light emitting. Interface and quantum confinement in low-dimensional Si nanostructures are two knobs to relax the momentum conservation law of optical transition. We find the high-energy Γ-Γ direct band gap transition in Si quantum dots is slightly blue-shifted to higher energy instead of being rapidly red-shifted with reduced dot size as suggested by T. Gregorkiewicz and his co-workers. Our theory confirms that the light emission efficiency of Si quantum dots increases exponentially as reducing dot size, but its highest reachable efficiently is still two orders of magnitude smaller than that of direct bandgap InP and GaAs. Fortunately, we also discovered that Si/Ge magic sequence superlattices exhibit orders more efficient at emission light than their existing counterpart records and approach more than 10% brightness of real direct gap materials, such as GaAs. Furthermore, we propose a strain doping method to realized real direct bandgap Ge, a new CMOS-compatible pathway towards on-chip lasers.

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Luminescence properties for III-nitride semiconductor nanostructures and optoelectronic devices with wavelength range from green to ultraviolet

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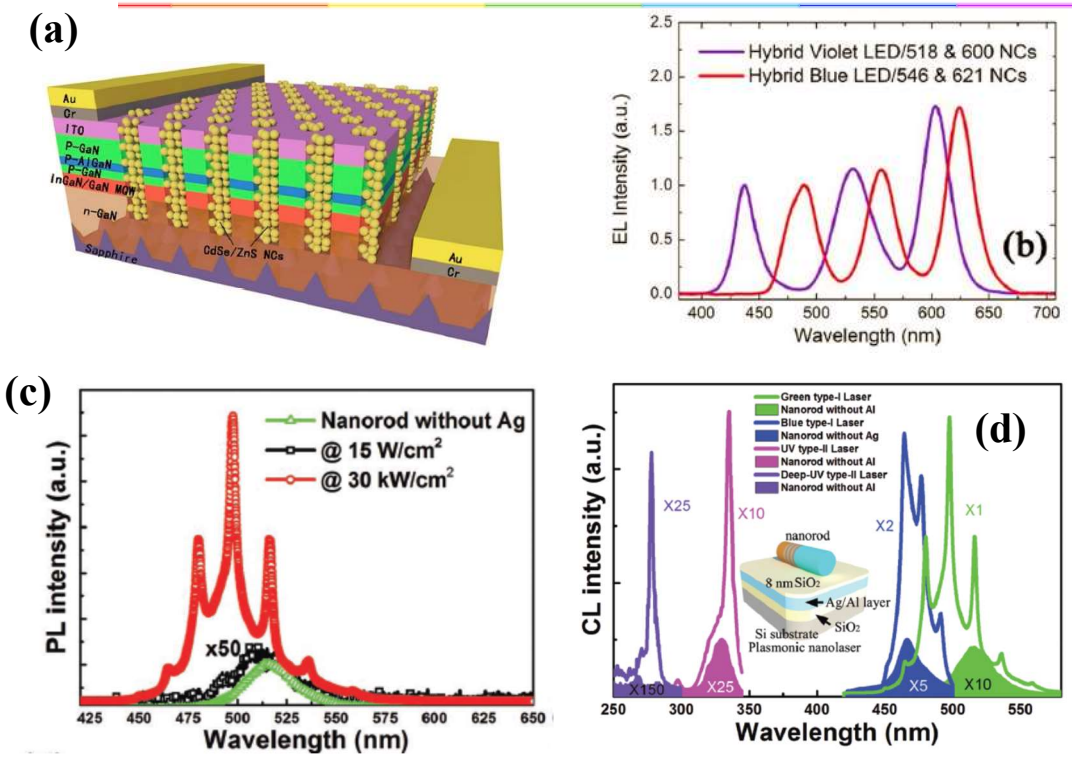
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III-nitride semiconductors are a unique semiconductor material system with a direct band gap and covers a wide spectral range from deep ultraviolet (DUV) to near infrared. In recent years, the micro/nano-structured light-emitting diode(LED) emerging technology has shown great potential in the applications of super-resolution displays, optical interconnects, and highly compact on-chip integration.

Here, at first, we demonstrate an excellent hybrid III-nitride/quantum dots micro/nano-structured light-emitting diode (LED) has been developed between violet/blue emitting c-plane InGaN/GaN(0001) multiple quantum wells (MQWs) and various wavelength emitting II-VI quantum dots (QDs) as color conversion mediums. InGaN/GaN MQWs are fabricated into micro/nano-holes by soft nanoimprint lithography or UV optical lithography. A series of hybrid Micro-LEDs with complementary RGB color electroluminescence(EL) have been demonstrated[1].

Secondly, based on the principle of surface plasmon amplification by the stimulated emission of radiation (SPASER), plasmonic nano-laser with metal/dielectric/semiconductor hybrid structures was designed. InGaN/GaN and AlGaN/GaN nanorods were fabricated by our developed UV-soft nanoimprint lithography and dry etching techniques[2]. We have demonstrated single-mode and multi-mode lasing with an optical pumping power density as low as 0.3 kW/cm^2 at room temperature in blue-green visiable wavelength range. With time-resolved photoluminescence(PL) characterizations, ultra-fast decay time ~ 123 *ps* is observed proving high rate of energy-transfer process from excitons to SPs. These phenomena should be attributed to the SPP coupling-induced strong electric field confinement in the hybrid nanostructures. Furthermore, the realization of deep-UV cathodeluminesce(CL) lasing emission from AlGaN nanorods by excitation electron beam density ~ 1A/cm^2[3]. These findings might provide innovative insight that will contribute to realizing a new generation of ptoelectronic and information devices.



Figures (a) Schematic diagrams of hybrid III-nitride/quantum dots nano-hole LEDs, (b) EL spectra of white emission hybrid LEDs. (c) Room temperature PL spectra of the nanolaser and green nanorod without Ag, (d) plasmonic nanolasing from the green to the deep-UV region by electron beam pumping.

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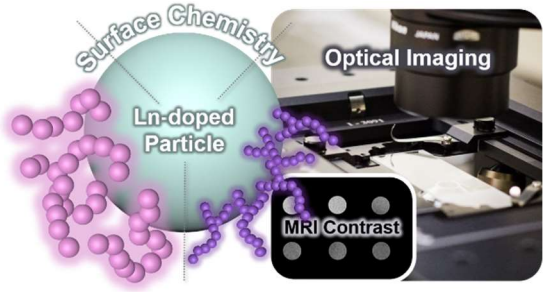
Rare-earth-based particles via microwave-assisted synthesis – potential and challenges

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Today's world faces global challenges, such as Health and Environmental/Energy Concerns, that have to be addressed for a sustainable development. While none of these concerns is easy to solve, material scientists are designing the building blocks that are key to sustainable energy and health strategies. Advanced optical materials act as novel optical bioprobes for diagnosis or therapies. Novel optoelectronic/magnetic nanomaterials will increase device efficacy and endow them with yet unseen multifunctionality (photocatalysts, solar, storage devices). Herein, the remarkable optomagnetic properties of the rare-earths (RE) make RE-based materials ideal for biomedical and energy applications. Yet, challenges remain; low emission intensity and efficiency of small nanoparticles (NPs), and reliable and fast synthesis routes. As material chemists, we tackle these challenges with new designs of RE-NPs, accompanied by chemically controlled synthesis, application-oriented surface chemistry, and understanding of structure-property-relationships. Alkali metal rare-earth fluorides of the general composition $MREF_4$ are our favorite materials, and we developed a microwave-assisted fast and reliable approach allowing crystalline phase and size control of $NaREF_4$ nanoparticles in the sub 15 nm realm as well as $LiREF_4$ microparticles.[1-2] This presentation will shed light on our recent findings about microwave-synthesized RE-based nano- and microstructures as well as their structural and optomagnetic properties.[3-5]



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Synergistical electroluminescent manipulation for efficient blue perovskite light-emitting diodes

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Perovskite light-emitting diodes (PeLEDs) with green and red emissions have made tremendous progress in recent years. However, the realization of efficient and stable blue-emission PeLEDs remains challenging, which greatly limits their potential applications in high-quality full-color displays and solid-state lighting. A delicate control over the entire electroluminescence process is indispensable to overcome the efficiency limitations of blue PeLEDs. Here, we demonstrate an efficient device architecture to synergistically reduce the energetic losses during electron-photon conversion and boost the extraction of trapped light in the device. An interfacial nucleation seeding scheme via the supplier of heterogeneous nucleation seeds is proposed to control the crystallization process of highly emissive perovskite nanocrystals and suppress the trap-mediated non-radiative recombination losses due to interfacial hydrogen bonding interactions. This manipulation results in external quantum efficiencies (EQE) of 12.8% for sky-blue PeLEDs emitting at 486 nm and 4.1% for deep-blue device emitting at 469 nm, along with the improved spectral stability and operation lifetime. Additionally, the maximum EQE reaches 16.8% after combining an internal outcoupling structure without spectral distortion, which can be further raised to 27.5% when using a lens-based structure on top of the device. We anticipate that our work provides an effective method for its application in high-performance blue PeLEDs.

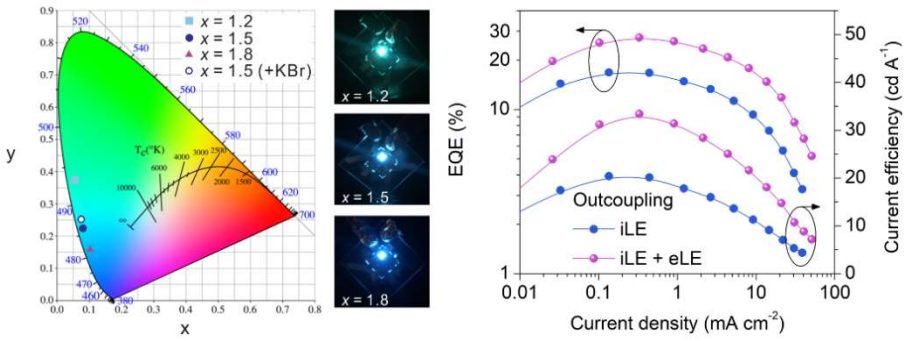


Figure A synergistical manipulation of the electroluminescence process in blue PeLEDs.

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Doublet emission from light-emitting radical materials and devices

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A new kind of OLEDs based on radicals, in which the emission comes from a spin doublet rather than from a singlet or triplet exciton was developed. The emission process is spin-allowed in these systems, usefully, the classical triplet-limiting efficiency for OLEDs is circumvented for doublets.[1] After continually optimizing materials and devices, a D-A type luminescent radical emitter, TTM-3NCz, was used as the emitter of an OLED which has a nearly 100% internal quantum efficiency. [2]

We found a series of light-emitting radicals whose electronic structures do not following the Aufbau Principle, which means the singly occupied molecular orbital(SOMO) lies below the doubly occupied highest occupied molecular orbital(HOMO). The quasi-close-shell character enhances the stability of the radicals remarkably and maintains high luminescent efficiency simultanesouly.[3] The mechanism of doublet emission from radicals was further studied, and non-alternant systems are found to be necessary to lift the degeneracy of the lowest energy orbital excitations of radicals.[4]

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The inside charge and wavelength management of all-solution OLEDs

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Solution-processed OLEDs have always been the hot topic in the research of OLEDs. The electron-hole evolution in all solution processed OLEDs involves the carrier transportation, the exciton recombination and dissociation. The dynamic of excitons plays a crucial role in governing the ultimate device performance. Therefore, the dynamics of excitons by using transient photoluminescence measurements combining with transient electroluminescence measurements on the prepared different OLEDs were investigated. Then, we tried to optimize the performance of OLEDs by maneging the carrier injection and using the inside charge.

For blue OLEDs, an optical micro-cavity based on metal electrodes to regulate electroluminance (EL) spectra of sky-blue organic light emitting diodes were prepared to obtain a saturated deep blue emission with a narrowed full-width at half-maximum (FWHM). By tuning micro-cavity modes, EL peak wavelength of blue OLEDs can shift in the range from 479nm to 493nm, with FWHM from 69.8nm to 83.2nm, compared to devices without micro-cavity whose EL peak wavelength is 487nm with FWHM of 87nm approximately.

Synthesis of nanocrystal core/shell quantum dots for efficient and stable emitters

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Semiconductor nanocrystal core/shell quantum dots (QDs) have successfully extended their original fundamental research into many practical applications. Here we report how to design and synthesize of high luminescence ZnCdSe-based core/shell QDs by precisely controlled shell growth. We utilized high-temperature injection for the synthesis of QD cores and an even higher temperature for shell growth to obtain core/shell QDs that showed high QYs near to 100% as well as high photostability. Due to higher temperature shell growth procedure, the as-synthesized QDs can have higher chemical/photochemical stability than QDs prepared by low temperature shell growth method. Alloyed ZnCdSe core with certain ratio of Cd and Zn have been pre-synthesized first. Following by accurate ZnS shell growth, the as-synthesized core/shell QDs are nonblinking with the nonblinking threshold volume of > 100 nm3. Förster resonance energy transfer can be effectively suppressed after growing 10 multilayer of ZnS shell. All these superb characteristics including nonblinking, single exponential PL decay dynamics, and supressed Förster resonance energy transfer can be beneficial to high quality QD-based lighting-emitting diodes. We believe this study will lead to fast development of QLED into practical display and solid state lighting applications, and QLED technology will widely penetrate into our daily life.

Photon avalanching at nanoscale: Challenges and new possibilities

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Photon avalanche (PA) emission is a specific type of up-conversion, which was observed for the first time in Pr^{3+} doped $LaCl_3$ and $LaBr_3$ single crystals in 1979. This phenomenon and materials hosting it were originaly aiming to act as infrared photons counters or serving as up-conversion lasers. PA is characterized by very steep pump power dependence of the anti-Stokes emission intesity and long luminescence risetimes above the treshold, which tend to saturate and speed up, respectively, at larger excitation intensties. PA-hosting materials for the pumping powers above the characteristic threshold value undergo a photon-driven phase transition-like modification, in which excited state absorption is enhanced significantly, making these luminescent materials substantially different from conventional ones in terms of behaviour and offering new applicative potential. Until recently, great majority of studies on PA were devoted to various singly Ln^{3+} doped (e.g. Pr^{3+}, Tm^{3+}, Ho^{3+}, Nd^{3+}) bulk materials (e.g. crystals, glasses), mostly in cryogenic temperatures, but the observations of PA at micro- or nanoscale at room temperature was beyond the experimental possibilities. Recently, a demonstration of all plethora of photon avalanche emission features was presented in colloidal Tm^{3+}-doped $NaYF_4$ nanocrystals in room temperature with very high non-linearity $(I_{EMI}=(I_{PUMP})^S$, with S exceeding 30) [1], which confirmed previous predictions of suitability of such PA nanomaterials for a new type of single excitation beam superresolution imaging [2].

Because the PA phenomenon is a positive feedback system with strong looping gain, it can be further hypothesized that the PA behavior will be highly susceptible to perturbations in energy looping [3]. Energy looping, essential for the PA, is dependent on the energy distribution between available energy levels and the rates of energy transfer processes between them, establishing complex system conditioned by multiple phenomena. Based on theoretical modelling and some experimental evidences, a few most spectacular examples of potential biomedical applications of these novel nanomaterials will be discussed, e.g. sub-diffraction super-resolution imaging [1], sensitive bio-detection [3] and remote luminescence-based thermometry [4].

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Exciton and crystalline engineering for highly efficient perovskite light-emitting diodes

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Perovskite light-emitting diodes and lasers are promising for next generation lighting and displays because of their high colour purity and performance. While the management of singlet and triplet excitons is fundamental to the design of efficient organic light-emitting diodes and lasers, the nature of how excitons affect performance is still not clear in perovskite-based devices. In this talk, I will first introduce our new finding that triplet excitons are key to efficient emission in green quasi-2D perovskite devices and that quenching of triplets by the organic cation is a major loss path. Employing an organic cation with a high triplet energy level (phenylethylammonium) in a quasi-2D perovskite based on formamidinium lead bromide yields efficient harvesting of triplets. Furthermore, we observed that upconversion of triplets to singlets can occur, making 100% harvesting of electrically generated excitons potentially possible. The external quantum (EQE) and current efficiencies of our champion green devices reached 12.4% and 52.1 cd/A, respectively. We further improved EQEs over 21% through crystalline engineering with extended device operational lifetimes.

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Towards high-performance solution-processed light-emitting didoes based on quantum dots

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Quantum dots (QDs) are a unique class of emitters with size-tunable emission wavelengths, saturated emission colors, near-unity luminance efficiency, inherent photo- and thermal- stability and excellent solution processability. In the past few years, efficiency and lifetime of quantum-dot light-emitting diodes (QLEDs) achieved tremendous progresses. These encouraging facts foreshadow the commercialization of QLEDs, which promises an unprecedented generation of cost-effective, large-area, energy-saving, wide-color-gamut, ultra-thin and flexible displays [1]. Here we review our activities associated with QLEDs, including exciton-generation mechanisms, material chemistry of charge-transporting layers and device engineering [2-8].

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Development of white persistent phosphors by tailoring lanthanide ions and garnet host composition

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Lanthanide ions act as excellent luminescence centers and as good charge carrier traps. By selecting proper lanthanide ions, persistent phosphors with the desired luminescent color can be developed. In addition, an appropriate host material can give not only better persistent luminescence performance but also an additional function. We successfully develop bright white persistent phosphors of Pr^{3+}-Tb^{3+}-Eu^{3+} tri-doped paramagnetic $Gd_3Ga_5O_{12}$(GGG). The GGG phosphors singly doped with Pr^{3+}, Tb^{3+} and Eu^{3+} show reddish-white (^3P_J-^3H_J), blue (^5D_J-^7F_J) and red ($^5D_0$-^7F_J) photoluminescence, respectively, by UV excitation. On the other hand, the GGG samples codoped with Pr^{3+}-Eu^{3+} and with Tb^{3+}-Eu^{3+} show only Pr^{3+} reddish-white persistent luminescence and Tb^{3+} blue persistent luminescence, respectively (Figure 1). The GGG:Pr^{3+}-Eu^{3+} persistent luminescence is the brightest and the longest among the reported white persistent phosphors. Based on the thermoluminescence glow curves, it is found that the Eu^{3+} ion acts only as an electron trap in the persistent luminescence mechanism and the trapped electrons are released at around 325K. The cool-white persistent luminescence is achieved by combining Pr^{3+} and Tb^{3+} persistent luminescence centers in the GGG:Pr^{3+}-Tb^{3+}-Eu^{3+} phosphors. It will be demonstrated that the white persistent phosphor powder in water can be dragged around by a permanent magnet due to the paramagnetic property of GGG [1].

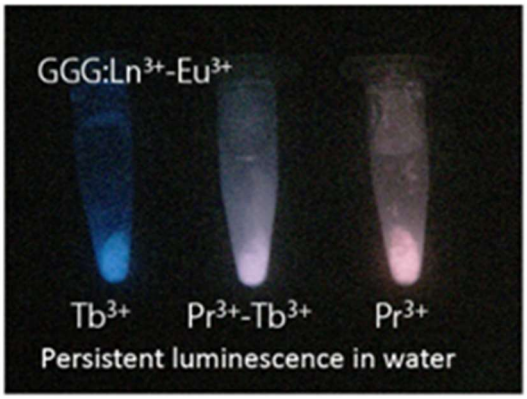


Figure 1. Photograph of GGG:Tb^{3+}-Eu^{3+}, Pr^{3+}-Eu^{3+} and Pr^{3+}-Tb^{3+}-Eu^{3+} persistent phosphors[1].

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Advanced in vivo imaging and sensing by using super-brigth nanoparticles synthesized by ultrafast photochemistry

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Since the pioneering works of Dubertret et al., visible-emitting semiconductor quantum dots have been widely used as contrast agents for bioimaging. The low penetration depth of visible light into tissues, however, has limited their application for *in vivo* imaging and prevented their clinical use. To solve this issue, a new family of semiconductor nanocrystals emitting in NIR-II had to be sought. Among this new generation of nanostrucutres, Ag_2S NPs receive special attention due to its real-time, deep-tissue, high-resolution preclinical imaging capability. Despite the promising results obtained, making their clinical application a reality needs a radical improvement in their brightness that, in turn, increases their effective penetration depth and enables high-contrast high-resolution imaging at low nanoparticle doses and minimal excitation power densities.

Boosting the fluorescence properties of a well-established material, however, requires an imaginative and groundbreaking approach. In this work we have developed a new synthesis route for nanomaterials combining the traditional chemistry-based approach with ultrafast laser irradiation. We have found that the synergy between multiple laser-activated physical and chemical processes transform the currently available Ag_2S nanodots into what we call Ag_2S superdots. Ultrafast laser pulses trigger an 80-fold improvement in the fluorescence quantum yield of Ag2S nanodots without affecting the spectral shape of the emission. After checking its applicability under in vivo conditions, we have also studied its capability for thermal sensing. It was verified that its luminescence lifetime can be used as reliable parameter to infer the temperature of an internal organ in a small animal model.

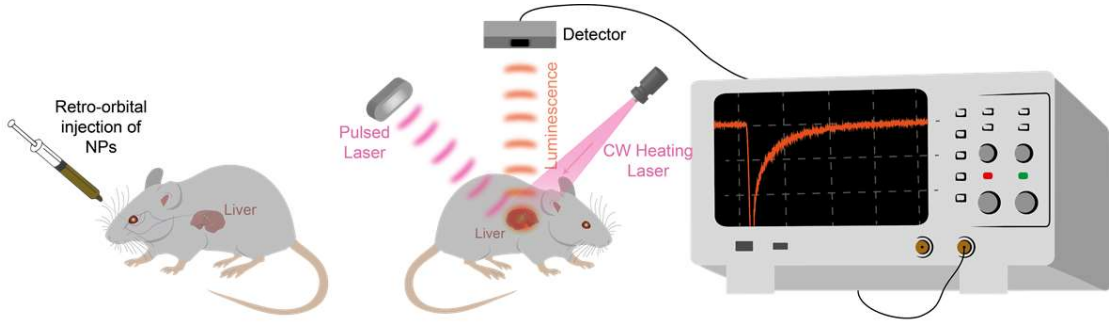


Figure – Schematic representation of the in vivo experiment in which the temperature of the liver of a CD1 mouse was inferred through the luminescence of Ag_2S superdots.

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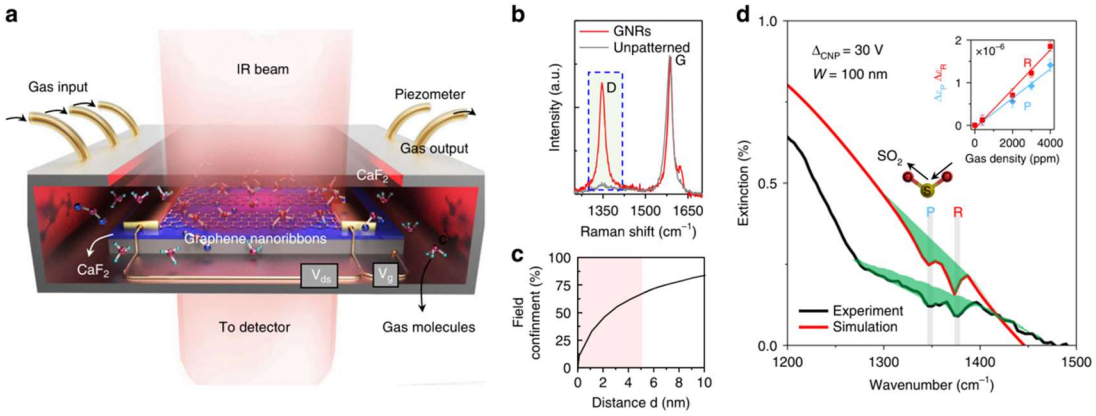
Surface enhanced infrared spectroscopy with two dimensional materials

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Infrared spectroscopy is a powerful characterization method for bulk materials by detecting molecular vibrations in the fingerprint region. However, molecular fingerprinting at the nanoscale level still remains a significant challenge, due to weak light–matter interaction between micron-wavelength infrared light and nano-sized molecules. Highly confined two dimensional polaritons can confine and manipulate infrared light at deep subwavelength nanoscale, which can be used in subdiffraction imaging, sensing and engineering of spontaneous emission [1]. We demonstrated molecular fingerprinting at the nanoscale level using a specially designed graphene plasmonic structure on CaF_2 nanofilm, which not only avoids the plasmon–phonon hybridization, but also provides in situ electrically-tunable graphene plasmon covering the entire molecular fingerprint region. It significantly pushes the current detection limit of far-field mid-infrared spectroscopies. We then reported label-free identifification of gas molecules SO_2, NO_2, N_2O, and NO by detecting their rotational-vibrational modes using graphene plasmon [2]. Besides graphene plasmon, h-BN polaritons also have ultrahigh confinement, especially for monolyaer h-BN. Recently, we measured phonon polaritons in monolayer h-BN by using EELS in a scanning transmission electron microscope and find an extremely high confinement (>487 times smaller wavelength than that of light in free space). These results open up a broad range of opportunities for the engineering of metasurfaces and strongly enhanced light–matter interactions [3].



(a) Experimental scheme of our device. Plasmons were excited in graphene ribbon arrays. (b) Raman spectrum of the graphene nanoribbons compared with pristine graphene. (c) Plasmonic field confinement of graphene nanoribbon. (d) Experimental (black curve) and simulated (red curve) extinction spectra of graphene nanoribbon for SO_2 gas identifification.

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Electron transfer processes in lanthanide-doped materials: Insights from multiconfigurational calculations

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Lanthanide ions are notorious for their ability to change oxidation state. This manifests itself in the presence of low-lying excited states, so-called charge-transfer states (CTS), where an electron is transferred between the lanthanide dopant and another center in the luminescent material. Well-known are the ligand-to-metal charge transfer (LMCT) states of Eu^{3+}-doped materials in the near-UV that enable the use of these materials in e.g. fluorescent lamps thanks to their high absorbance for the 254 nm Hg emission [1].

Less known are metal-to-metal charge transfers (MMCT), especially those between lanthanide impurities. In this contribution, it will be motivated that these states deserve more attention because they can dramatically impact phosphor performance. Depending on the case, they can cause additional absorption or even emission bands, quench luminescence, …[2].

In this presentation, several examples of electron transfer processes between lanthanide centers in crystalline solids are given. In all cases, diabatic electron transfer diagrams are constructed from first principles and used for the interpretation of experimental results [2]. It will be shown that MMCT states occur in reality, inducing quenching pathways [3,4], but at the same time providing opportunities to design novel luminescent materials [5,6].

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Mapping strain/pressure with ZnO nanowire arrays by piezotronic and piezo-phototronic effect

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Emulation of human senses via electronic means has long been a grand challenge in research of artificial intelligence as well as prosthetics, and is of pivotal importance for developing intelligently accessible and natural interfaces between human/environment and machine. Unlike other senses (seeing, hearing, smelling and tasting), capability of skin for touch sensing remains stubbornly difficult to be mimicked, which necessitates the development of large-scale pressure sensor arrays with high spatial-resolution, high-sensitivity and fast response. In this talk, we present a novel design of ZnO nanowire arrays, which can be used to directly record the strain distribution by piezotronic and piezo-phototronic effect.

First, we have reported large-array three-dimensional (3D) circuitry integration of piezotronic transistors based on vertical zinc oxide nanowires as active taxel-addressable pressure/force-sensor matrix for tactile imaging with a high resolution of 100 μm1. Using the piezoelectric polarization charges created at metal-semiconductor interface under strain to gate/modulate transport process of local charge carriers, piezotronic effect has been applied to design independently addressable two-terminal transistor arrays, which convert mechanical stimuli applied on the devices into local electronic controlling signals. The device matrix has been demonstrated for achieving shape-adaptive high-resolution tactile imaging and self-powered, multi-dimensional active sensing. However, the signal of the piezotronic transistors array is the change of the resistance of each NWs, which can only be measured in a series way. That means such piezotronic transistors array can only mapping a static strain.

Different with the electrical signal, the optical signal can be measured in a parallel way. And in our previous work, we have demonstrated how the piezo-phototronic effect can be effectively utilized to enhance the emission intensity of an n-ZnO/p-GaN NW LED.2,3 The emission light intensity and injection current at a fixed applied voltage has been enhanced by a factor of 17 and 4 after applying a 0.093% compressive strain, respectively. Here, we extend the single NW device to NW LEDs array, for pressure/force sensor arrays for mapping strain with a resolution as high as 2.7 μm. Such sensors are capable of recording spatial profiles of pressure distribution, and the tactile pixel area density of our device array is 6250000/cm2, which is much higher than the number of tactile sensors in recent reports (~ 6-27/cm2) and mechanoreceptors embedded in the human fingertip skins (~ 240/cm2)4,5.

When the device is under pressure, the images unambiguously show that the change in LED intensity occurred apparently at the pixels that were being compressed by the molded pattern, while those were off the molded characters showed almost no change in LED intensity. Instead of using the cross-bar electrodes for sequential data output, the pressure image is read out in parallel for all of the pixels at a response and recovery time-resolution of 90 ms. This may be a major step toward digital imaging of mechanical signals by optical means, with potential applications in touch pad technology, personalized signatures, bio-imaging and optical MEMS.

Furthermore, our recent studies achieve such piezo-phototronic effect induced strain mapping in a flexible n-ZnO NWs/p-polymer LEDs array system composed of PEDOT:PSS and patterned ZnO NWs with a spatial resolution of 7 μm for mapping of spatial pressure distributions. The emission intensity of the LED array sensor matrix is dominated by locally applied strains as indicated by piezo-phototronic effect. Therefore, spatial pressure distributions are immediately obtained by parallel-reading the illumination intensities of LED arrays based on electroluminescence working mechanism. A wide range of pressure measurements from 40 MPa to 100 MPa was achieved through controlling the growth conditions of ZnO nanowire array.6,7

Lastly, the piezo-phototronic effect was achieved on Si wafer based on a n-ZnO nanofilm/p-Si micropillar heterostructure (ZSH) LEDs array.8 White light emissions at room temperature, featuring with emission peaks in both visible and near-infrared regions were obtained. By applying a strain onto the top of the ZSH LEDs, the light emission intensity of ZSH LEDs array was enhanced as well by 120% under -0.05% compressive strains. A pressure map can be created by reading out in parallel the change of the electroluminescent intensities from all the pixels in the near future. This research not only introduce a novel approach to fabricate Si-based light-emitting components with high performances, but also may be a great step toward digital imaging of mechanical signals using optical means, having potential applications in artificial skin, touch pad technology, personalized signatures, bio-imaging and optical MEMS, and even and smart skin. Moreover, these technologies are totally compatible with the dominate silicon microelectronic industry, which means large-scale integrated device could be easily achieved for future assembling in silicon-based photonic integrated circuits (PIC) and optical communication systems..

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Recent progress of ternary organic solar cells

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A series of ternary organic photovoltaics (OPVs) are fabricated with one wide bandgap polymer D18-Cl as donor, and well compatible Y6 and Y6-1O as acceptor. The open-circuit-voltage (VOC) of ternary OPVs is monotonously increased along with the incorporation of Y6-1O, indicating that the alloy state should be formed between Y6 and Y6-1O due to their excellent compatibility. The energy loss can be minimized by incorporating Y6-1O, leading to the VOC improvement of ternary OPVs. By finely adjusting the Y6-1O content, a power conversion efficiency of 17.91% is achieved in the optimal ternary OPVs with 30 wt% Y6-1O in acceptors, resulting from synchronously improved short-circuit-current density (JSC) of 25.87 mA cm−2, fill factor (FF) of 76.92% and VOC of 0.900 V in comparison with those of D18-Cl : Y6 binary OPVs. The JSC and FF improvement of ternary OPVs should be ascribed to comprehensively optimal photon harvesting, exciton dissociation and charge transport in ternary active layers. The more efficient charge separation and transport process in ternary active layers can be confirmed by the magneto-photocurrent and impedance spectroscopy experimental results, respectively. This work provides new insight into constructing highly efficient ternary OPVs with well compatible Y6 and its derivative as acceptor

Table 1. Key photovoltaic parameters of all OPVs with different Y6-1O content.

Y6-1O content (wt%)	J_{SC} (mA cm^{-2})	V_{OC} (V)	FF (%)	PCE (Ave. ± Dev.[a]) (%)
0	25.53	0.881	75.88	17.07 (16.86 ± 0.21)
15	25.89	0.889	76.27	17.55 (17.37 ± 0.23)
30	25.87	0.900	76.92	17.91 (17.83 ± 0.21)
50	24.16	0.911	76.07	16.74 (16.49 ± 0.27)
100	22.72	0.929	73.14	15.44 (15.26 ± 0.19)

[a]Average and deviation (Ave. ± Dev.) of PCEs were calculated with 10 individual cells from different batches.

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GaN-based blue/UV LEDs and laser diodes grown on Si

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Direct growth of III-Nitride semiconductors on large-diameter cost-effective silicon is a promising game-changing technology to GaN-based LED and laser industry. However, hetero-epitaxial growth of GaN on Si encounters a large mismatch in both lattice constant and coefficient of thermal expansion, often resulting in a high density of defects and even micro-crack networks. By carefully engineering the Al-composition step-graded AlN/AlGaN multilayer buffer between Si and GaN, we have not only successfully eliminated the crack formation, but also effectively reduced the dislocation density.

This talk presents the R&D and mass production of Ga(Al)N-on-Si blue/UVA LEDs. Upon the Ga(Al)N-on-Si template, InGaN/AlGaN UVA multiple quantum well active region is overgrown and caped by p-AlGaN electron blocking layer and a thin p-GaN cap-layer, which are processed into high power vertical UVA LEDs.

Besides blue and UVA LEDs, we have achieved electrically injected blue, violet, and UVA edge-emitting laser diodes with a ridge structure on Si at room temperature. In addition, InGaN-based electrically injected microdisk lasers have also been realized on Si. GaN-based laser could be a useful on-chip light source for monolithically integrated III-Nitride photonics.

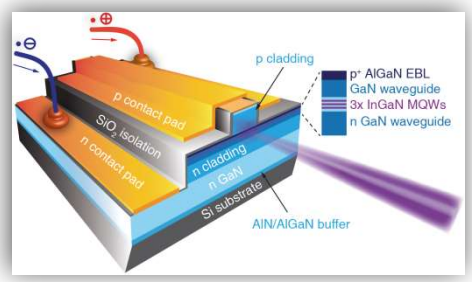


Figure 1. GaN-based edge-emtting laser diode directly grown on Si.

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Modulating surface-interface structure of InGaN nanorods for efficient photoelectrochemical water splitting

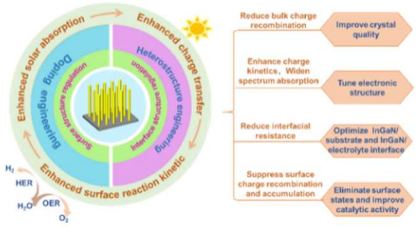
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Hydrogen production via solar photoelectrochemical (PEC) water splitting technology is one of the most promising methods to solve the energy crisis[1, 2]. As the key block of the PEC cell, the photoelectrode semiconductor material determines the solar to hydrogen conversion (STH) efficiency[3, 4]. InGaN nanorods with high carrier mobility, tunable band gap (3.4 eV~0.69 eV), suitable band edge potential, and large reactive area are ideal candidate for high-efficiency hydrogen production, showing great application prospects for PEC water splitting[5, 6]. To obtain state-of-the-art InGaN nanorods-based photoelectrodes, tremendous efforts have been devoted to enhance light absorption capacity, charge carrier dynamics, and redox activity. This work reports three photoelectrode optimization strategies by doping and heterostructure engineering to improve the crystal quality of InGaN nanorods and eliminate the interface resistance between the nanorods, the growth substrate and the electrolyte, thereby promoting the carrier separation efficiency and comprehensively enhancing the PEC performance of the InGaN nanorods. Finally, perspectives on remaining challenges and future development of InGaN nanorods photoelectrodes are also outlined.

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The research approach in this work: the strategy and mechanism for the improved PEC performance of InGaN nanorods

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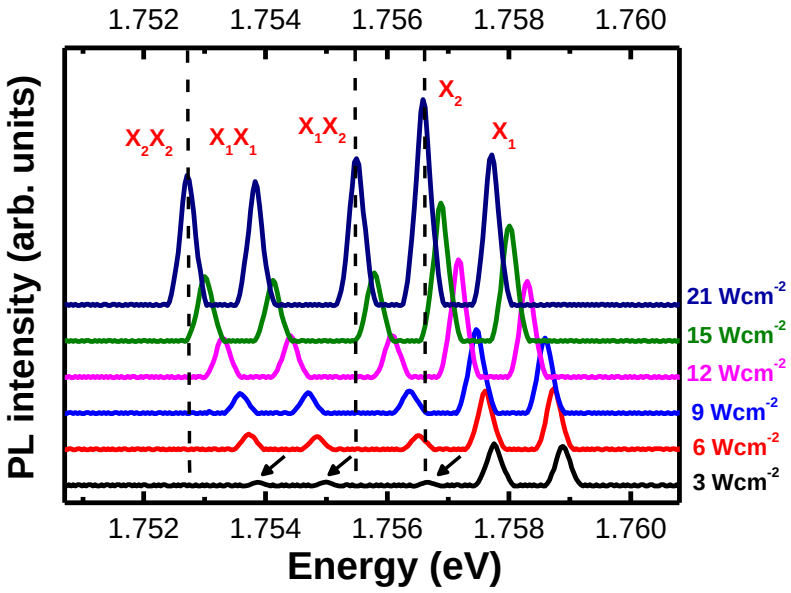
Optical coupling process in a single coupled quantum dot molecule

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Recently, the droplet epitaxy techniques allow us to grow laterally coupled quantum dot (CQD) structure. The vertically CQDs have been intensively investigated in terms of optical coupling and entangling states [1,2] When the interdot distance between two quantum dots is short enough (d< 10nm) to result in a wave function overlap between the two quantum dots via the tunneling effect, the optical coupling is controlled by the interdot distance and external DC electric fields along the coupling direction. However, in the case of a laterally CQD, the separation of two quantum dots is not small enough to give rise to a sufficient wave function overlap for tunneling to occur, the exciton dipole-dipole interaction can be used as an alternative method to understand long range optical coupling procedure.



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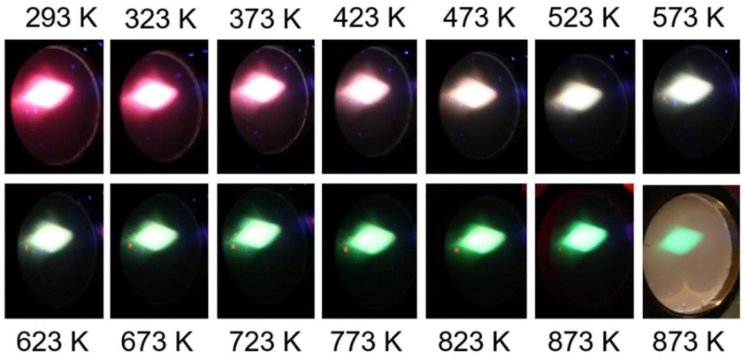
Luminescent thermometer for sensitive sensing over a wide temperature range [1]

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Luminescence thermometry is used in a variety of research fields for noninvasive temperature sensing. Lanthanide-doped micro-/nanocrystals are exceptionally suitable for this. The popular concept of luminescence-intensity ratio thermometry is based on emission from thermally coupled levels in a single lanthanide ion, following Boltzmann's law. These thermometers can measure temperature with low uncertainty, but only in a limited temperature range. Herein we presented a novel Ho^{3+}-based thermometer and developed a quantitative model with sustained low temperature uncertainty from room temperature up to 873 K. The thermometer shows bright green and red luminescence with a strong and opposite dependence on temperature and Ho^{3+} concentration. This is the result of temperature-dependent competition between multi-phonon relaxation and energy transfer, feeding the green- and red-emitting levels, respectively, following excitation with blue light. This simple and quantitative model of this competition predicts the output spectrum over a wide range of temperatures (300-873 K) and Ho^{3+} concentrations (0.1-30%). The optimum Ho^{3+} concentration can thus be determined for reliable measurements over any temperature range of interest. Quantitative modeling as presented here is crucial to optimally benefit from the potential of energy-transfer thermometers to achieve low measurement uncertainties over a wide temperature range.



Fluorescence images of $Na(YGd)F_4$:12%Ho^{3+} with increasing temperature from 293 to 873 K

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Theoretical spectroscopy of extrinsically and intrinsically defective halide perovskites

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Since the 1960s, the theoretical spectroscopy of transition metal and rare earth ions has played an important role for the discovery of novel luminescent materials [1]. However, there are quite few applications of such a theory to the very hot field of d- and f-elements activated halide perovskites emerging as new materials for photovoltaics and optoelectronics. In this talk, we will show the recent development and vigorous vitality of the theoretical spectroscopy by three typical examples. First, the near-unity narrow-band green emission in $(C_{10}H_{16}N)_2MnBr_4$ zero-dimensional (0-D) perovskites can be unveiled by a proposed universal regulating strategy based on the Dexter's energy transfer theory [2]. Second, the calculated electronic structures of rare earth-doped CsPbX_3 (X=F, Cl and Br) shown in Figure 1 can be thought of as a good reference for clarifying the photon-electric upconversion mechanism of $CsPbF_3$: Zn^{2+}/Yb^{3+}/Er^{3+}(or Tm^{3+}) nanocrystals [3]. Finally, the origin of the green luminescence in Cs_4PbBr_6 0-D perovskites is revealed by considering the existence of isolated $CsPbBr_3$ nanoclusters [4].

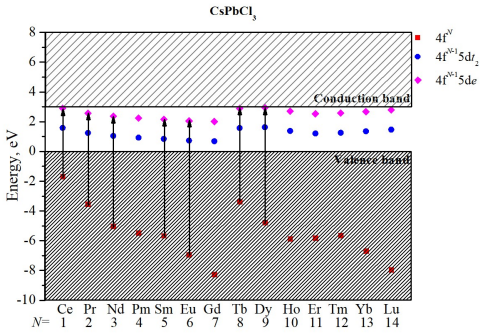


Figure 1 Calculated 4f- and 5d-HRBE diagrams of the trivalent lanthanides doped in $CsPbCl_3$

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Light-matter interaction in semiconductor materials at miroc/nanoscale

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Our current research is mainly focusing on the optical properties of semiconductor materials at micro/nanoscale by using micro-region steady-state and transient optical spectroscopy. We establish the internal relationship between material performance an structure, and then provide optical understanding for the low loss and ultra-fast optoelectronic devices. Our talk mainly include the following aspects: 1) dynamics of exciton related states in microcavity and superlattice systems; 2) gain properties of semiconductor materials and micro/nano lasers; 3) nonlinear optical properties of semiconductor materials in micro/nano scale.

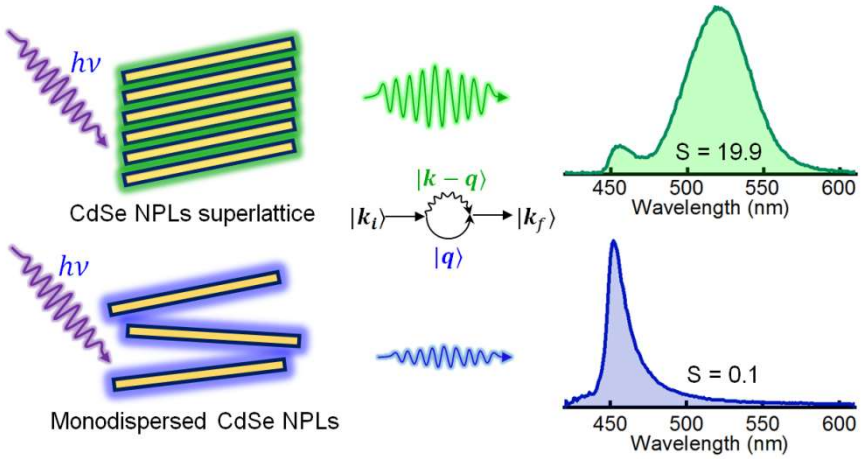


Diagram of the CdSe NPLs superlattce sreucuture versus the dispered counterparts

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Manipulating the light emission of 2D semiconductors by different stacking and heterogeneous integration

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The manipulation of light emission of 2D semiconductors is of great importance for both fundamental researches and practical device applications. In this talk, I will summarize our recent works on the manipulation of second harmonic generation (SGH) and photoluminescence (PL) in 2D semiconductor layers. We realized a variety of inversion-symmetry-breaking (3R-like phase) transition metal dichalcogenides (TMDCs (WSe_2, WS_2, MoS_2) atomic layers, spiral structures, and heterostructures, which show a quadratically increased SHG intensity with respect to layer numbers and a high circular polarization [1, 2]; By direct vapor growth of monolayer PbI_2 on monolayer TMDCs to form bilayer vertical heterostructures, we can manipulate the PL emissions from the bottom TMDC layers from apparently enhanced (for WS_2) to greatly quenched (for WSe_2) compared to their monolayer counterparts, which can be attributed to the band alignment–induced distinct interfacial charge transfer behaviors [3, 4]; We report on room temperature high-spin polarization in 2D layers by reducing its carrier lifetime via the construction of Van der Waals heterostructures. A near unity degree of circular polarization is observed in PbI_2 layers with the formation of type-I and type-II band aligned heterostructures with monolayer WS_2 and WSe_2 [5].

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ICL 2020

T Defect-related optical properties and optoelectronic applications of 2D materials

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Two dimensional transition metal dichalcogenides exhibit semiconducting properties and their electronic structure is adjustable with the number of layers. As the number of layers decreases from multiple layers to monolayers, their band structure changes from indirect band gap to direct band gap, so photoluminescence can be achieved. Most of the band gaps of two-dimensional transition metal dichalcogenides are in the visible spectral range, which lays a foundation for their applications in the fields of display, lighting, visible light communication and so forth. In this presentation, we will report the progress of fluorescence pattering in two-dimensional transition metal dichalcogenides, explore the originations of the fluorescence pattering from the boundary state, spatial distribution of defects, physical/chemical adsorption and other aspects, and improve the fluorescence quantum yield by defect engineering.

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Efficient quantum dot light-emitting diodes based on CsPbX3

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Lead halide perovskites, which have quickly grown to encompass the whole optoelectronic research community, such as photovoltaics, light-emitting diodes, lasing and photodetectors, are showing a great promise as a new generation of emitter materials. In addition to their composition independent optoelectronic properties, these emitters in nanocrystal (NC) form have a high photoluminescence (PL) quantum yields (QYs) of up to 95% and narrow light emitting peak with FWHM of about 20 nm, making them particularly attractive for high quality lightings and displays. Among various reported perovskite NCs, inorganic perovskite cesium lead halides ($CsPbX_3$, X = Cl, Br, and I) is more promising for practical applications owing to the high thermal stability and low moisture sensitivity comparison with organic-inorganic hybrid counterparts. Herein, I will give a detailed introduction on some strategies for the efficient $CsPbX_3$ quantum dot light-emitting diodes (QLEDs) reported by our group, including "mixed solvent purification", "organic-inorganic hybrid passivation", "bilateral passivation", and device optimization.

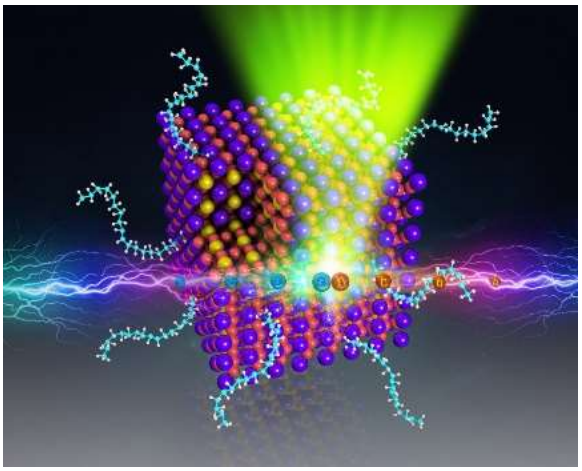


Figure 1 Illustrates the $CsPbX_3$ quantum dots with high luminescence efficiency

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Quantum dots/perovskites based light-emitting devices

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Colloidal quantum dots/perovskites based light-emitting diodes (QLEDs/PeLEDs) have attracted extensive attention for lighting and display applications because of their excellent advantages, such as narrow emission bandwidth, color tunability, high brightness and low-cost fabrication techniques. The external quantum efficiencies (EQEs) for QLEDs/PeLEDs are catching up with those for commercial organic light emitting diodes (OLEDs), thanks to the quantum efficiency improvement, the device configuration optimization as well as the deep understanding of electroluminescence principle. Despite the rapid advance in device performance has been achieved, the operational lifetime of these devices still cannot meet the requirements for practical applications. In this report, we will present our latest advances in improving performance and stability of high color-purity QLEDs/PeLEDs.

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Exciton luminescence and dynamics in 2D lead halide perovskites

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Two-dimensional (2D) lead halide perovskites with distinct excitonic feature have shown exciting potential for optoelectronic applications. Compared to their three-dimensional counterparts with large polaron character, how the interplay between long- and short- range exciton-phonon interaction due to polar and soft lattice define the excitons in 2D perovskites is yet to be revealed. Here, we seek to understand the nature of excitons in 2D CsPbBr3 perovskites by static and time-resolved spectroscopy. Compared to transition metal dichalcogenides with comparable exciton binding energy, we observe more than one order of magnitude smaller exciton-exciton interaction induced spin flip constant and counterintuitively, longer exciton spin lifetime at higher temperature. The anomalous spin dynamics implies excitons in 2D perovskites exist as exciton polarons with significantly weakened inter- and intra- excitonic interactions by dynamic polaronic screening, despite large steady state exciton binding energy. We also show quantitatively an intermediate exciton-phonon coupling in 2D CsPbBr3 where exciton polarons are momentarily self-trapped by lattice vibrations. The 0.25 ps ultrafast interconversion between free and self-trapped exciton polaron with a barrier of ~ 34 meV gives rise to intrinsic asymmetric photoluminescence with a low energy tail at room temperature. This study reveals a complex and dynamic picture of exciton polarons in 2D perovskites and emphasizes the importance to regulate exciton-phonon coupling.

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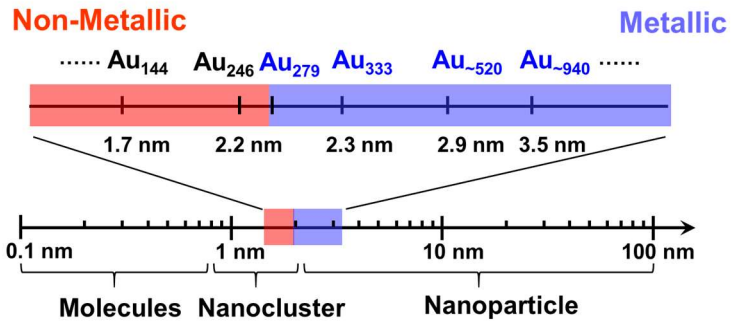
Evolution from metallic to molecular state in gold nanoclusters probed by ultrafast spectroscopy

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The transition from metallic to molecualar state in metal nanoparticles remains a central question in nanoscience. Atomically precise Au nanoclusters consist of tens to hundreds of gold atoms, which bridge the metallic and non-metallic gold nanoparticles. These nanoclusters provide a good platform to probe such a transtion while it requires good methods to probe the electronic properties and the metallicity of these ultrasmall nanoparticles. Here, we will indroduce our recent work on probing the evolution from metallic to excitonic state in gold nanoclusters by ultrafast pump-probe spectroscopy. We will also discuss some critera to determine the metallicity of metal nanoclusters.



Evolution from metallic state to molecular state in gold nanoclusters.

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Efficient quantum dot light-emitting diodes based on CsPbX3

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Lead halide perovskites, which have quickly grown to encompass the whole optoelectronic research community, such as photovoltaics, light-emitting diodes, lasing and photodetectors, are showing a great promise as a new generation of emitter materials. In addition to their composition independent optoelectronic properties, these emitters in nanocrystal (NC) form have a high photoluminescence (PL) quantum yields (QYs) of up to 95% and narrow light emitting peak with FWHM of about 20 nm, making them particularly attractive for high quality lightings and displays. Among various reported perovskite NCs, inorganic perovskite cesium lead halides ($CsPbX_3$, X = Cl, Br, and I) is more promising for practical applications owing to the high thermal stability and low moisture sensitivity comparison with organic-inorganic hybrid counterparts. Herein, I will give a detailed introduction on some strategies for the efficient $CsPbX_3$ quantum dot light-emitting diodes (QLEDs) reported by our group, including "mixed solvent purification", "organic-inorganic hybrid passivation", "bilateral passivation", and device optimization.

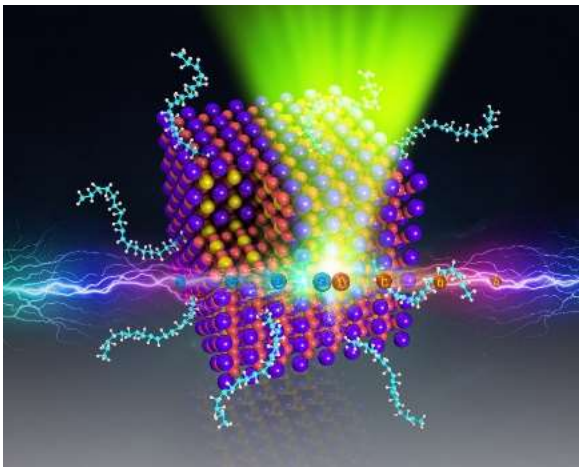


Figure 1 Illustrates the $CsPbX_3$ quantum dots with high luminescence efficiency

References

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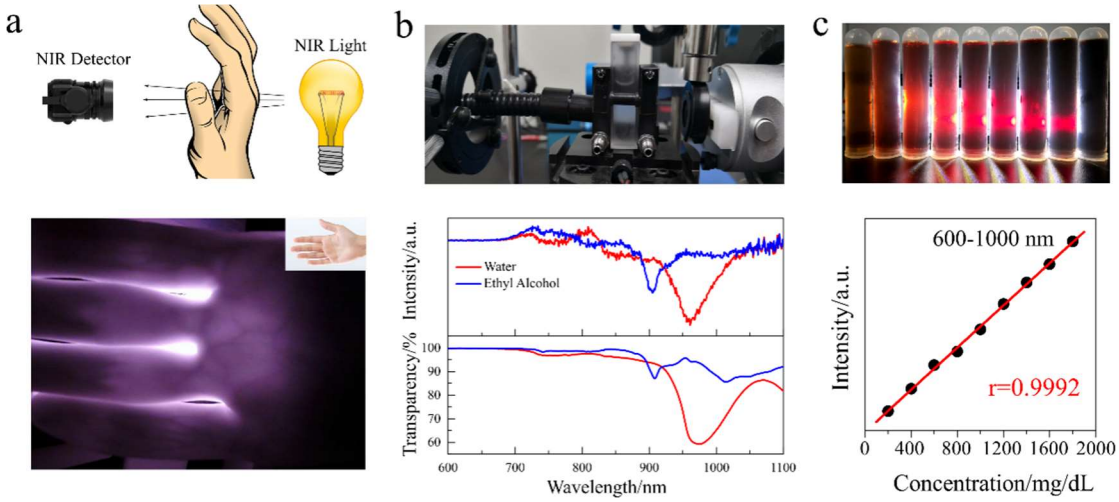
Cr^{3+} doped broad band far red/NIR phosphor and its application

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Phosphor converted LED (pc-LED) was proved to be a perfect solid state lighting source in the past twenty year. However, the spectrum range of pc-LED only covered 400-700 nm range which limits its application, for example, in NIR spectroscopy. New kind of far red/NIR phosphors that expanding spectrum range of pc-LED to 700-1100 nm are demanded for this purpose. In the past five years, Cr^{3+} has been proved to be a prefect far red/NIR luminescence center for highest efficiency and broadest bandwidth. This paper will discuss many topics, such as, Stokes shift, Cr^{4+}, and energy transfer that affect efficiency and bandwidth of Cr^{3+} doped phosphors. The applications of far red/NIR phosphor in fabrication of light sources for special lighting and spectroscopy will also be discussed.



Application of broad band NIR pc-LED. (a) Photos of the NIR light from 0.3 W pc-LED transilluminating palm. (b) Transmission spectra of water and ethyl alcohols measured by the NIR pc-LED and spectrometer, respectively. (c) Measuring concentration of bovine hemoglobin solution.

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A highly efficient and suitable spectral profile Cr^{3+}-doped garnet near-infrared emitting phosphor for regulating photomorphogenesis of plants

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Broadband near-infrared (NIR) emitting phosphors have attracted considerable attention in food, bioimaging, night vision, and plant lighting. However, NIR phosphors targeting the absorption of far-red/phytochrome (P_{FR}) have rarely been reported. We note that gallium garnets are more suitable for satisfying the photomorphogenesis needs of plants. Accordingly, we have designed a Cr^{3+}-doped $Gd_{2.4}Lu_{0.6}Ga_4AlO_{12}$ NIR phosphor from original $Gd_3Ga_5O_{12}:Cr^{3+}$ by substituting the large Gd^{3+} and Ga^{3+} ions with small Lu^{3+} and Al^{3+} ions to regulate relative energies and sequence of the two lowest excited states ^2E_g and $^4T_{2g}$. The optimal $Gd_{2.4}Lu_{0.6}Ga_{3.87}AlO_{12}:0.13Cr^{3+}$ sample exhibits greater spectral overlap with the absorption of P_{FR}, originated from the raised peak emissions and the blue-shift of emission band. Meanwhile, the luminescence is greatly enhanced by 2 times when the flux of H_3BO_3 was added during the synthesis. Thanks to the excellent EQE and low thermal quenching behavior, a NIR pc-LED was fabricated by integrating the $Gd_{2.4}Lu_{0.6}Ga_{3.87}AlO_{12}:0.13Cr^{3+}$,3 wt%$H_3BO_3$ on a blue chip-on-board chip, which has a high output power of 505.99 mW and photoelectric efficiency of 11.24% at 300 mA. To further evaluate the potential of this device for plant growth, pea seedlings (*Pisum sativum* L.) as the model was investigated. The difference is achieved the 79.84% and 67.72% in dry and fresh weight under different treatments. This study provides a reference to regulate the spectral profile of Cr^{3+}-doped NIR phosphors and sheds light on the practical application of Cr^{3+}-doped NIR phosphors in the field of plant lighting.

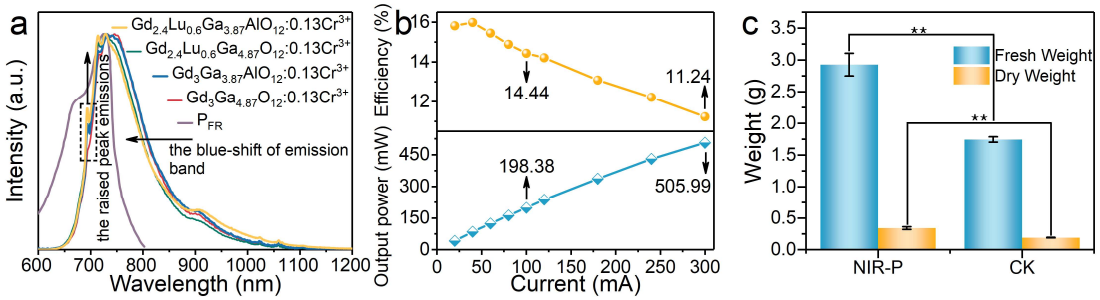


Figure 1. (a) The normalized PL spectra of different samples and the absorption spectrum of P_{FR}. (b) NIR output power and photoelectric conversion efficiency under different driving currents. (c) Fresh and dry weight in two treatments; N = 6. Average ± standard error (SE). Asterisks indicate significant differences at $p < 0.05$ (*), $p < 0.01$ (**), $p < 0.001$ (***).

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Controlled assembly of upconverting nanoparticles for low-threshold microlasers and their imaging in scattering media

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Micron-sized lasers fabricated from upconverting nanoparticles (UCNP) coupled to whispering gallery mode (WGM) microresonators can exhibit continuous-wave anti-Stokes lasing useful for tracking cells, environmental sensing, and coherent stimulation of biological activity. The integration of these microlasers into organisms and microelectronics requires even smaller diameters, however, which raises threshold pump powers beyond practical limits for biological applications. To meet the need for low lasing thresholds and high fidelity fabrication methods, we use correlative optical and electron microscopy to uncover the nanoparticle assembly process and structural factors that determine efficient upconverted lasing. We show that 5 μm microspheres with controlled submonolayer UCNP coatings exhibit, on average, 25-fold lower laser thresholds (1.7 ± 0.7 kW/cm2) compared to the mean values of the lowest threshold UCNP lasers, and variability is reduced 30-fold. WGMs are observed in the upconversion spectra for TiO2-coated microspheres as small as 3 μm, a size at which optical losses had previously prevented such observations. Finally, we demonstrate that the WGM signatures of these upconverting microlasers can be imaged and distinguished through tissue-mimicking phantoms. These advances will enable the fabrication of more efficient upconverting lasers for imaging, sensing, and actuation in optically complex environments.

Enhanced upconversion emission in Er^{3+}: $BaWO_4$ through Gd^{3+} incorporation and optical thermometry

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The Er^{3+} is the most popular RE ion, which gives intense UC emissions extending from ultraviolet to NIR regions. It has been found that the UC luminescence efficient of Er^{3+} ions can be enhanced by co-doping Yb^{3+} ions. Further enhancement of the Er^{3+} UC emission intensity has also been observed by co-doping with Li^{+}, Mn^{2+}, Zn^{2+} and other metal ions. A few reports account that the UC luminescence efficiency of Er^{3+} ion is increased by co-doping Gd^{3+} ions. The $BaWO_4$ material with scheelite structure tungstate demonstrates fascinating peculiar features. Such as the low symmetry of its crystal lattice, its low phonon frequency (~800-1000 cm^{-1}), non-toxic and non-hygroscopic properties. However, as far as we know, the UC luminescence characteristics of Er^{3+}/Gd^{3+} co-doped $BaWO_4$ materials have not been studied, and further attention is needed.

In this report, a series of Er^{3+}/Gd^{3+} co-doped $BaWO_4$ phosphors have been synthesized through solid state reaction method. The corresponding upconversion(UC) luminescence properties were investigated under 980 nm excitation. The UC emission intensities of Er^{3+} ions were enhanced with Gd^{3+} doped, which was interpreted by crystal field deformation. Based on the fluorescence intensity ratio (FIR) technique, the temperature sensing characteristics of Er^{3+} ions were investigated. The maximum absolute sensitivity reached 15.49×10^{-3} K^{-1} at 523 K. The above results indicated that the Er^{3+}/Gd^{3+} co-doped $BaWO_4$ phosphor was a high efficient UC luminescence material and it could be used as photonic devices, temperature sensor purposes and an optical heater.

Luminescence thermometry from Er^{3+}/Yb^{3+} co-doped yttrium niobate with high NIR emission and NIR-to-visible upconversion quantum yields

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The growing demand aiming non-invasive diagnosis techniques applications has become an emerging field for developing more efficient bioprobes working in the near infrared (NIR) biological windows [1]. In this context, we present NIR and NIR-to-visible upconversion (UC) emission from the multifunctional Er^{3+}/Yb^{3+} co-doped yttrium niobate, synthesized via sol-gel method, and its exploitation as an efficient luminescent thermometer. X-ray diffraction analysis points out to the formation of cubic Y_3NbO_7 crystalline phase after annealing at 1100 °C. Intense and narrow 1.5 μm emission (FWHM ~24 nm) and $^4I_{13/2}$ lifetime of 5.5 ms are observed under excitation in the host absorption band (276 nm). Under 980 nm excitation, this compound showed a strong UC luminescence, affording a yellowish-green emission color. The UC process were explained by the ESA and ETU mechanisms by the well-known power law [2]. NIR and UC quantum yield (QY) were reported for the first time for Y_3NbO_7 material, where the excitation at 980 nm provided values of 18% in the NIR range and 0.0020% in the visible range. Y_3NbO_7 exhibited luminescence properties of a primary thermometer, where the absolute temperature is calculated by the Boltzmann law, and the thermometric parameter (Δ) is expressed by intensity ratio of the $^2H_{11/2} \rightarrow {}^4I_{15/2}$ and $^4S_{3/2} \rightarrow {}^4I_{15/2}$ transitions of Er^{3+} ions [3]. The maximum relative thermal sensitivity of 1.13 ± 0.02 % K^{-1}, the maximum repeatability was determined as 99.4%, and the minimum temperature uncertainty of 0.37 K was obtained, which attest the potentiality of its use as primary thermometer. Besides, the relatively high QY values in NIR and UC emission, comparable to fluorides and higher than other oxides, make it interesting as multifunctional probe aiming biological applications.

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Enhanced color conversion of $CsPbBr_3$ perovskite QDs by surface passivation and plamsonic coupling

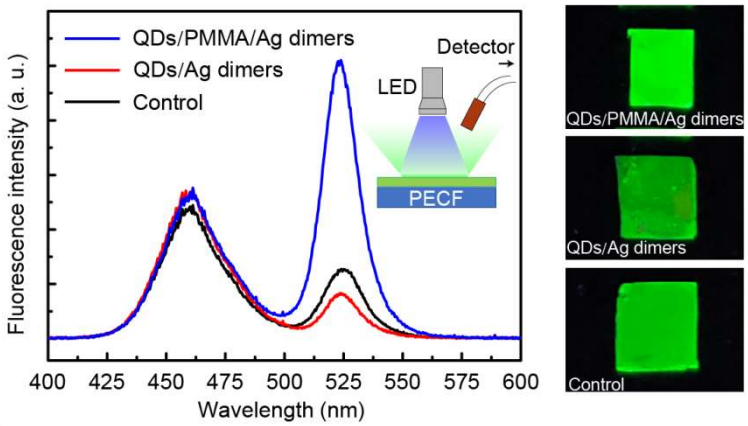
J. Yin,[1] W. J. Hui,[1] T. Ping,[1] J. Li,[1] and J. Y. Kang[1]

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Metal halide perovskites has proved to be a very promising optoelectronic materials due their excellent properties.[1] Especially, the all-inorganic $CsPbX_3$ (X= Cl, Br or I) quantum dots (QDs) with impressive high quantum yield, narrow luminescence peak, and short exciton lifetime, demonstrates the great potential application in the fields of high performance display and lighting. For the actual application in color-conversion, enhancing the fluorescence intensity and manipulate the photophysic dynamics have been considered to the most critical issues.

Here, we proposed using a novel strong coordinated molecule (oxygen-containing cesium sulfonate) to passivate the commonly existed surface defects of the prepared $CsPbBr_3$ QDs,[2] thus leading a significantly improved fluorescence with corresponding suppressed non-radiative recombination. Additionally, a dual-mode plasmonic resonances based on a metal dimer structure was developed to simultaneously enhance the absorption under short-wavelength excitation and excitons' emission at longer wavelengths for $CsPbBr_3$ QDs.[3] The fabricated hybird films exhibited a significant about 3.95-fold overall fluorescence enhancement when using blue light excitation, showing the novel advantages of dual-mode plasmonic coupling of semiconductor quantum structures for color conversion applications.



Plasmonic dimer sturcture enhanced fluorescence for the $CsPbBr_3$ QDs film

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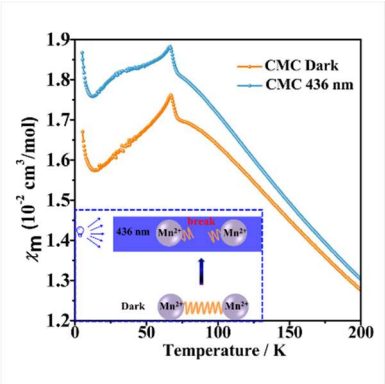
Mn^{2+}-Mn^{2+} magnetic coupling effect on photoluminescence revealed by photomagnetism in $CsMnCl_3$

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Magnetic coupling interaction of Mn^{2+}-Mn^{2+} in Mn^{2+}-included phosphors could induce shorter emission decay time, compared with that of isolated Mn^{2+}, which could overcome the photoluminescence (PL) saturation when stimulated by a high photon flux due to the long lifetime of Mn^{2+} excited state. However, little literature has directly proved the Mn^{2+}-Mn^{2+} coupling effect on the PL decay. In this paper, the effect on PL of $CsMnCl_3$ (CMC) and its hydrates is revealed by the photomagnetism results, excluding the interference effects of site symmetry and phonon energy. The antiferromagnetic interaction of the CMC is larger when Mn^{2+} at photoexcited state than at dark state, while it is contrary to the hydrates with weak Mn^{2+}-Mn^{2+} interaction. The research not only helps to understand the fundamental optical process but also is instructive for designing high performance of Mn^{2+}-doped phosphors in the field of displays and lighting.



The magnetization of the CMC is larger when Mn^{2+} is at photoexcited state than that at dark state

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Synergetic effect of tetraethylammonium bromide addition on the morphology evolution and enhanced photoluminescence of rare-earth metal–organic frameworks

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Controlled synthesis of rare-earth metal–organic frameworks (RE-MOFs) is of great significance to match their emerging multifunctional luminescence applications. Herein, we propose a green and general solvent-free synthetic strategy for the adjustment of morphology and dimension of various RE-MOFs (RE = Eu, Tb, Er, Dy, Y, Tm) by using a tetraethylammonium bromide-assisted thermal-heating method. These self-assembled RE-MOF materials possess controllable morphologies and hierarchical structures while retaining the structural topology of MIL-78, proving that the strategy is a feasible and effective way in opening up large-scale synthesis of RE-MOFs. It is further found that the tetraethylammonium could be carbonized into carbon dots and encapsulated in Eu/Tb-MIL-78 to enhance the fluorescence emission intensities significantly, making the hierarchical Eu/Tb-MIL-78 MOF materials good candidates for the latent fingerprints recognition application. This work provides a novel strategy for effectively controlling the morphology and dimension of RE-MOFs materials with enhanced photoluminescence and has great potential in their scaling-up syntheses and exploring the new luminescence applications.

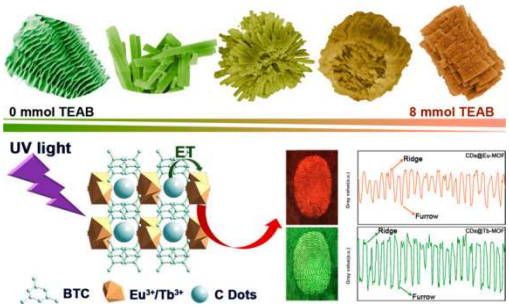


Fig. 1 Schematic diagram of the morphological evolution and fluorescence enhancement mechanism of RE-MOFs and its application in fingerprint detection

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$CsPbX_3$ nanocrystals based highly efficient light-emitting diodes

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Colloidal cesium lead halide ($CsPbX_3$) perovskite nanocrystals (NCs) have been considered as the next-generation light emitters for light-emitting diodes (LEDs) due to their excellent optoelectronic properties.[1] However, the surface defects and unstable lattice structure of $CsPbX_3$ NCs and the unbalanced carrier in devices transfer seriously influence the device performances.[2] In oreder to improve the optical properties and stability of $CsPbX_3$ NCs as well as the device performance of LEDs, we carried out some research from two aspects of material optimization including simultaneous Sr doping and Cl passivation,[3] ligand exchange of short chain using octylphosphonic acid,[4] Cd alloying,[5] and PbS capping,[6] as well as device structure design including top emitting device structure,[7, 8] and ZnO–Ti_3C_2 MXene mixed electron transport layer.[9] Consequently, the photoluminescence quantum yields of $CsPbX_3$ NCs were increased to more than 90%, and the device performances of corrosponding LEDs were also significantly improved, the maximum luminance up to 14725 cd m^{-2}, the peak external quantum efficiency up to 17.4%.

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In vivo luminescence nanothermometry: challenges, solutions, and opportunities

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Luminescence nanothermometry is promising for non-invasive probing of temperature in biological microenvironment at nanometric spatial resolution. Yet, wavelength- and temperature-dependent absorption and scattering of tissues distort measured luminescence spectral profile, rendering conventional luminescence nanothermometers (ratiometric, intensity, band shape, or spectral shift) problematic for in vivo temperature determination. Here, we present a state of the art technologies, especially the near infrared luminescence lifetime technique, to address this problem, providing exciting opportunities for preclinical applications.

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Bismuth-containing materials for tumor imaging and therapy

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Cancers is a major public health problem worldwide that threaten the survival of people, and a large amount of people die from various kinds of cancers every year [1]. Early diagnosis and treatment of cancers are critical to the survival of patients. Great efforts have been made by researchers to develop various imaging modalities and tumor treatment methods in the past decades [2, 3]. The development of a biocompatible platform that integrates diagnostic and therapeutic functions is a broad prospect for cancer therapy. Recently, many kinds of inorganic luminescent materials have been designed and developed to realize this goal. Among them, bismuth-containing materials have received extensive attention due to their unique advantages. Bismuth is a high atomic number element, which possesses high K-edge value and good X-ray attenuation properties. In addition, bismuth-containing luminescent materials have also been widely explored [4-6]. It is worth mentioning that bismuth is the only heavy metal that is nontoxic. Therefore, bismuth-containing mateials have the potential to be used as safe agents for multimodal imaging and treatment of cancer. In our research work, we have successfully reported a series of bismuth-containing materials, such as Bi_2O_3, $NaGdF_4$:Yb^{3+},Tm^{3+},25% Bi^{3+}, PVP-Bi, $AgBiS_2$, $NaBiF_4$, and $K_{0.3}Bi_{0.7}F_{2.4}$, for deep tumor imaging and cancer [3, 7-11]. The experimental results show that our synthetic bismuth-containing materials have very high biosafety and have broad application prospects in the field of cancer diagnosis and treatment. These works also further broaden the application of bismuth-containing materials.

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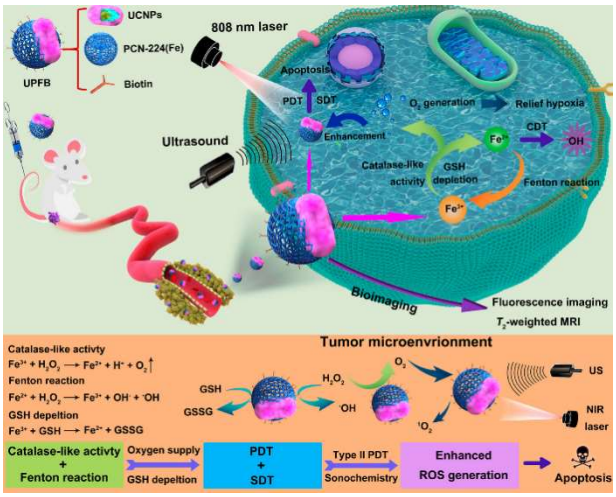
Construction and performance of diagnosis and treatment system based on up-conversion luminescence

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As well known, cancer is a global public health issue and the second leading cause of death for humankind. Its diagnosis and treatment have always been difficult problems in the medical field. In view of the advantages of upconversion luminescence, such as high penetration depth of tissue, low self-fluorescence background, high signal-to-noise ratio and low light damage, upconversion nanoparticles are always used to realize the integration of multimodal diagnosis and treatment for tumors, mainly including photodynamic therapy, chemodynamic therapy, photothermal therapy, sonodynamic therapy, MRI, CT and upconversion luminescence imaging. Accordingly, a kind of near-infrared light-induced multimodal synergistic therapeutic systems were developed, such as upconverted metal-organic framework Janus architecture and second near-infrared based theranostic system. The multimodal optical and therapeutic properties of a single multifunctional nanoparticle were revealed. It was found that a variety of therapeutic modes could be controlled in a unified way. The synergistic and efficient anticancer effect of different therapeutic modes werr realized, and the model of cooperative therapeutic behavior was established.



Schematic illustration of antitumor mechanism of upconverted metal-organic framework Janus architecture

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The development of highly photostable organic fluorescent probes for STED nanoscopy imaging

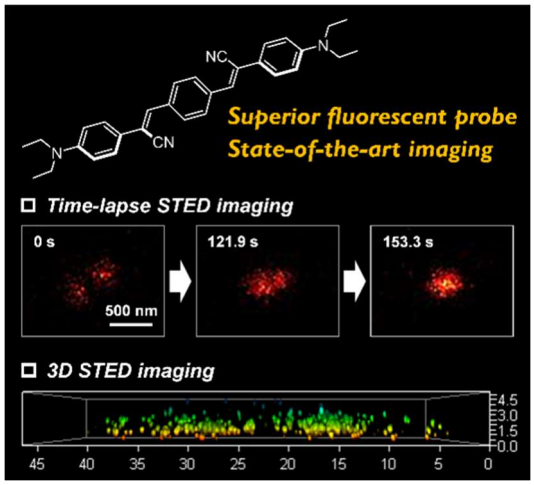
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Stimulated Emission Depletion (STED) nanoscopy fluorescence imaging is a powerful tool to visualize the organelle structures and dynamic processes on the nanoscale in living cells, thus wining the Nobel Prize in Chemistry (2014). However, the practical utility of STED imaging is largely limited by the availability of advanced fluorescent probes that can be efficiently depleted by the STED laser as well as exhibits significantly high photostability. In this context, the development of superior fluorescent probes has attracted much attention in recent years and emerged as a cutting-edge topic in the field of fluorescence bio-imaging.

Herein, we report a new small-molecular fluorescent probe Lipi-DSB which exhibits high photostability and brightness, large Stokes shift, low saturation intensity for STED laser, and good staining specificity toward cellular lipid droplets (LDs). These features enable the probe to be ideally applied in STED nanoscopy imaging of LDs, *e.g.* time-lapse STED imaging, two-color STED imaging, as well as 3D STED imaging. Consequently, the dynamics and the spatial distribution of LDs have been precisely visualized at the unprecedented nanoscale resolution. Moreover, employing the probe for time-lapse STED imaging has uncovered the fusion process of nascent LDs for the first time.



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ICL 2020

Lanthanide luminescence to mimic molecular logic and computing through physical inputs

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Since the first digital-programmable computer was developed the information technology has been growing up continually.[1] Computers and related systems have become more efficient and smaller because of the scaling shrinkage of the silicon-based components over a relatively short period of time. Nevertheless, there is a general interest to become computers even smaller, smarter and powerful and the only way to achieve such purpose is by designing a miniaturized scale of the computer circuit components.[2] Classical miniaturization of the computer with silicon-based components eventually is reaching its limits, in terms of physical limitations[3] and high economical costs.[4] In this sense, it is when molecular logic gates come into consideration, allowing the integration of self-assembly molecular technology whose dimensions are in the order of atom sizes.

Since the 80's molecular logic devices constituted by luminescent signaling molecules are being reported as an alternative approach towards molecular computing, showing that molecules can perform some of the computational functions achieved in semiconductor technology. The examples listed in the literature present molecules that are actuated almost exclusively by chemical species.

Recently we reported the use of monolithic silicon-based structures incorporating Ln^{3+} complexes for performing logical functions.[6] Elementary logic gates (AND, INH and DEMUX), sequential logic (KEYPAD LOCK), and arithmetic operations (HALF ADDER and HALF SUBTRACTOR) exhibiting a switching ratio >60 % are demonstrated for the first time using non-wet conditions. Additionally, this is the first report showing sequential logic and arithmetic operations combining molecular Ln^{3+} complexes and physical inputs. Contrary to chemical inputs, physical inputs may enable the future concatenation of distinct logical functions and reuse of the logical devices, a clear step-forward towards input-output homogeneity that is precluding the integration of nowadays molecular logic devices.

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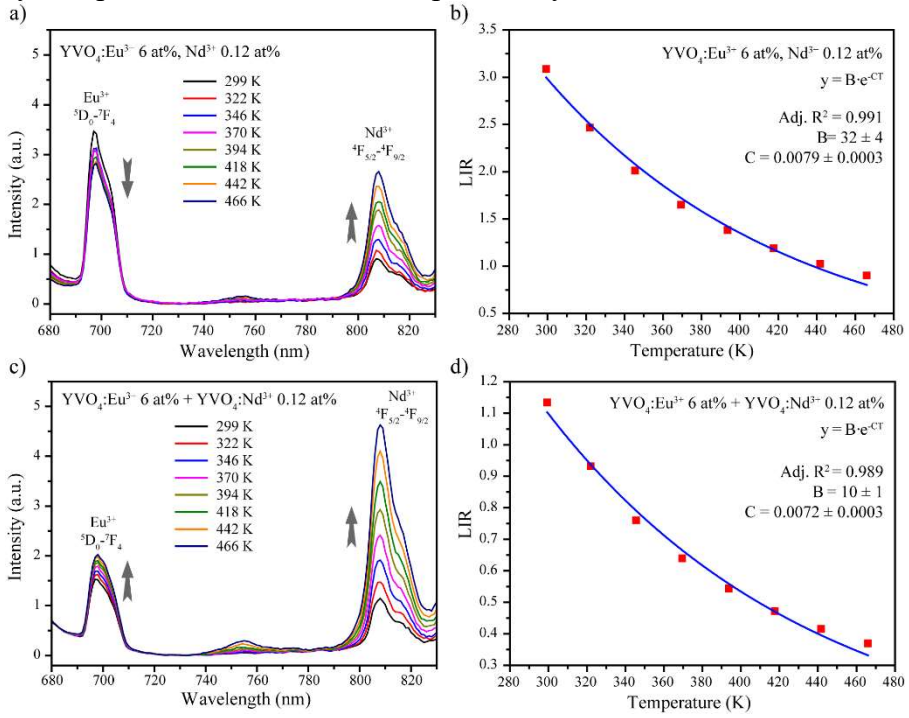
Dual-center ratiometric $YVO_4:Nd^{3+}/Eu^{3+}$ nanothermometers based on co-doped and mixed phosphors

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Luminescence nanothermometry provides outstanding opportunities for researchers in physical, biomedical, and chemical science, because it allows non-contact thermal reading with high spatial and temporal resolution. Ratiometric technique is the most commonly used for luminescence thermal sensing due to independence of temperature measurement on external factors such as excitation power, phosphor quantity or spatial distribution of sample. Here we report ratiometric sensing using luminescence bands originating from two different active centers [1]. Co-doped and mixed $YVO_4:Eu^{3+}/Nd^{3+}$ samples with different doping concentrations were successfully demonstrated for contactless thermometry in 299–466 K range. The thermometric performances were studied and compared with earlier reported thermal sensors in terms of thermal sensitivity, temperature resolution, and repeatability.



Emission spectra of (a) co-doped and (c) mixed NPs at various temperatures; LIR of (b) co-doped and (d) mixed NPs as a function of temperature.

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The radiation-induced darkening and its suppression methods in Yb^{3+}-doped silica laser fibers

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Ytterbium -doped silica fiber (YDF) amplifier has been demonstrated to meet future long-haul inter-satellite optical communications needs by NASA in 2015, because of its low weight, size, and high average power combined with good beam quality. However, the YDFs will face a harsh ion radiation of various types (such as proton, electron, X- and γ-ray) during their space mission. The radiation-induced darkening (RD) effect mainly due to the generation, at the microscopic scale, of color centers can seriously deteriorate the laser performance of YDF. However, the nature, generation mechanism and suppression method of color centers in YDF are less studied until now.

In this talk, the ytterbium doped silica glasses (YDGs) co-doped with different elements (Al, P, Ce, F et.) were prepared by using sol-gel combining high temperature sintering method [1-6]. The YDFs were prepared by MCVD combined with sol-doping. The effects of glass compositions and pretreatment methods on radiative resistance behaviors of YDGs and YDFs will be presented. The laser behaviors of YDF before and after gamma radiation will be compared and the related mechanism will be revealed by combining the radiation-induced absorption (RIA), photoluminescence (PL), and electron paramagnetic resonance (EPR) spectroscopies.

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A new incarnation of Fe^{3+}: a promising activator for highly sensitive luminescence thermometry

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The presence of Fe^{3+} ions in phosphors is usually considered a significant limitation because these ions are known as effective quenchers of luminescence. However, careful control of their concentration and the intentional selection of the matrix make it possible to obtain an intense red/ near infrared luminescence of Fe^{3+} ions. In this work, we demonstrate the application potential of the aluminates $MAl_4O_7:Fe^{3+}$ (M=Ca, Sr, Ba)[1] in luminescence thermometry and investigate the influence of the host composition on the spectral and thermometric properties of these phosphors. The strategy of modulation of the relative sensitivity of luminescent thermometers operating in a single intensity (Fig. 1a), ratiometric, or decay time (Fig. 1b) approaches by subtle modulation of the crystal field strength is investigated in detail and propositions for a targeted design dependent on the temperature range to be sensitively detected are proposed.

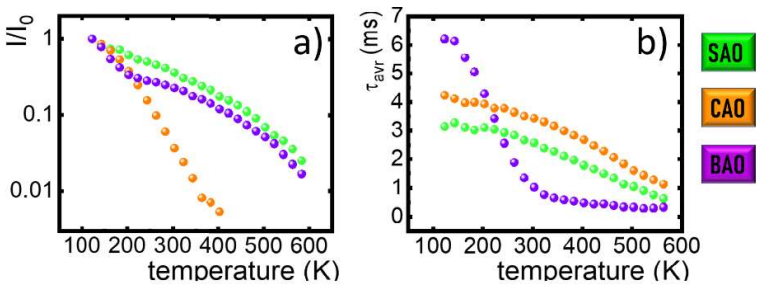


Figure 1. The influence of the temperature on integral luminescence intensity of Fe^{3+} ions a) and the τ_{avr} of the $^4T_1$ state b) in the MAO phsophors.

Acknowledgements

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Experimental insight of single nanoparticle dynamic in water at high temperature by optical tweezers

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Nanofluids (NFs, colloidal dispersions of nanoparticles in fluids) has been applied in many fields, such as fundaments study of Brownian motion, fluorescent imaging in vivo, and heat and temperature control in hyperthermia treatment [1-3]. While much attention has been paid to its physical and chemical properties, there is a few researches on the internal interactions among NFs. Nanoparticles (NPs) suspended in a fluid undergoes interaction with their surrounding molecule and interaction among NPs. Although it has been demonstrated that the interparticle interactions can have significant impact on the luminescent properties of colloidal suspensions of upconverting nanoparticles (UCNPs) [4, 5], experimental insight of the interaction of NP-fluid is still missing.

In order interference, in this work, optical tweezers has been used to study NP-water interaction by exploring single-nanoparticle dynamics at high temperature. Here hydrodynamic drag method was used to calibrate the optical trapping force acting on a single UCNP. Luminescence generated from UCNP under the excitation of 980 nm laser was used to determine whether nanoparticles are in traps or not. Simple data analysis allows us to determine the diffusion velocity of a single NP in the 15−70 °C range. An unexpected increment in nanoparticle velocity at temperatures above a certain temperature (>36−43 °C, depending on the pH), has been correlated with the two-liquid to one-liquid phase transition of water that affect the collision between UCNP and cluster of water molecules, resulting a decrease in the effective water viscosity at the nanoscale.

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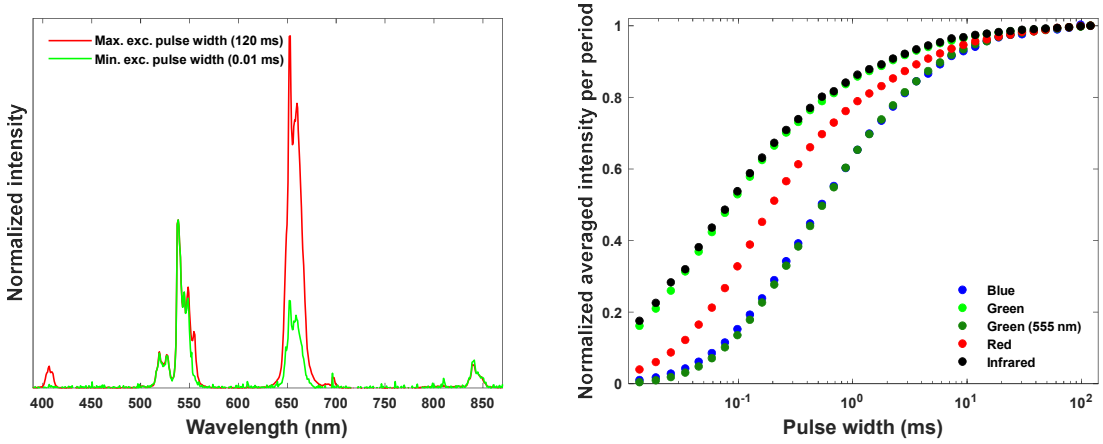
Upconversion nanoparticle kinetics studied by time-modulated excitation.

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Transient states of luminescent dyes have been extensively studied by TRAST technique by temporally modulating the excitation light in the range relevant to the decay rates of their energy levels. Those energy levels would be populated in significantly different magnitudes depending on the repetition rate, the width, and the height of the excitation pulses. Consequently, the time-averaged emitted intensity would vary with the excitation pulse characteristics, reflecting the changes in kinetics of the studied luminescent material. TRAST technique requires minimum experimental equipment and it is even compatible with low time-resolution detection, such as CCD cameras.[1] In this work, we apply for the first time this technique to study the kinetics of upconversion nanoparticles from a different perspective.[2] We have observed the dependence of $NaYF_4$:Er,Yb and $NaYbF_4$:Yb,Tm emission on the modulation of the excitation (see Figure), which mainly depends on the decay rate of the energy levels originating the transitions. TRAST technique allows spectrally overlapping transitions originating from different energy levels to be identified, as well as different emission bands coming from the same energy level (see Figure).



(Left) Emission spectra of $NaYF_4$:Er,Yb upconversion nanoparticles under time-modulated excitation at 980 nm. (Right) Averaged emitted intensity within each excitation period plotted versus the excitation pulse width for the different emission bands of $NaYF_4$:Er,Yb upconversion nanoparticles. The plotted curves show that the emission peak at around 555 nm is generated by a different transition than the band with which it spectrally overlaps and that the green and infrared emission bands are originated by the same energy level.

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Coherent phonon dynamics reveals intrinsic lattice anharmonicity in hybrid perovskite nanocrystals

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Organic–inorganic halide perovskite nanocrystals (PNCs) are gaining increasing attention in contemporary research due to their promising performance in light emitting as well as solar technology. Photoexcitation of these PNCs with an ultrashort laser pulse can produce coherent phonons along the lattice displacement coordinate, leading to lattice vibrations. Here, we employ femtosecond pump–probe spectroscopy to initiate the photophysics by the formation of coherent phonons and to observe the subsequent coherent vibrational dynamics of highly luminescent formamidinium lead halide ($FAPbX_3$, X=Br, I) PNCs.[1] We find that the $FAPbX_3$ PNCs generate halide-dependent coherent vibronic wave packets upon non-resonant excitation, and the dominant contributions are attributed to the Pb–X bending and stretching modes of PbX_6^{4-} octahedral units of the lattice. More importantly, for the first time, we observe higher harmonic vibrational modes in $FAPbI_3$ PNCs, which points to a more anharmonic potential energy surface in the case of $FAPbI_3$ as compared to $FAPbBr_3$ PNCs. This is likely due to the weaker interaction between the central FA moiety (which sits in a larger octahedral interstitial site) and the inorganic cage for $FAPbI_3$ PNCs, and thus the PbI_6^{4-} unit can vibrate more freely (Fig. 1a). This weakening reveals the intrinsic anharmonicity in the Pb-I framework, and thus facilitating the energy transfer into overtone and combination bands (Fig. 1b). Furthermore, our control experiment with $MAPbBr_3$ reveals the energy transfer between framework phonons due to the intrinsic anharmonicity of the lead-halide framework is indeed influenced by the interaction between the framework and the organic molecules, and not only by the halide nature. The insights interestingly not only unravel the underlying reason for the halide-dependent stability of these materials but also shed light on their charge-carrier mobility and light emission properties.

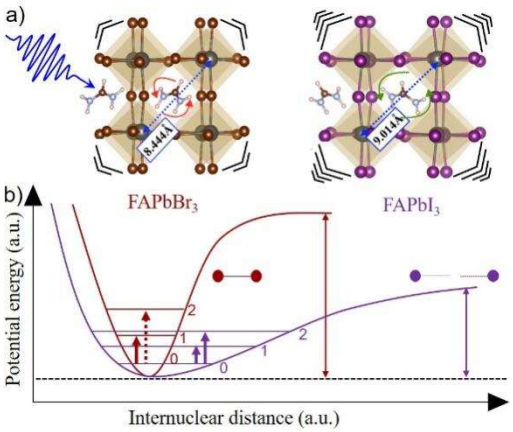


Figure1 a) shows the relaxed structures and b) schematic illustration showing the extent of anharmonic character in $FAPbBr_3$ and $FAPbI_3$, respectively.

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ICL 2020

Femtosecond photoluminescence from epitaxial graphene on SiC

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Graphene is one of promising materials for optoelectronics owing to an intriguing electronic structure. Applications of graphene in light emission devices have been demonstrated recently. One of relaxation paths of photoexcited electron system is energy transfer to phonon systems in graphene and a substrate. For the light emission device applications, it is expected to use graphene with weak coupling to phonons of the substrate. Our femtosecond time-resolved photoluminescence (PL) measurements showed that monolayer graphene (MLG) transferred onto SiC emitted longer-lived PL compared to MLG epitaxially grown on SiC [1]. This result was explained by slow energy transfer from transferred graphene to the substrate because of longer distance between graphene and the substrate.

Here, we investigated femtosecond PL from bilayer graphene (BLG) epitaxially grown on SiC and compared it with the PL from MLG [2]. The observed PL from BLG showed longer decay and exceeding 10-fold stronger intensity than that from MLG. The PL consisted of two components originating from thermal and nonthermal electron systems as shown in our previous study [3]. The PL component from thermal electron system was analyzed by three-temperature model calculation [1], where the energy transfer between the electron system in graphene and strongly coupled phonon systems in graphene and the substrate. The model calculation revealed that the temperature of the electron system at 100 fs after the pulse excitation in the BLG was 120 K higher than that in the MLG. This higher temperature was caused by slow energy transfer from the electron system to the phonon system in the BLG, and it explained the long-lived and strong PL in the BLG.

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Anisotropic response of type-II Weyl semimetal TaIrTe4 under ultrafast photoexcitation

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We perform angle-resolved transient reflection spectroscopy to study the dynamical evolution of anisotropic properties of Type-II Weyl semimetal TaIrTe4 under photo excitation. The dynamical relaxation of photoexcited carriers exhibits three exponential decay components relating to optical/acoustic phonon cooling and subsequent heat transfer to the substrate. The angle resolved measurement reveals that the anisotropy of reflectivity is reduced in the pump induced quasi-equilibrium state, suggesting a reduction of the anisotropy in dynamical conductivity in hot carrier dominated regime. Such anisotropic response is very similar to its two-dimensional layered counterparts, black phosphorus(BP) while the anisotropy of BP is enhanced in hot carrier dominated regime. These results are indispensable in designing high field, angle sensitive electronic, optoelectronic and remote sensing devices exploiting the dynamical electronic anisotropy.

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ICL 2020

Exploring temperature sensing ability of $La_2MgTiO_6:Er^{3+}$ double perovskites using thermally coupled and uncoupled energy levels

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Temperature is one of the most important physical parameters which presents in many fields of science and life. The luminescent thermometer has been gained significant interest in many recent studies due to its ample advantages such as non-contact measurement, high sensitivity, quick response, high spatial resolution as compared to the conventional thermometer. To design a luminescent thermometer, one of three main approaches is based on the temperature dependence of luminescent intensity ratio between two transition levels. This work aims to explore the temperature sensing performance of La_2MgTiO_6: Er^{3+} double perovskites based on thermally coupled and uncoupled energy levels. The samples were prepared by the co-precipitation method. The crystal structure, chemical composition, and morphology of the samples were investigated by powder X-ray diffraction, scanning electron microscope, energy-dispersive X-ray spectroscopy, respectively. The temperature-dependent emission spectra of La_2MgTiO_6: 5% Er^{3+} was investigated in the range of 77 – 400 K. The quenching temperature ($T_{0.5}$), at which the emission intensity drops by 50 % of the initial emission, is obtained at 198 K. The highest sensitivity was 3%/K corresponding to the thermally coupled levels, $^2H_{11/2} \rightarrow {}^4I_{15/2}$ and $^4S_{3/2} \rightarrow {}^4I_{9/2}$ as compared to 1.9%/K for the uncoupled energy levels, $^2H_{11/2} \rightarrow {}^4I_{15/2}$ and $^2H_{9/2} \rightarrow {}^4I_{15/2}$. Furthermore, the 300 K luminescent decay profiles were analyzed using the Inokuti – Hirayama model. The energy transfer among Er^{3+} ions was mainly regulated by the dipole–dipole mechanism. The critical transfer distance R_0, critical concentration C_0, energy transfer parameter C_{da}, and energy transfer probability W_{da} were 9.81 Å, 2.53×10^{20} ions.cm^{-3}, 5.38×10^{-39} cm^6.s^{-1} and 6020 s^{-1}, respectively.

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ICL 2020

A 10-fold improvement in the performance of luminescent thermometers by combining multiparametric sensing and multiple linear regression

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Luminescent nanomaterials have been extensively used as thermal probes to measure the temperature at the sub-micron scale through temperature-induced spectral changes, giving rise to improved spatial and temporal resolution for remote thermal readouts.[1] In order to make a luminescent thermometer suitable for real-world applications, good reproducibility and high accuracy are required. For that reason, new approaches have been developed to use different luminescent properties arising from the same sample to improve the reliability of thermal readouts. Despite the ability for providing self-calibrated thermometers,[2] this so-called multiparametric thermal sensing lacks improvements in relative thermal sensitivity (S_r), making it harder to reach lower temperature uncertainties (δT) and more accurate temperature determination. In this sense, we present a new methodology that paves the way for using different spectral changes simultaneously to increase the thermal sensitivity, where multiparametric temperature sensing is combined with multiple linear regression to achieve thermal resolutions during *in vivo* experiments better than 0.1 degrees. The synergy between multiparametric readouts and multiple linear regression makes possible a 10-fold improvement in S_r and δT (the figures of merit used to compare the performance of a luminescent thermometer), reaching a world record of 50 $\%\cdot K^{-1}$ and 0.05 K, respectively. This is achieved without requiring the development of new materials or upgrading the detection system as illustrated by using the enhanced green fluorescent protein and Ag_2S nanoparticles, respectively.

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Addressing an unreliable readout: multiparametric sensing overcomes the "tissue issue" of *in vivo* luminescence thermometry

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Luminescence thermometry has emerged over the past decade as an exciting field of research due to its potential applications where conventional methods have been demonstrated to be ineffective[1]. Preclinical research has been one of the areas that have benefited the most from the innovations proposed in the field. Luminescence thermometry has made possible deep abdominal temperature sensing, in vivo recording of subcutaneous thermal videos, and the identification of incipient diseases in the well-known biological windows (BWs)[2], where absorption and scattering of light in biological tissues are minimized. Nevertheless, certain questions concerning the reliability of the technique under in vivo conditions have only recently been thorougly investigated by the scientific community.

To figure out the role played by the tissue optical properties in *in vivo* luminescence thermometry, hyperspectral imaging (HIS) technology was the optical approach of choice, illustrating the significant wavelength-dependent spectral distortions even within BWs range. These distortions, in turn, lead to erroneous thermal readouts as large as 11 ºC[3] which is not acceptable for preclinical application. The effect is owing to the thermal dependence of light absorption, refractive index, and scattering processes in tissues. As such, the time has come to propose a new method to obtain a fully-reliable thermal readout under *ex vivo* and *in viv*o conditions.

In this work, we introduce the multiparametric method to address the described issue. This new approach accounts for the analysis from different spectroscopic parameters such as intensity ratio, peak position, bandwidth, lifetime and/or emitted intensity. The main idea of the method is the following: if the different thermal readouts converge, then there is a higher chance that the *in vivo* thermal readouts are reliable, i.e. the experiments are artefact-free. With a careful selection of thermometric parameters, we were capable of demonstrating that the convergecence of different thermal readouts (standard deviation of 0.5 ºC), obtained with no special calibration, agreed with the exact value provided by a calibration under the presence of the tissue.[4] Thus, given the special conditions upon which the given method could work. we propose the analysis of multiple parameters as a proven pathway to avoid the temperature readout errors induced by biological tissues.

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ICL 2020

Er^{3+}, Yb^{3+}: $K(RE)_3F_{10}$ nanoparticles for nanothermometry and theranostic applications

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Rare Earth (RE) doped upconversion nanoparticles (UCNPs) have recently attracted considerable attention in luminescence thermometry and theranostics due to their great optical and physicochemical properties [1-3]. In this work we studied monodisperse spherical Er^{3+}, Yb^{3+}: $K(RE)_3F_{10}$ nanoparticles (NPs) prepared by EDTA assisted hydrothermal synthesis. Intense green emission (Er^{3+} $^2H_{11/2}\rightarrow{}^4I_{15/2}$ and $^4S_{3/2}\rightarrow{}^4I_{15/2}$) and red emission ($Er^{3+}$ $^4F_{9/2}\rightarrow{}^4I_{15/2}$) were observed under monitoring NIR light (980 nm). In addition, significant infrared emission centered at 1530 nm (Er^{3+} $^4I_{13/2}\rightarrow{}^4I_{15/2}$) was observed under excitation at 980 nm. These UCNPs show cell viability on glioblastoma multiform tumors (T98G cells) close to 95 % for 1.5 mg. mL^{-1} concentration in the biological medium. Single NPs presented intense green and red emissions under 975.5 nm excitation, attesting their use as primary nanothermometers by employing the Luminescence Intensity Ratio technique. It was determined the temperature felt by the NPs by integrating the intensity ratio between the thermally coupled $^2H_{11/2}\rightarrow{}^4I_{15/2}$ and $^4S_{3/2}\rightarrow{}^4I_{15/2}$ levels of Er^{3+}ions in the colloidal phase and at the single NP level. The best thermal sensitivity of a single Er^{3+}, Yb^{3+}: $K(RE)_3F_{10}$ NP was 1.17% K^{-1}, indicating potential application of this material as accurate nanothermometer in the thermal range of biological interest. These preliminary results suggest the potential application of these UCNPs in theranostic, acting as bioprobes, light converters in photodynamic therapy for cancer treatment and accurate luminescence nanothermometers.

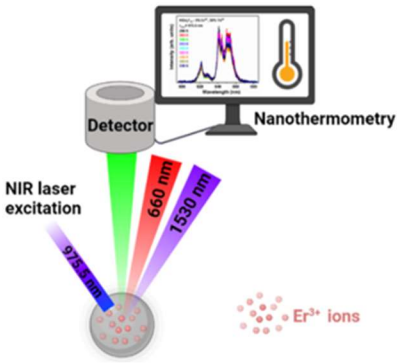


Figure 1. Schematic illustration of Er^{3+}, Yb^{3+}: $K(RE)_3F_{10}$ NP visible and infrared emissions.

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In vivo near-infrared imaging using ternary selenide semiconductor nanoparticles with uncommon crystal structure

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Fluorescence imaging, as an emerging imaging method, is still not established in clinical applications. Compared with magnetic resonance imaging, nuclear imaging, and positron emission tomography, fluorescence imaging is inexpensive, allows for faster image acquisition and makes use of a probing radiation that is not harmful. However, fluorescence imaging relies on fluorescent contrast agents, whose optical performance determine the resolution and penetration depth of in vivo images.

In this work, AgInSe2 nanocrystals with an unusual orthorhombic crystal structure were synthesized. These nanocrystals demonstrated emission in the second biological window (1000-1400 nm). After transferring phospholipid-mediated to aqueous media, the nanocrystals showed good hydrophilicity, good colloidal stability, and negligible toxicity. Compared to commercial Ag2S nanoparticles (the stable in fluorescence imaging), AgInSe2 nanocrystals showed superior brightness. Imaging experiments pointed to the great potential of the novel AgInSe2 nanocrystals for high-resolution, whole-body in vivo imaging. Their extended permanence circulation time within blood vessels makes them especially suitable for prolonged imaging of the cardiovascular system.

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Optimization of Mn^{4+} phosphors by sensitization with uranyl $[UO_2]^{2+}$

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Color displays require narrow band or line emitting phosphors enabling high color purity and color points that generate up a large color gamut. These conditions are best fulfilled by using narrow band green and red emitting phosphors. However, commonly employed Eu^{2+} activated phosphors usually exhibit broad emission bands. Thus, alternative approaches are investigated, such as the use of quantum dots (QDs). Their application is problematic, as QDs suffer from high sensitivity towards moisture, oxygen, elevated temperatures, and UV radiation. In that regard, the narrow band red emitter Mn^{4+} has drawn a lot of interested in recent years and $K_2SiF_6:Mn^{4+}$ is a commercially available product for use in LED displays. While Mn^{4+} also shows some stability issues in fluoride hosts, it can be overcome by surface passivation. A more severe problem is the comparatively low absorption cross-section of Mn^{4+} due to the respective 3d-3d transitions being parity-forbidden. Furthermore, Mn^{4+} in fluoride hosts is not known to show any absorption around 410 nm which would be a match for near-UV LED chips that gain popularity due to their high efficiency. For that reason, sensitization of Mn^{4+} is a promising way to overcome these problems. Due to its large oxidation potential, Mn^{4+} cannot be sensitized by Ce^{3+} or Eu^{2+}. Various trivalent lanthanides have been investigated, but these have low absorption cross-sections on their own due to spin- and parity-forbidden transitions, making these attempts interesting in a scientific way, but not for commercial application.

We successfully attempted sensitization of Mn^{4+} by the uranyl cation, $[UO_2]^{2+}$, in $K_3UO_2F_5:Mn^{4+}$, which results in a broad excitation band from 250 to 500 nm due to a highly efficient uranyl – Mn^{4+} energy transfer. While energy transfer from uranyl to various activators such as Eu^{3+} is well known, energy transfer to Mn^{4+} has not been reported previously.

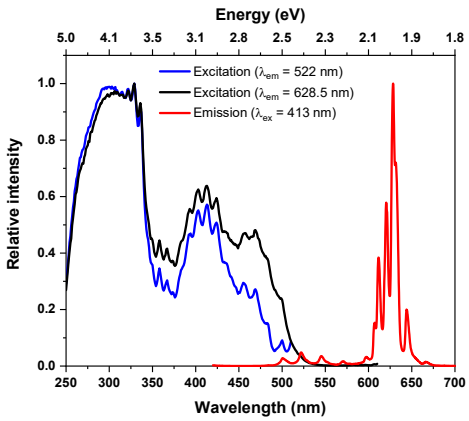


Fig. 1: Excitation (black and blue line) and emission (red line) spectra of $K_3UO_2F_5:Mn^{4+}$ [1]

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Novel light-emitting micro plastic particles with lanthanide diketonate complexes

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Plastic is nowadays well known as an environmental pollutant due to its long degradation times[1]. Especially small micro plastic particles (MPs) that usually occur during the decomposition of plastic waste cause the major problem. The fate and risks of these particles and their uptake into cells are not sufficiently clarified so far. This is due to the fact that detection methods for MPs are not well investigated and that they have a bad limit of detection[2]. One option to better detect very small particles could be the sensing by fluorescence microscopy. There exist reports about light-emitting MPs, but they are using Nile Red as dye usually[3] and no tests about influences on the optical or chemical behavior of the MPs are reported. This work presents an affordable mechanism of coating PP-MPs with bright light emitting Eu^{3+} and Tb^{3+} diketonate complexes. A very effective energy transfer from excited organic ligands to the rare earth ions can explain the emission. Thus, a very small amount of coating is sufficient to obtain strong emitting MPs with unchanged physical behavior.

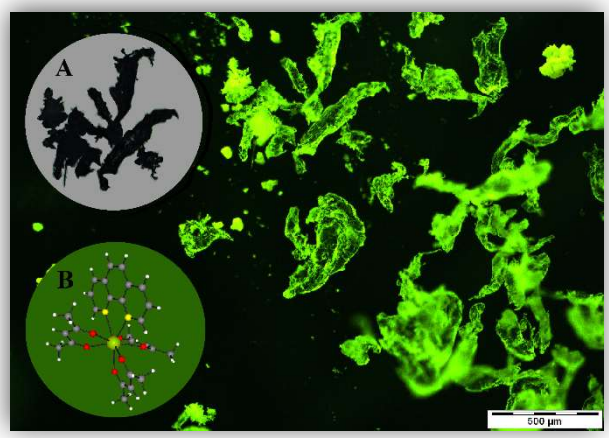


Figure 1: PP-MPs coated with $Tb(acac)_3phen$ in a fluorescent microscope in dark field mode. A: MPs monitored in bright field mode. B: Schematic picture of the used $Tb(acac)_3phen$ complex.

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Fabrication, structural and spectroscopic characterizations of first translucent ceramics from cubic nano-crystalline La_2MoWO_9 activated by Nd^{3+} ions

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Nd^{3+}-doped mixed molybdato-tungstate powders of chemical formula La_2MoWO_9, which crystallize in the cubic system (space group $P2_13$ (No. 198)), were studied so that in further research they could serve to the fabrication of transparent optical ceramics. Previously, we reported first translucent micro-ceramics activated by Yb^{3+}ions. However, in these ceramics the segregation of the second phase on the grain boundary, containing much higher Yb^{3+} ion concentration than inside the grains was observed [1,2]. With Nd^{3+} ions we obtained much better results. Similar ionic radius of Nd^{3+} ion to La^{3+} one leads to receipt the mono-phase translucent micro-ceramics.

The purpose of these studies was to carry out a detailed structural analysis by XRD technique to confirm that in case of this chemical composition only one, pure cubic phase is observed, regardless of the Nd^{3+} activator concentration, which is a great advantage of this host lattice compared to the simple di-lanthanum di-molybdates. SEM technique confirmed very high homogeneity and phase purity of the obtained materials. The micro-crystalline solid solutions obtained by the high-temperature solid-state reaction characterized by an intense luminescence are useful for both detailed fundamental analysis and for application as efficient phosphors and ultra-short pulses (pico, femto) laser materials.

Both in nano/micro-crystalline molibdato-tungstates, and in first translucent ceramics a big structural disorder was observed. High-resolution techniques, such as absorption spectra at 4.2K, as well as low-temperature site selective laser spectroscopy confirmed a multisite character of Nd^{3+} ions in this host lattice.

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ICL 2020

Photoluminescence properties of SiAlON:Tm^{3+} gradient coatings grown by DC/RF combinatorial reactive magnetron sputtering

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We have explored the photoluminescence properties of Tm^{3+} doped SiAlON thin films in a wide Tm, Si, and Al composition. The coatings were prepared through combinatorial reactive DC/RF co-sputtering by the gradient deposition method [1]. This method consists in depositing films with a composition gradient character and combining local composition, as determined by energy dispersive x-ray spectroscopy data, with laser excited emission spectra and optical transmission. The deposition used Al, Si and Tm 99.9% targets as precursors in an Ar + N_2 + O_2 mixed atmosphere in different ratios. Using this approach, Tm^{3+} emission intensity and time decay profiles were varied and correlated to changes in [Si]/[Al] and [N]/[O] concentration ratios. Additionally, ternary phase diagrams could be constructed by directly correlating the relationship between the composition with Tm^{3+} emission intensity, time decay and refractive index. The observed room temperature photoluminescence spectra in the visible range is composed of three main lines corresponding to the following *4f – 4f* transitions: $^1G_4 \rightarrow {}^3H_6$ (~ 469 nm), $^3F_4$ (~ 655 nm), and $^3H_4 \rightarrow {}^3H_6$ (~ 800 nm). In the nitride rich sub-set of coatings, this emission signature was excited through the charge transfer related energy transfer band at 240 nm [2]. Under the same excitation energy, Tm^{3+} luminescence is hardly spotted in the oxide rich sub-set.

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Spectroscopic properties of Ba_2MgWO_6 polycrystals and ceramics doped with the Nd^{3+} ions

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Ba_2MgWO_6 (BMW) belongs to the double perovskite compounds with the general formula of $A_2MM'O_6$, (where A is an alkaline-earth ion, M a divalent metal ion, M' a hexavalent W or Mo transition metal ion). Ba_2MgWO_6 compound possesses a unique cubic structure with an Fm-3m space group [1]. Doped rare earth or metal transition ions are located at the sites with very high point symmetry, thus the electrical dipole transitions are forbidden. Spectroscopic properties of the BMW crystalline powders and ceramics doped with the Nd^{3+} ions were measured and analyzed. The crystalline structures have been confirmed with the XRD measurement. The strongest Nd^{3+} is the $^4F_{3/2} \rightarrow {}^4I_{11/2}$ emission for both samples and different temperatures. At 77 K the shape of the peaks is changed. Interestingly, the rarely observed $^4F_{3/2} \rightarrow {}^4I_{15/2}$ transition is also observed.

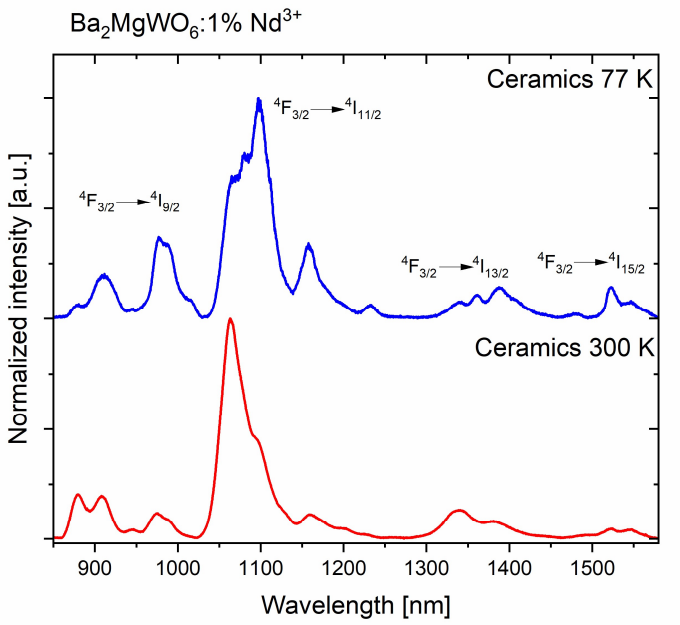


Fig. 1. The emission spectra of the $Ba_2MgWO_6:Nd^{3+}$ ceramics.

References

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Acknowledgments

This study was supported by "The National Science Centre" under Grant No. 2017/25/B/ST5/02670, which is gratefully acknowledged.

Self-compensation emissions of defect-induced non-equivalent Eu^{2+} sites toward extraordinary thermal stability blue-violet phosphor

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Highly thermal stability phosphors are very desired for high-power LEDs or laser-based white light-emitting diodes (WLEDs)[1,2]. Herein, we report a, thermal stability $Sr_{10.5-x}(PO_4)_7$:5%Eu^{2+} (SPO:Eu^{2+}) blue-violet phosphor with a predicated ultrahigh thermal quenching (TQ) temperature of ~ 973 °C that, shows merely emission losses of 5% and 8% at 200 °C and 300 °C. Significantly, we discover a unique TQ mechanism in SPO:Eu^{2+} phosphor, where Eu^{2+} ions occupying at two non-equivalent Sr sites (Sr1 and Sr2) show the reverse TQ behaviors, viz. emissions of Eu^{2+} at Sr1 sites increases gradually with rising temperature, whereas emissions of Eu^{2+} at Sr2 sites successively decreases. The extraordinary TQ resistance of SPO:Eu^{2+} is attributed to structural superiorities including high structural rigidity (Debye temperature, Θ_D = 559 K) and wide bandgap (E_g = 8.313 eV) of host. On the other hand, spectral analysis and DFT results demonstrate that the appearance of defects in SPO:Eu^{2+} sample enables self-compensation emissions of Eu^{2+} at Sr1 and Sr2 sites, resulting in extraordinary TQ resistance of SPO:Eu^{2+}. By using SPO:Eu^{2+} phosphor, two WLEDs prototypes, featuring high color render index (~ 87.3) or wide color gamut (88% National Television System Committee (NTSC)), are achieved. These findings demonstrate that SPO:Eu^{2+} phosphor has potential applications in solid-state lighting and displays.

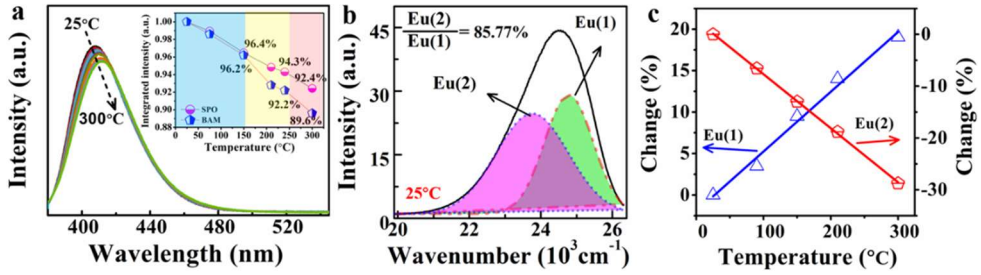


Figure 1 (a) Temperature-dependent PL spectra/integrated emission (inset) of SPO:Eu^{2+} sample. Temperature-dependent emission behaviors (b) and changes rate (c) of Eu(1) and Eu(2).

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Eu doped Y_2O_3 films with optimized optical properties for quantum technologies

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Rare earth (RE) doped oxides have demonstrated a great potential for photonic applications and have also appeared as promising candidates for quantum memories and microwave to optical transducers.[1] Here, we investigate the potential of Chemically Vapor Deposited (CVD) europium-doped Y_2O_3 thin films on silicon substrate as a new platform for integrated quantum devices.[2] We aim at improving the optical properties of such thin films by carefully controlling the RE ion's environment. In particular, we study the effect of annealing post treatments and demonstrate that a significant source of broadening of the optical transition arises from interfacial reactions with the silicon substrate. We thus propose to encapsulate RE ions between undoped high-quality thick layers in order to limit the impact of interfacial reactions on their properties during thermal annealing. Using this approach, we succeeded to measure a narrow inhomogeneous linewidth of 18 GHz and a homogeneous linewidth of 5 MHz inferred from spectral hole width, which are the lowest values ever measured for Eu:Y_2O_3 films. These results are promising towards the use of these engineered RE doped thin films for the development of a scalable nanostructured spin-photon interface. In addition, our strategy could be applied to a large variety of oxide films for a broad range of applications.

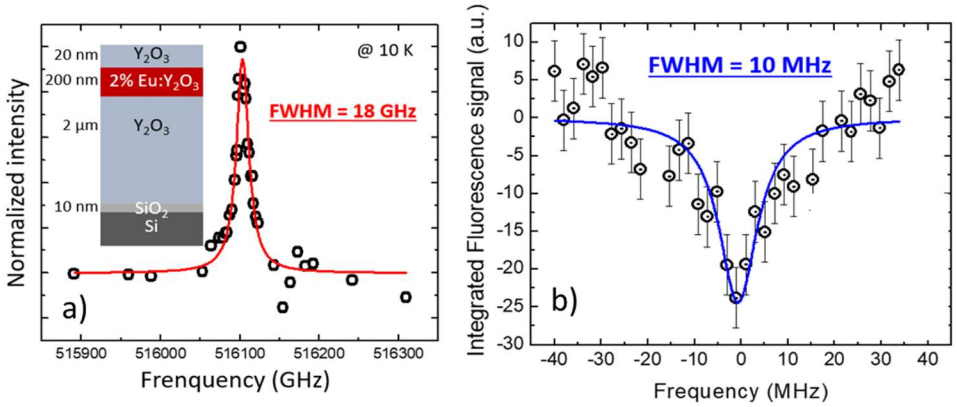


Figure : – a) Inhomogeneous linewidth of the as grown Eu:Y_2O_3. b) Spectral hole burning experiment at 3K showing a hole width Γ_{hole} of 10 MHz of a 2 µm-thick multilayer CVD sample with 2-step annealing.

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Plasmon-mediated spatial coherence from Nd^{3+} quantum emitters

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Rare Earth (RE) doped systems are currently the focus of great attention due to their broad range of applicability in relevant scientific and technological fields, such as quantum light-matter interfaces or photonics networks. In this context, controlling the emission features of RE ions is necessary to develop novel devices. For that matter, the association of plasmonic structures with RE doped crystals has proven useful giving rise, for instance, to solid-state nanolasers with improved and novel characteristics [1].

Here, we are going a step forward towards the manipulation of coherence and angular distribution of the RE emission in the absence of photonic cavity. By means of Fourier microscopy experiments, we show the presence of an interference pattern in the emission of Nd^{3+} ions located in the vicinities of a single plasmonic chain formed by closely-spaced Ag nanoparticles (NP) The results are interpreted by numerical simulations, which support the presence of a near-field coherent coupling of the Nd^{3+} emitters with the plasmonic mode of the NP chain, radiating light to the far field at specific directions.

The work provides fundamental insights of the near-field coupling between quantum emitters and plasmonic nanostructures, and offers novel ways of controlling the RE emission, which could be of potential interest for quantum-light interfaces or integrated optical circuits.

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Molecule-based coherent light spin interfaces for quantum information processing

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Rare-earth ions (REI) are known for exhibiting narrow optical linewidhts and optically addressable spin states at cryogenic temperatures, which makes them appealing candidates for photonic quantum devices. Incorporated into molecules, REIs could in addition benefit from advantages associated to molecular systems, including fine structural tuning, scalability and facility for integration into photonic structures.

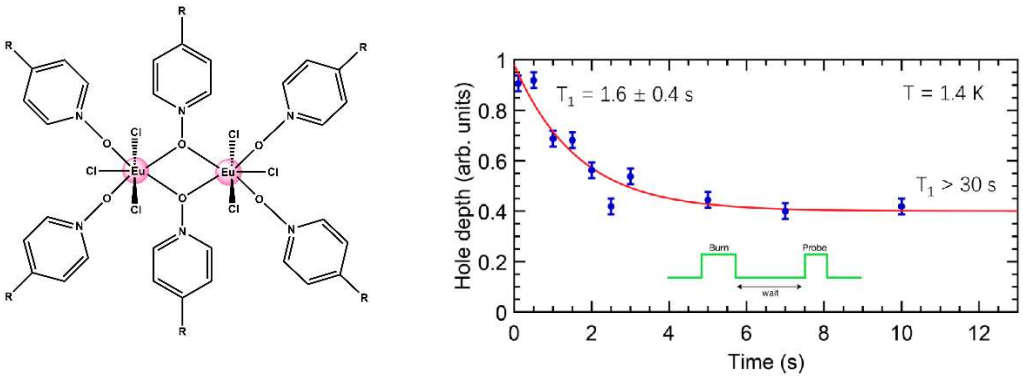


Figure 1: Left: Binuclear Eu^{3+} complex. Right: Spectral hole decay showing a faster decay constant of 1.6 s and a slow component with $T_1 > 30$ s.

In this study, we demonstrate that narrow spectral holes can be burned in the inhomogeneously broadened $^5D_0 \rightarrow {}^7F_0$ optical transition of a binuclear Eu^{3+} complex, rendering a homogeneous linewidth of 22 MHz at 1.4 K, which translates as $T_2 = 14.5$ ns. These spectral holes are also long-lived, enabling optical polarization of the Eu^{3+} ground state nuclear spins, a fundamental requirement for all-optical spin initialization and addressing. These results elucidate the usefulness of REI-based molecular complexes as versatile coherent light-spin interfaces for applications in quantum communications and processing.

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Photon echo and spectral hole burning in ^{171}Yb:LiNbO$_3$ crystal

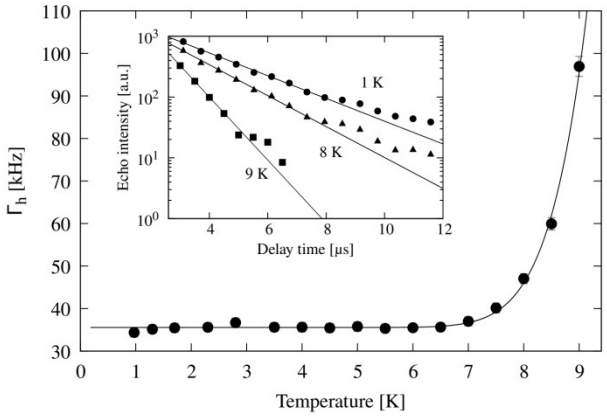
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A lot of progress has been lately achieved in micro-and nano-fabrication of lithium niobate (LN) in terms of waveguides, thin films and nano-resonators, paving the way for its application in integrated photonics [1]. For this reason and the possibility to incorporate Rare-Earth ions, LN is also a promising platform for quantum information processing [2]. As a preliminary step, however, it is necessary to study the coherent properties of Rare-earths doped LN bulk crystal, as well as the hyperfine level structure and spin relaxation rate. To this purpose, we report the photon echo and spectral hole burning measurements on LN crystal doped with ^{171}Ytterbium ions in the (1-10) K temperature range. We estimate an optical homogeneous linewidth of 34 kHz at 1 K, and for the spin flip-flop rate, two components equal to 8.3 s^{-1} and 40 s^{-1}.



Two pulses photon echo decay (inset) and temperature dependence of the homogenenous linewidth (main) of ^{171}Yb:LN.

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Nonlinear optical thermometry - A novel thermometric strategy via second harmonic generation (SHG) and upconversion luminescence

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Non-linear optical spectroscopy may be a powerful tool for optical sensing of various intrinsic properties of materials and different state functions of the system. This is due to the strong dependence of non-linear phenomena on numerous physicochemical factors. The feasibility of simultaneous employing the second harmonic generation (SHG) and upconversion luminescence (UCL) processes in $BaTiO_3:Ho^{3+}$, Yb^{3+} for optical temperature sensing is demonstrated. Under 976 nm laser excitation, the evolution of SHG and UCL band intensity ratio was correlated with temperature and calibrated within the temperature range of 25 - 305 ℃. The band intensity ratio between SHG and UCL exhibits a sigmoidal dependence on temperature, and, hence, it can allow the detection of phase transitions from non-centrosymmetric to centrosymmetric systems, and vice versa. Most importantly, from the perspective of optical temperature sensing, this work provides a novel and effective strategy for non-linear optical thermometry, with high sensitivity of up to 2.78 % $℃^{-1}$.[1]

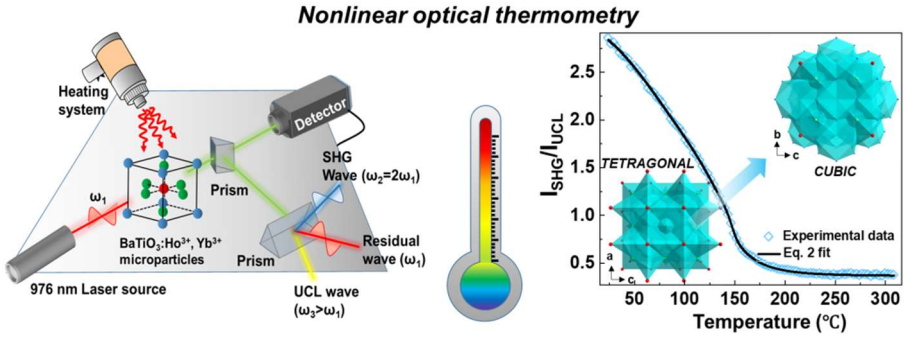


Fig.1 (left) Schematic representation of the experimental setup. (right) I_{SHG}/I_{UCL} band intensity ratio as a function of temperature.

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ICL 2020

NIR photon downshifting via host sensitization in Yb^{3+}-doped $La_2Ti_2O_7$ and $BaTi(PO_4)_2$

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Recently, we have been investigating NIR photon downshifting via host sensitization in some Yb-doped titanates [1,2]. However, there are still doubts about the mechanism that would give rise to this phenomenon. Hypothesis about its origin include electronic states associated with oxygen vacancies, and a ligand to metal charge transfer state as the mediating agents between the titanate fundamental states and the $^2F_{5/2}$ Yb^{3+} electronic excited state. Since the degree of localization-delocalization of the exciton in a wide variety of titanates is well-known, it is also possible to test the effect this fact has on the sensitization of the Yb^{3+} emission in those compounds. Among titanates with the highest exciton localization are $BaTi(PO_4)_2$ (BTP) and $La_2Ti_2O_7$ (LTO) [3]. Thus, in this work, series of $La_{2-x}Yb_xTi_2O_7$ and $Ba_{1-y}Yb_yTi(PO_4)_2$ solid solutions were synthesized. Formation of both series of compounds was checked by X-ray diffraction. Broad absorption bands present in the UV ascribed to the fundamental transition, are compatible with excitation bands when Yb^{3+} emission at around 970 nm is monitored (Fig. 1 (a)) in both series of titanates. From the photoluminescent excitation and emission spectra shown in Figure 1, it is concluded that NIR photon downshifting via host sensitization is achieved in Yb^{3+}-doped $La_2Ti_2O_7$ and $BaTi(PO_4)_2$. However, the localization of the exciton does not seem to play an important role in this process, since the level of localization is similar, but the integrated emission intensity is quite different for Yb^{3+} optimal (and comparable) molar concentrations in both compounds (Fig. 1 (b)).

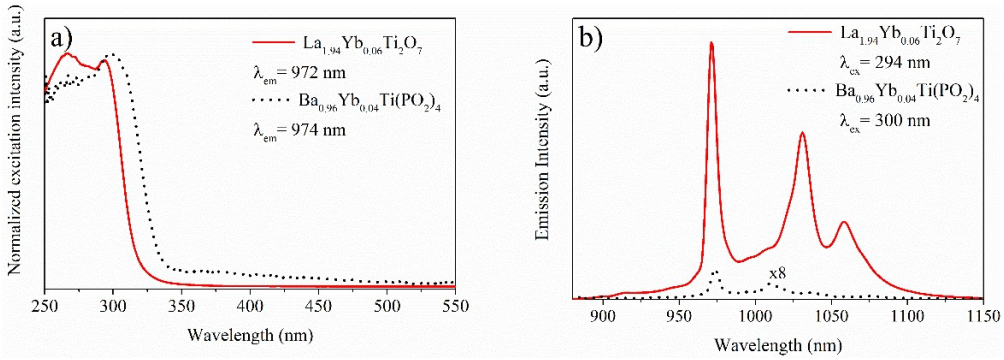


Figure 1. Luminescence spectra of $La_{1.94}Yb_{0.06}Ti_2O_7$ and $Ba_{0.96}Yb_{0.04}Ti(PO_2)_4$. Normalized excitation spectra (a), and emission spectra (b).

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ICL 2020

Ultra-broadband NIR emission from rare earth triply doped SiO_2-Nb_2O_5 and SiO_2-Ta_2O_5 glass ceramic materials for photonic applications

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Nowadays, one of the most pressing technological challenges to overcome is the ever-increasing demand for telecommunication networks that can carry larger data volumes. Under this perspective, developing efficient new materials for telecommunications is imperative. Over the past decades, much attention has been dedicated to obtaining luminescent materials that emit broad emission bands in the near infrared (NIR) region for optical amplification. Several strategies concerning host and doping have been adopted to enlarge NIR emission [1,2]. In this sense, we have prepared photonic glass ceramic materials to enlarge the so-called third-window telecom bands in the 1.5-μm region. Herein, it is reported the synthesis, structural and morphological characterization, and luminescent properties of rare earth ion (RE^{3+}) triply doped SiO_2-Nb_2O_5 and SiO_2-Ta_2O_5 glass ceramic materials prepared by the sol-gel methodology. The results showed the crystallization of orthorhombic Nb_2O_5 and Ta_2O_5 dispersed in the SiO_2-based amorphous matrix, which strongly affected the luminescent properties. Under 808 nm excitation, broadband NIR emission (FWHM up to 173 nm) in the third telecommunication window has been obtained. The structural and luminescent investigation indicated that the glass ceramic obtained materials are promising candidates for photonic applications as planar waveguide amplifiers to be achieved for applications in integrated optics as well as in remote sensing.

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Judd-Ofelt calculation strategy for RE^{3+} doped materials

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Judd-Ofelt theory quantitatively describes the optical transitions of the electrons intra 4f configurations for trivalent rare earth (RE) ions by using parametric method. Judd-Ofelt theory have been widely adopted for presenting the optical transitions mainly for the RE^{3+} doped transparent hosts such as glasses and crystals. However, the application of Judd-Ofelt theory for the RE^{3+} doped opaque hosts is struggled owing to the difficulty of absorption spectrum measurements.

In this work, we presented some application skills of Judd-Ofelt theory for the RE^{3+} doped opaque hosts including powdered phosphors and non-transparent ceramics. We have developed a route for calculating the Judd-Ofelt parameters of Eu^{3+} doped phosphors by using the emissions spectra. This route was also suggested to be used for Tb^{3+}, Dy^{3+} and Sm^{3+} doped powdered materials. Moreover, universal Judd-Ofelt calculation route for RE^{3+} doped phosphors has also been developed and presented. In this route the diffuse-refraction spectrum the intrinsic lifetime for a excited state are required. In addition, a fluorescence decay route for Judd-Ofelt calculation has also been developed. In this route more than 3 intrinsic lifetimes for the excited states are needed. The application of this route is not limited by the samples' morphology, shape and transparency as long as more then 3 intrinsic lifetimes are known.

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On the role of the trivalent terbium $^7F_5$ as an energy acceptor level

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Unlike its trivalent complementary ion (Eu^{3+}), the trivalent terbium ion (Tb^{3+}) has its first excited state ($^7F_5$) 2000 cm^{-1} above the ground state $^7F_6$ (in the case of the Eu^{3+} ion, this equivalent energy separation is around 300 cm^{-1}, $^7F_1$ – $^7F_0$). The drastic influence of this very fact on non-radiative energy transfer in compounds of Tb^{3+} ions has been noticed [1–3] and emphasized. The reason is that the lifetime of the $^7F_5$ of the Tb^{3+} ion is considerably high. Depending on the Tb^{3+} compound, it could be found to lies in the range from 5 to even more than 30 milliseconds [4,5]. Besides the very low multiphonon decay, this clearly is also due to a considerably low radiative decay that goes with the third power of the transition energy difference between the $^7F_5$ and the $^7F_6$. To the best of our knowledge, in general this fact has been overlooked in the literature.

In the present theoretical work, we explore more deeply the reasons of this rather abnormal lifetime of the $^7F_5$ level based on its radiative decay in the infrared and the associated multiphonon relaxation towards the $^7F_6$ ground state. The main objective is to provide a guide for modelling Tb^{3+} compounds in energy transfer processes, and eventually excited state absorption, in terms of the radiative and non-radiative decays, and the population of the $^7F_5$ level. This could be particularly useful in the case of intramolecular energy transfer in Tb^{3+} coordination compounds, since the $^5D_4 \leftrightarrow {}^7F_5$ transition is allowed by the exchange mechanism, which might be by far the dominant one, in contrast to transitions involving the $^7F_6$ ground state which would require the multipolar mechanisms [2,3].

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Study on the structure and luminescence properties of Sr-rich (Sr,Ca) $AlSiN_3$:Eu orange phosphors synthesized by slight positive pressure

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Abstract: For the first time, a Sr-rich (Sr,Ca)$AlSiN_3$:Eu orange phosphor was synthesized based on $Sr_2Si_5N_8$ and other raw materials under high temperature and slight positive pressure condition. The effect of Eu concentration changes on the structure and luminescence properties of fluorescent materials was studied; at the same time, the optoelectronic performance and aging performance of the nitride orange phosphor versus silicate orange phosphor packaged devices were studied. The results show that: $(Sr_{0.97-x}Ca_{0.03})$ $AlSiN_3$: xEu^{2+} fluorescent material can be synthesized based on $Sr_2Si_5N_8$ and other raw materials under high temperature and slight positive pressure. And the optimal Eu doping concentration is x=0.001. The use of nitride orange phosphors to package white light devices has higher color rendering index, packaged light efficiency and device stability than silicate orange powder packaged white light devices.

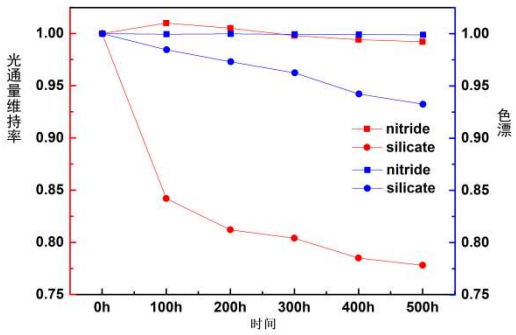


Fig. 1 Light decay and color drift curve of golden yellow light device packaged with nitride orange phosphors and silicate orange phosphors after aging for 500h

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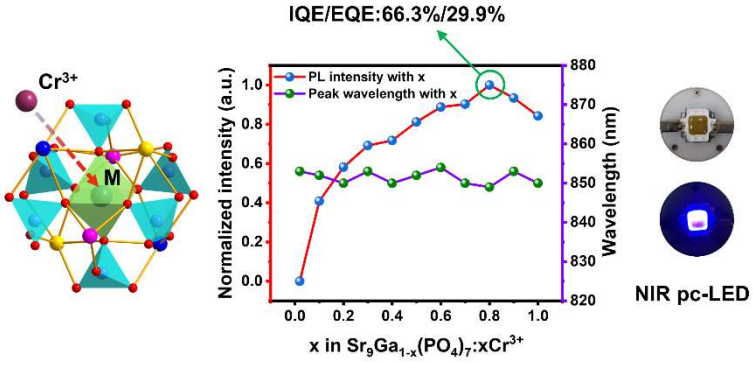
Structural confinement for Cr^{3+} activators toward efficient NIR phosphors with suppressed concentration quenching

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Cr^{3+}-doped near-infrared (NIR) phosphors have been widely studied due to their tunable emission wavelengths and broad applications. However, the luminescence of Cr^{3+} has a low intensity due to the forbidden electric dipole transition. Although increasing Cr^{3+} content could intensify NIR luminescence, this strategy will fail due to the concentration quenching effect. Here we report a series of efficient NIR phosphors with suppressed concentration quenching, $Sr_9M_{1-x}(PO_4)_7:xCr^{3+}$ (M = Ga, Sc, In and Lu), showing a broad-band NIR emission ranging from 700 to 1100 nm peaking at 850 nm[1]. The emission peak position is almost independent on the type of M ion and Cr^{3+} dopant content, and the type of M ion has little influence on the luminescence thermal quenching. Besides, the NIR emission intensities monotonously increase with Cr^{3+} content increasing from 0 to 80%, and the thermal quenching behavior is slightly dependent on *x*. These effects can be attributed to the formation of the rigid framework and the suppressed energy transfer due to structural confinement effect. The optimal sample, $Sr_9Ga_{0.2}(PO_4)_7:0.8Cr^{3+}$, has the internal/external quantum efficiency of 66.3%/29.9%. Then, in $Sr_9Cr(PO_4)_7$ (SCP) structure, we utilize the structural confinement effect and energy transfer to another efficient thermally stable luminescence center Yb^{3+} to enhance the luminescence thermal stability. The close Cr^{3+}-Yb^{3+} distance contributes to the highly efficient energy transfer (ET) from Cr^{3+} to Yb^{3+} and further suppresses the ET between Cr^{3+} ions. The integrated emission intensity of SCP:0.15Yb^{3+} phosphor at 375/425 K can keep 100/50% of that at 80 K. The structural confinement could serve as an effective strategy to improve the luminescence intensity of Cr^{3+} in NIR phosphors.



$Sr_9M(PO_4)_7:Cr^{3+}$ phosphor with suppressed concentration quenching

References

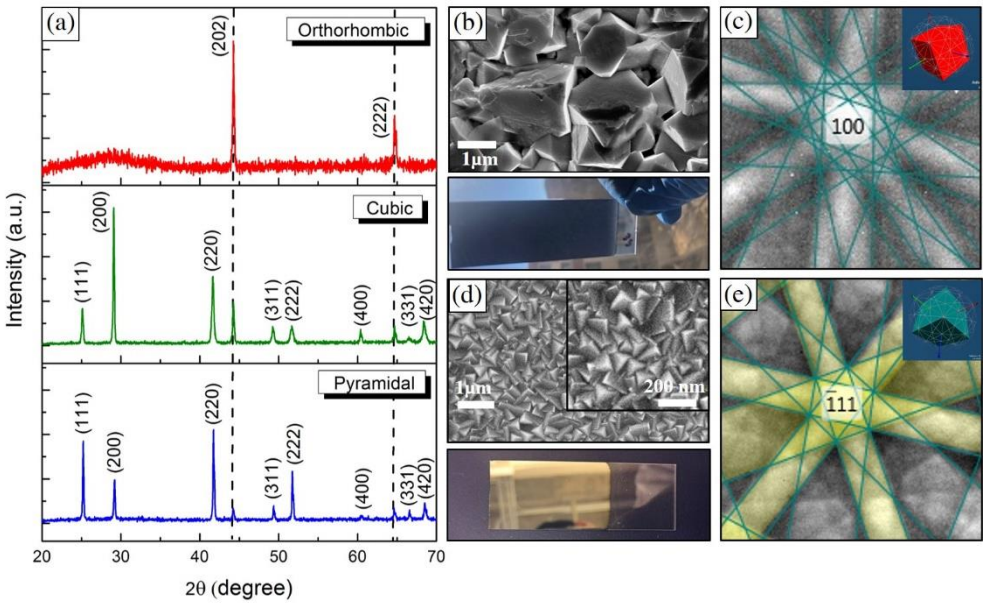
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Oriented Growth of Lead Selenide (PbSe) Nanocrystals (NCs) For Mid-Infrared Photonic Detector Applications

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Midinfrared (MIR) photodetectors, known as essential components in remote sensing and gas analysis, have attracted significant attention. The design and fabrication of highly sensitive and low-cost MIR detectors operating at room temperature play a crucial role in developing a new generation of on-chip sensing technology. One way to achieve this goal is using nano-crystallized (NCs) active materials operating in the MIR range. Lead selenide (PbSe) NCs, due to their large Bohr radius, strong quantum confinement, and broad bandgap-tunability, can be promising candidates. This study introduces a unique chemical deposition method to grow oriented PbSe NCs on glass substrates. This method offers high-quality NCs with lower manufacturing costs compared to using crystallized substrates. Moreover, by controlling NCs size, the response peak can be tuned over the MIR range. In addition, through a numerical simulation, we indicate the functionality of a photonic structure named High Contrast Grating (HCG) to provide more freedom to control the response curve over an extended range in the MIR window. We anticipate that this new synthesis method combined with a proper photonic design will open a new pathway to advance fully integrated optoelectronic on-chip devices.



(a) X-ray diffraction patterns of three samples deposited in three different topologies (orthorhombic, cubic, pyramidal). **(b)** A top-view SEM image of the PbSe thin film deposited by the IBI mechanism. **(c)** The Kikuchi pattern diffracted from the IBI sample. **(d)** A top-view SEM image of the PbSe thin film deposited by the OA mechanism. **(e)** The Kikuchi pattern diffracted from the OA sample. Insets show a 3D view of (100)-oriented NCs (red cube) and (111)-oriented NCs (blue cube). The appearance of the given films is shown beneath each growth method.

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Interfacial optimization for the high-performance of PbS quantum dot photovoltaics

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Lead sulfide (PbS) colloidal quantum dot solar cells (CQDSCs) have gained considerable attention as the third-generation solar cell technology due to their size dependent band gap (0.41-1.6 eV), capability for multiple exciton generation, and solution processability for the low-cost, large-area manufacturing. However, the complicated interface of colloidal quantum dots (CQDs) leads to huge surface-trap density and residual insulated long-chain ligands, which causes difficulties in carrier transport and recombination of solar cells. Consequently, we tried to improve the photovoltaic performance of CQDSCs through the synergistic interfacial optimization of PbS CQDs.

We ultilized ammonium acetate to modulate the phase-transfer ligand exchange process of PbS CQDs and reduce the amount of residual long-chain ligands. Then a thermal-assisted surface-ligand rearrangement method were introduced to further eliminate the long-chain ligands and optimize surface-traps passivation. And we developed a pressure post-treatment to reduce the structure defects of CQDs films, and enhance the inter-dot electronic coupling.

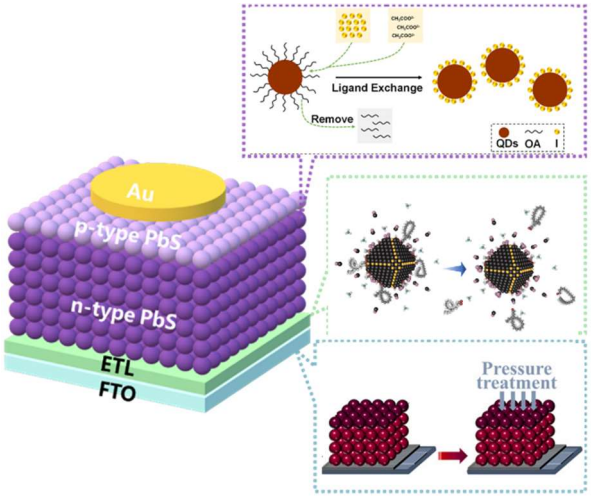


Figure 1. PbS CQDSCs optimized by ammonium acetate assisted and thermal assisted phase-transfer ligand exchange, as well as the pressure post-treatment.

Upconversion double quantum dots

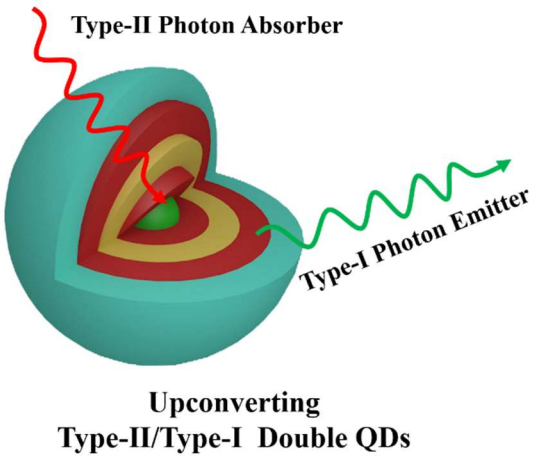
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Solution-processed core/multi-shell semiconductor quantum dots (QDs) could be tailored to facilitate the carrier separation, promotion and recombination mechanisms necessary to implement photon upconversion. In contrast to other upconversion schemes, upconverting QDs combine the stability of an inorganic crystalline structure with the spectral tunability afforded by quantum confinement. Nevertheless, their upconversion quantum yield (UCQY) is fairly low.

Here, we uncover design rules that enable to significantly enhance the performance of double QD upconversion systems, and leverage these findings to fabricate upconverting QDs with increased photon upconversion efficiency and reduced saturation intensities under pulsed excitation. Our results show how one can overcome some of the limitations of previous upconverting QDs, with potential applications in biophotonics and infrared detection.



Upconverting double quantum dots

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ICL 2020

High efficiency and stability quantum dots light emitting diodes based on $CsPbBr_3$@Ce-MOF@SiO_2 nanocomposites

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All-inorganic perovskite quantum dots (PQDs), which possess outstanding photophysical properties, are regarded as rising star materials for optoelectronic applications. However, severe stability problems hinder their promising applications. In this work, a novel encapsulation strategy is developed through the in-situ growth of $CsPbX_3$ PQDs in pre-synthesized mesoporous cerium-based metal organic frameworks (Ce-MOF) and further silane hydrolysis-encapsulation, generating bright PQD@Ce-MOF@SiO_2 composites with significantly enhanced stability. The resulting composites exhibit a high photoluminescence quantum yield of 76 %. Moreover, the light outcoupling efficiency in the composites is investigated through simulation. The pore boundary of Ce-MOF has a waveguide effect on the PQDs emission, constraining PQDs light in the bodies of Ce-MOF and suppressing the self-reabsorption losses, thus increasing the overall light conversion efficiency of the PQDs. The stability of PQD@Ce-MOF@SiO_2 composites is greatly improved due to the Ce-MOF@SiO_2 protective shell which effectively blocks the contact between external ambient environment and the internal embedded PQDs. Meanwhile, a white light-emitting diode is obtained with ultra-high luminous efficiency of 87.8 lm/W, which demonstrates their great potential in optoelectronic applications.

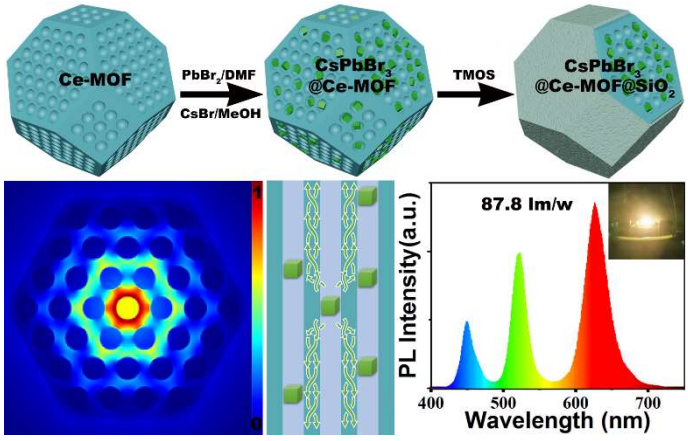


Figure 1 - Formation process of $CsPbX_3$@Ce-MOF@SiO_2, FDTD simulation of waveguiding effects, and LED application of green and red emitting PQD@Ce-MOF@SiO_2.

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Narrow emitting blue InP/ZnS quantum dots synthesized with highly active precursor

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InP QDs have been recognized as an alternative material for cadmium-based quantum dots, due to the low toxicity. At present, the performance of red and green QDs has been greatly improved, but the development of blue-emitting InP QDs is still lagging behind that of red and green QDs. Because InP has a strong covalent bond, it is difficult to obtain small-sized particles using highly reactive precursors. Adding zinc ions during the nucleation process can blueshift the emission of InP quantum dots. However, the blue emission of quantum dots obtained by using widely used precursors such as ZnI_2 is generally around 480nm. In our work, we synthesize blue-emitting quantum dots by injecting $Zn(ClO_4)_2$ during the nucleation process. The highly reactive $Zn(ClO_4)_2$ precursor enhances zinc incorporation during the reaction. As the zinc content increases, the emission shows a gradual blue shift. At the same time, the increase in zinc content can also inhibit the excessive growth of InP particle size, and finally obtain uniform-sized InP QDs with an emission wavelength of 466nm and a narrow bandwidth of 41nm.

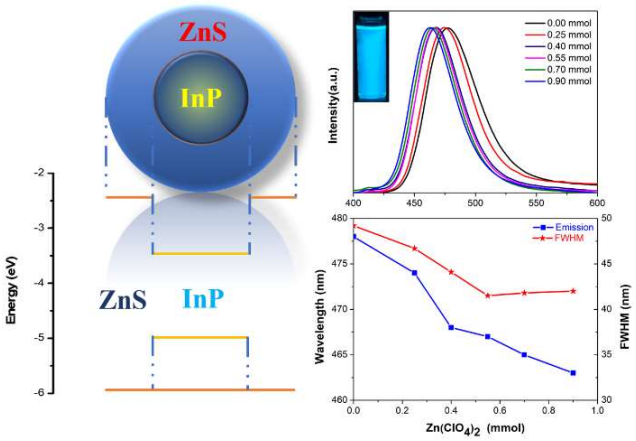


Figure 1 – (left) Schematic of a core-shell InP/ZnS QD, (right) emission spectra of (In,Zn)P/ZnS QDs and the peak position and FWHM of the (In,Zn)P/ZnS emission synthesized with different concentrations of the $Zn(ClO_4)_2$ precursor

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A new series of luminescent tetrakis Ln^{3+}-complexes with α-substituted β-diketonate ligands and Na^{+} as countercation

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The Ln^{3+} β-diketonate coordination compounds have received growing attention in the past few years, mainly due to their inherent huge variety of applications. The *tris* and *tetrakis* species have also been widely used as an emitting layer in organic light-emitting diodes (OLEDs) due to their high intensity and monochromatic emission. The *tetrakis* complexes usually present improved properties such as thermal and chemical stabilities, besides higher luminescence lifetimes than its correspondent *tris* complexes. Moreover, the commonly hydrated *tris* Ln^{3+}-complexes show a luminescence quenching due to vibronic coupling between H_2O molecules and the Ln^{3+} principal emitting levels (*e.g.*, $^4G_{5/2}$, $^5D_0$, $^5D_4$, $^4F_{9/2}$ and $^1G_4$ of the Sm^{3+}, Eu^{3+}, Tb^{3+}, Dy^{3+} and Tm^{3+} ions, respectively) [1]. The acetylacetone (2,4-pentanedione) ligand, Hacac, is one of the most extensively used and studied β-diketonate ligands, especially for the Tb^{3+} ion. Nevertheless, the α-substituted Ln^{3+} β-diketonate complexes are relatively scarce in the literature [2]. Hence, this work reports the synthesis, characterization, and photoluminescent study of a new series of *tetrakis* coordination compounds containing the α-substituted β-diketonates 3-chloro acetylacetone (Cl-acac), presenting the general formula $Na[Ln(Cl\text{-}acac)_4]$, where Ln: Sm^{3+}, Eu^{3+}, Tb^{3+}, Dy^{3+}, and Tm^{3+}.

All complexes were characterized by elemental analysis, complexometric titration, thermal analysis, infrared absorption spectroscopy (FTIR), and X-ray powder diffraction (XPD). The Ln^{3+} complex photoluminescent properties (Figure 1) as well as the experimental intensity parameters ($\Omega_{2,4}$) of the Eu^{3+} were determined.

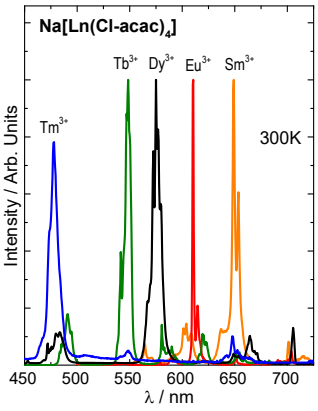


Figure 1. Emission spectra of the $Na[Ln(Cl\text{-}acac)_4]$ complexes, where Ln: Sm^{3+} ($^4G_{5/2} \rightarrow {}^6H_{9/2}$), Eu^{3+} ($^5D_0 \rightarrow {}^7F_2$), Tb^{3+} ($^5D_4 \rightarrow {}^7F_5$), Dy^{3+} ($^4F_{9/2} \rightarrow {}^6H_{13/2}$) and Tm^{3+} ($^1G_4 \rightarrow {}^3H_6$) recorded at 300 K.

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Photoluminescent properties of the polyamide /Eu^{3+} β-diketonate complex for optical application

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The Eu^{3+} complex precursor, the polymeric (PA) optical marker and the plastic luminescent films obtained were characterized by infrared spectroscopy (FTIR), X-Ray diffractometry (DRX), emission spectroscopy, and thermogravimetry (TGA). The emission spectra of the Eu^{3+}–tta complex doped in the PA exhibited the characteristic bands arising from the $^5D_0 \rightarrow {}^7F_J$ transitions (J = 0-4). High values of the Ω_2 intensity parameter were obtained, indicating the hypersensitive character of the $^5D_0 \rightarrow {}^7F_2$ transitions and the Eu^{3+} ions are in a polarizable chemical environment. The high values of the Ω_4 parameter confirm the basicity of the oxygen donor from the polymer. Lifetime measurement suggests that doped Eu^{3+} ion has higher luminescence efficiency in the film than hydrated complex. The emission quantum efficiencies (η) and the highest value are observed in the system PA:$[Eu(tta)_3(H_2O)_2]$ 5%. The PA-optical marker resulted a luminescent plastic film, with high stability when processing.

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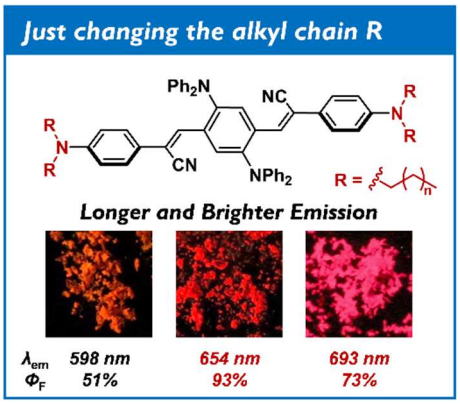
Just changing the alkyl chains of fluorophore: achieving longer and stronger deep red/near-infrared emission in crystalline state

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With the arm of developing organic fluorophores that display efficient deep red/near-infrared (NIR) emissions in solid state, much effort has been donated to control the molecular packing structures, *e.g.* suppressing the densely packing of molecules or tuning the molecular packing structures into special modes. Herein, a new molecular design strategy that focuses on tuning the molecular conformation rather than the molecular packing is proposed. The molecular design is controlling the transition character between the ground state and the excited state by tuning the molecular conformation in crystalline state via simply altering the terminal alkyl chains. A series of molecules **1**–**5** containing the same fluorophore and different alkyl chains have been synthesized. In crystalline state, molecules **1**–**3** exhibit strong orange emission with maxima (λ_{em}) of about 600 nm and quantum yields (Φ_F) around 60%, while molecules **4**–**5** display much longer emissions to deep red and NIR region as well as even higher efficiencies (λ_{em} = 693 nm, Φ_F = 73% for **4**; λ_{em} = 654 nm, Φ_F = 93% for **5**). The largely red-shifted emissions of **4**–**5** (up to 95 nm) while significantly improved Φ_F are very unusual and seem to break the energy gap law. Furthermore, the Φ_F of **4**–**5** represent the highest values among organic solids with similar deep red/NIR emission wavelengths. Based on the experimental measurements as well as theoretical calculations, the new molecular design strategy and the impressive emission properties are comprehensively investigated. Moreover, the NIR lasing measurement of crystal **4** demonstrates the potential optoelectronics application of these highly emissive organic materials.



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Organic light emitting devices based on ultrasmooth and nanostructured electrode

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Organic light emitting devices (OLEDs) have been already applied on flat-panel display, such as smart phone display and television, for their advantages of light weight, low power consumption, flexibility and broad color gamut. However, high external quantum efficiency (EQE) is still a challenge, which hindered the widespread popularization of full color panel display and the more extensive application on solid state lighting. In our research, we focused on the improvement of EQE using the ultrasmooth and nanostructured electrode by the manipulation of interface and optical modes.

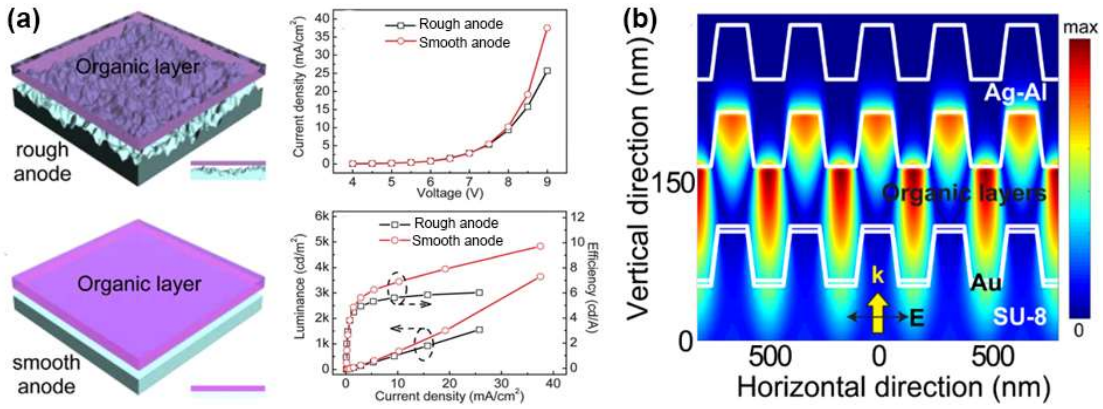


Figure 1 (a) The schematic for the contact area at the interface between the anode and the organic layer for the rough and smooth, and EL performances of OLEDs. (b) The distribution of the magnetic field intensity across the corrugated OLEDs with the normal incident light

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A highly efficient red emitting phosphor with enhanced blue-light absorption through a local crystal field regulation strategy

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Mn4+-doped oxide phosphors with emission in deep-red region are promising for the application of plant cultivation lighting. However, it remains a great challenge to synthesize these phosphors with high blue-light absorption efficiency, which is pivotal for their practical commercial applications. Herein, we conducted a local crystal field regulation strategy to notably improve the luminescent property of the Mg14Ge5O24:Mn4+ phosphor. For instance, by introducing F- ions into the host, the absorption efficiency in blue-light region increased remarkably from 13% to 28%. By further substitution of Ti4+ for Ge4+ ions, the absorption efficiency further increased to 50%. Meanwhile, the achieved internal photoluminescence quantum yield is up to 92% for the Mg28Ge5.42Ti2O38F10:Mn4+ phosphor under 422 nm blue-light excitation. Besides, the phosphor exhibits excellent photoluminecence thermal stability, i. e., the emission intensity at 423 K retained 96% of that at room temperature. By means of X-ray absorption near-edge structure and extended X-ray absorption fine structure analysis, the effect of introducing F- and Ti4+ ions on the local coordination and valence of Mn ions in the hosts and the luminescent property of the phosphors are discussed in detail. Finally, LEDs were packaged by combining blue diode chips and Mg28Ge5.42Ti2O38F10:Mn4+ phosphor, and their validity for promoting growth of plants were successfully demonstrated.

Exploring Yb^{3+}-doped $LuLiF_4$ single crystal as a new optical cooling candidate below the cryogenic temperature

Presenting B. Zhong,[1*] Y. Lei,[1] X. Duan, M. Tonelli[2] and J. Yin[1*]

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The scientist P. Pringsheim proposed the optical cooling of the condensed materials concept as early as 92 years ago[1]. However, it was not until 1995 that R. Epstein et al from Los Alamos National Laboratory first obsearved the anti-Stokes fluorescence net cooling of 0.3 K on Yb^{3+}:ZBLAN(P) fluoride glasses in experiment[2]. Anti-Stokes fluorescence cooling of solids can been utilized to solid-state optical refrigerators and radiation-balanced lasers. It is the imperious demands that exploring the materials with the excellent laser-cooling-grade[3,4]. However, only the Yb^{3+}-doped $YLiF_4$ crystal was cooled by the laser below to the cryegenic temperature 123K, which was demonstrated in experiment by the M. Sheik-Bahae's group at University of New Mexico and M. Tonelli's group at Universita` di Pisa[5]. We cool the Yb^{3+}-doped $LuLiF_4$ single crystal to absoult temperature 121 K by fiber laser firstly and exploring this crystal as a new optical cooling candidate below the cryogenic temperature.

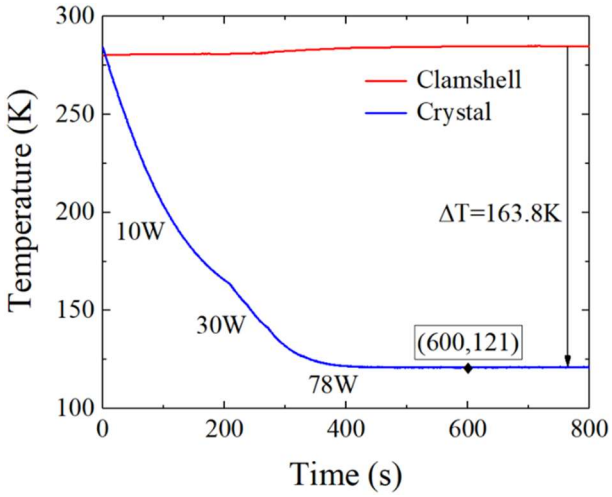


Figure 1. the temperarure of the Yb^{3+}:$LuLiF_4$ crystal pumped by fiber laser with the power of 78 W at 1020 nm depends on the time.

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Achieving dynamic luminescence in ZnS:Mn^{2+} via fluxing effect

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Owing to the increasing requirements of information security, data communication, and anti-counterfeiting, luminescent materials have triggered intensive interest because of their advantages such as good concealment, difficulty in replication, and good reproducibility. Compared with the conventional luminescent materials with unicolor and unimodal emission, those with multicolor, multitemporal, and multimodal luminescence in a single material have been considered as better candidates for advanced anti-counterfeiting. In this work, ZnS: KBr, Mn^{2+} phosphors with multi-mode dynamic luminescence are designed by simultaneously constructing intrinsic luminescence and Mn^{2+} emitting centers. Different fluxing agents were investigated including boric acid, ammonium halides, alkali and alkaline earth halides. The cooperation of fluxing effect and impurity doping, the as-obtained ZnS host materials show bright cyan emissions. The optimal formula composition belongs to ZnS: 4%KBr. Afterwards, with the combination of intrinsic cyan luminescence and Mn^{2+} yellow emission, the ZnS: 4%KBr, $x$$Mn^{2+}$ (x = 0.05-2.5%) phosphors present multicolor emissions under UV excitations. With increasing Mn^{2+} content, the emission color changes from cyan to yellow gradually. In addition, the phosphors emit different colors under 302 and 365 nm UV lamps due to the absorption difference between the intrinsic and Mn^{2+} emission centers. Moreover, after the removal of UV excitation, the phosphors exhibit orange afterglow in regardless of Mn^{2+} concentrations, which differs from the corresponding photoluminescence (PL) color. Furthermore, the ZnS: KBr, Mn^{2+} phosphors retain the mechanoluminescence (ML) feature as ZnS: Mn^{2+}. As shown in Fig. 1, the as-prepared materials exhibit a dynamic multiple color response, which shows a promissing application as a multimodal anticounterfeit material providing high level of security.

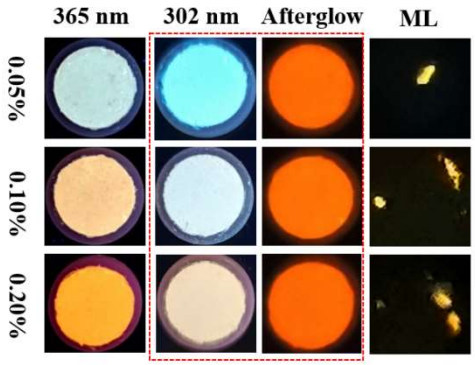


Figure 1. Images of PL (λ_{ex} = 365 nm), PL (λ_{ex} = 365 nm), afterglow, and ML of ZnS:KBr, $x$$Mn^{2+}$ (x = 0.05%, 0.10%, 0.20%).

Far-red phosphor, LED devices, and intensified gene expression in plant hormone metabolism pathway by the light

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The light-emitting diodes (LEDs) have changed our daily lives, by saving energy, reducing poluttion and providing us with a colorful world, as we can see the landscape lights made of LEDs nearly everywhere in addition to home and office lighting. Besides, the application of LEDs in mobile phones and laptops makes them stand for long time with light weight, which brings us great convenience. Beyond visible lighting and display, LEDs have much potential for application in invisible wavelength, such as iris recognition for information security, photomorphogenesis in photosynthetic agriculture, light sources for portable spectrometers used in food safety testing, light sources for phototherapy in medicines [1], etc. The far-red phosphors and LED devices are specially desired for a wide variety of functional applications, including the far-red emission peaked at 660 and 731 nm, which match for the Pr and Pfr states of plants phytochrome, respectively, used to control plants photomorphogenesis. In this work, we report a far-red phosphor, $YAl_3(BO_3)_4:Cr^{3+}$, and its synthesis. The absorbance, internal, and external quantum efficiencies of the phosphor reach to 56.40%, 53.72, and 30.30%, respectively. The light output power and energy conversion efficiency of the far-red LED devices packaged using the phosphor, driven under 100 mA, come up to 75.5 mW and 25.62%, respectively. Through transcriptome gene sequencing on analysis with the Kyoto Encyclopedia of Genes and Genomes (KEGG), more interesting, we observed the gene expression in plant hormone metabolism pathway of rice seedlings intensified by the far-red light. This discovery reveals an important mechanism of far-red light action on living things, which inspires us a way to regulate the secretion of neurotransmitters like dopamine and melatonin [1], hopefully used to therapy human Parkinson's and Alzheimer's diseases [1,2], by using a facile optical approach.

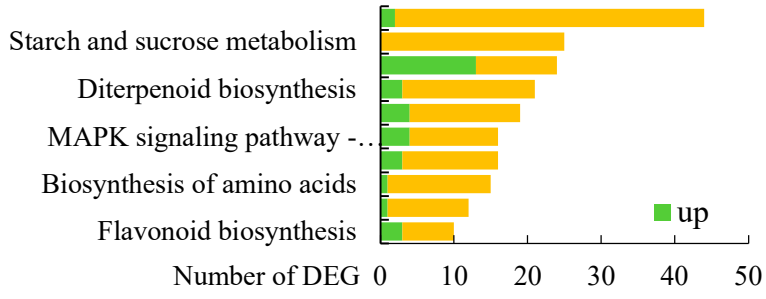


Figure 1 KEGG analysis on metabolism pathway of rice irradiated by far-red light

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Highly thermal conductive red-emitting AlN-$CaAlSiN_3:Eu^{2+}$ composite phosphor ceramics for high-power laser-driven lighting

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Thermally robust red-emitting phosphor ceramics are urgently required for laser lighting and displays with high luminance and better color saturation[1]. The most promising $CaAlSiN_3$:Eu ceramics have a low thermal conductivity of 4.2 W m^{-1} K^{-1} and a small luminance saturation of 0.5 W, making it hard to be used under high power laser irradiation[2,3]. In this work, we incorporated AlN into the $CaAlSiN_3$:Eu ceramic to produce red-emitting AlN$CaAlSiN_3$:Eu composite phosphor ceramics by spark plasma sintering. The fully densified phosphor ceramics have the highest thermal conductivity reported so far (53.5 W m^{-1} K^{-1}), which is about 13 times higher than the reported one. The luminance saturation of the composite ceramics occurs at a high threshold of 4.2 W under blue laser excitation, enabling them to be used for high power laser lighting. This work provides an idea of tackling the microstructure of nitride phosphor ceramics and of preparing thermally robust red-emitting color converters.

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Investigation on effect of trap on afterglow process in long wavelength PersL $SrMgGe_2O_6$: Mn^{2+}, Sm^{3+}

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The development history of persistent luminescent (PersL) materials is very long, and it has also been extensively studied and reported. At present, the research on short-wavelength visible PersL materials are relatively mature, however, the study and reports on long-wavelength (even near-infrared (NIR)) PersL materials are still deficient [1], therefore, exploring long-wavelength PersL materials are essential. So how to design and achieve long-wavelength PersL materials with good performance? Firstly, we choose the germanate as host in that it has suitable cation sites and smaller band gap [2]. Besides, Mn^{2+} ion is an excellent activator as its abundant energy level, which would prefer to generate long-wavelength emission [3]. Based on this, we realized $SrMgGe_2O_6$: Mn^{2+}, Sm^{3+} (NIR) PersL materials, calculated the defect formation energy with VASP to judge which site the Mn^{2+} will occupy and to analyze what kind of trap it caused by that dominate the afterglow process, thereby the possible mechanism is proposed.

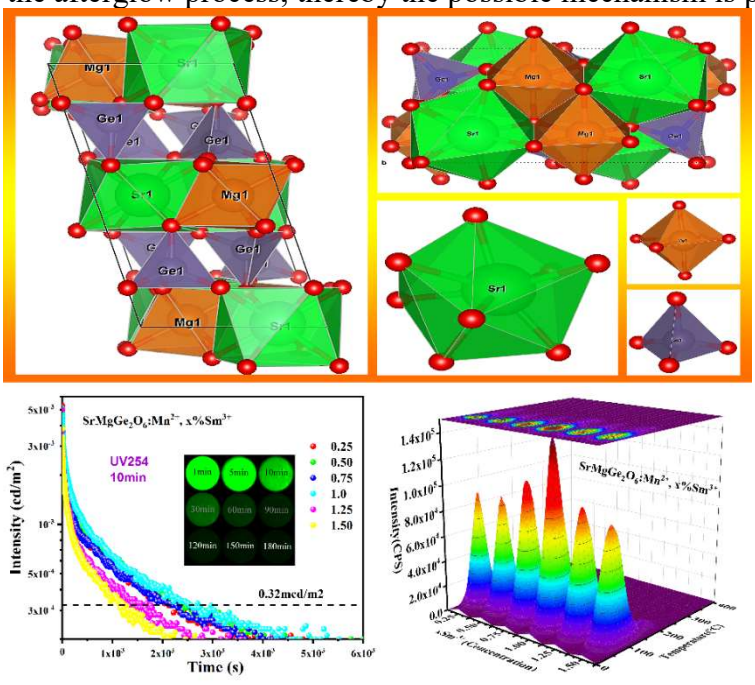


Figure. $SrMgGe_2O_6$: Mn^{2+}, Sm^{3+} (NIR) PersL materials

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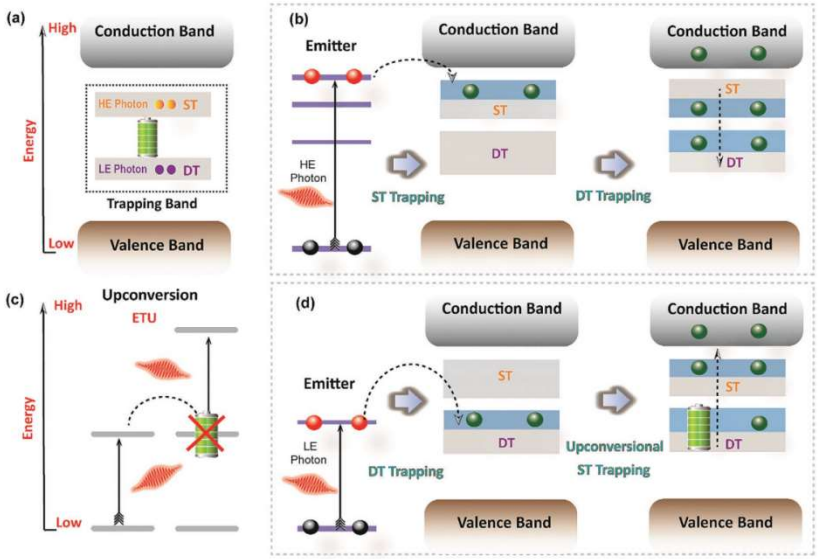
Trap energy upconversion-like near-infrared to nearinfrared light rejuvenateable persistent luminescence

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Persistent-luminescence phosphors (PLPs) have a wide variety of applications in the fields of photonics and biophotonics due to their ultralong afterglow lifetime. However, the existing PLPs are charged and recharged with short-wavelength high-energy photons or inconvenient and potentially risky X-ray beams. To date, deep tissue penetrable NIR light has mainly been used for photostimulated afterglow emission, which continues to decay and weaken after each cycle, Herein, a new paradigm of trap energy upconversion-like near-infrared (NIR) to near-infrared light rejuvenateable persistent luminescence in bismuth-doped calcium stannate phosphors and nanoparticles is reported. In contrast to the existing PLPs and persistent-luminescence nanoparticles, the materials enable the occurrence of a reversed transition of the carriers from a deep-level energy trap to a shallow-level trap upon excitation by low-energy NIR photons. Thus these new materials can be charged circularly via deep-tissue penetrable NIR photons, which are unable to be done for existing PLPs, and emit afterglow signals. This conceptual work will lay the foundation to design new categories of NIR-absorptive–NIR-emissive PLPs and nanoparticles featuring physically harmless and deep tissue penetrable NIR light renewability and sets the stage for numerous biological applications, which have been limited by current materials [1,2].



A model of an energy band depicting the carriers transfer process in defect clusters

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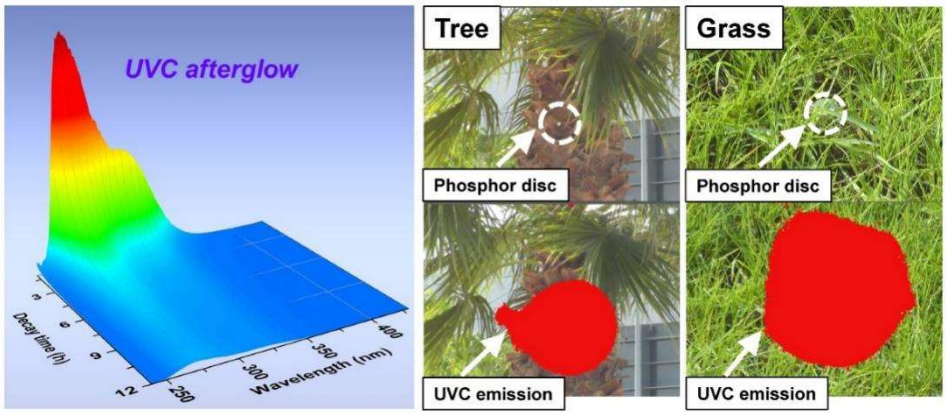
Ultraviolet persistent phosphors for covert optical tagging

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Visible and infrared persistent phosphors have gained considerable attention in recent years and are being widely used as glow-in-the-dark materials in dark environments. In contrast, the progress on persistent phosphors emitting at the other end of the spectrum, i.e., the shorter-wavelength ultraviolet (UV; 200-400 nm), is rather slow. Moreover, visible and infrared emitting persistent phosphors are not suitable to work in bright environments because of the enormous interference of ambient light including sunlight and indoor light [1,2]. Here, we report the design and synthesis of Pr^{3+}-doped persistent phosphor, $Lu_2SiO_5:Pr^{3+}$, which exhibits intense ultraviolet-C (UVC; 200–280 nm) persistent luminescence peaking at 270 nm and long persistence time of more than 12 h after irradiation by a 254 nm UV lamp [3]. UVC persistent luminescence from this phosphor can also be repeatedly revived under the short-time illumination of low-energy white light. Benefited from the zero solar UVC background on the earth surface, the UVC afterglow from the material can be clearly monitored and imaged by a corona camera in bright environments including direct sunlight and indoor light. The $Lu_2SiO_5:Pr^{3+}$ persistent phosphor is expected to find promising application in the covert optical tagging field.



Covert optical tagging application of $Lu_2SiO_5:Pr^{3+}$ UVC persistent phosphor

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ICL 2020

Emission from storage phosphors that glow even in bright ambient light

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Light-emission phenomena of storage phosphors have received widespread attention, provoking the continuous developments of persistent luminescence, photostimulated luminescence, and mechanoluminescence. In the study and application of storage phosphors, as a matter of experience, it is always necessary to avoid or eliminate ambient light. It is the requirement for ambient darkness that is hindering the further development of storage phosphors under different ambient conditions [1,2]. Here, we report an interesting glow phenomenon of storage phosphors in bright ambient light by introducing a concept termed ambient stimulated emission (ASE), in which the ambient temperature and ambient lighting can simultaneously release energy stored in the storage phosphors and lead to long-lasting emissions beyond the visible spectrum. As a proof of concept, we focus our discussion on an x-ray-charged $LaMgAl_{11}O_{19}:Gd^{3+}$ phosphor, which exhibits ASE in the ultraviolet-B region, with increased initial light emission when the phosphor is exposed to ambient illumination instead of dark conditions (Fig. 1) [3]. The ASE performances are found to depend on the illuminance and spectral distribution of ambient light. Moreover, our study indicates that the glow phenomenon in bright ambient light commonly appears in various storage phosphors, involving ultraviolet and infrared phosphors. The introduction of ASE brings different insights to luminescence research and offers approaches to further learn about and utilize storage phosphors.

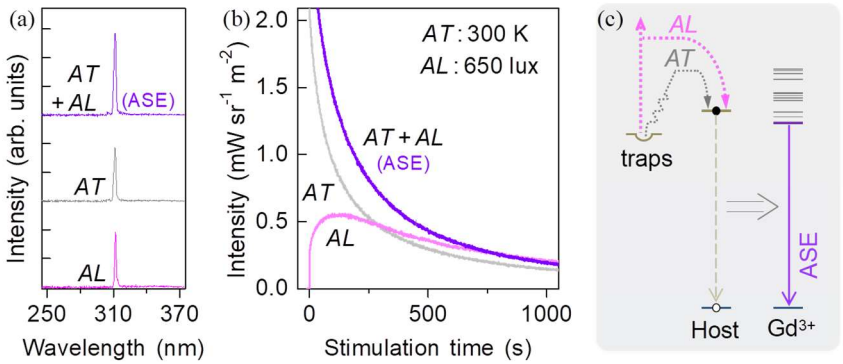


Figure 1. ASE spectra (a) and decay curves (b) of $LaMgAl_{11}O_{19}:Gd^{3+}$. Ambient temperature (AT) and ambient lighting (AL) contribute to the ASE. The corresponding schematic illustration of ASE is presented in (c).

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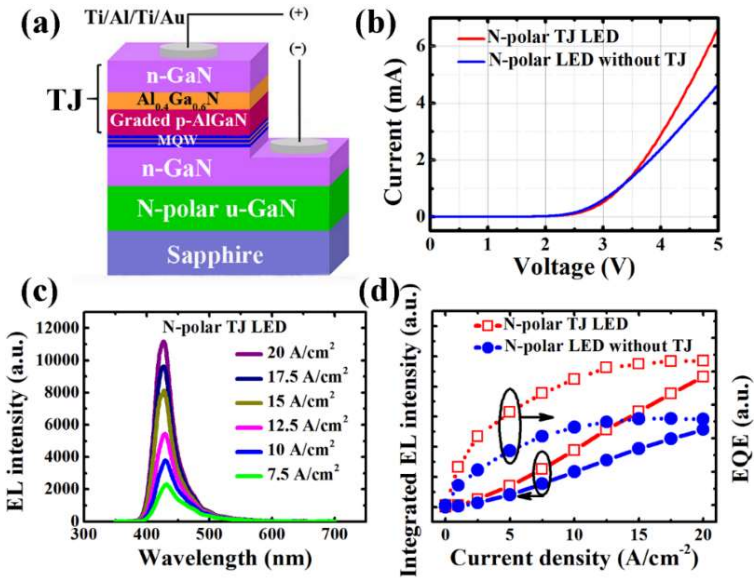
Demonstration of N-polar III-nitride tunnel junction LED

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In this study, we have demonstrated the N-polar III-nitride tunnel junction (TJ) light-emitting diode (LED). The LED was grown on the N-polar GaN template on sapphire substrates by metalorganic vapor phase epitaxy. The growth started with the n-GaN cladding layer whose doping condition was optimized by the periodic doping method and then the InGaN/GaN quantum well active region. Subsequently, the TJ was grown comprising a graded p-AlGaN layer, a thin undoped $Al_{0.4}Ga_{0.6}N$ interlayer, and the topmost n-GaN layer. The I-V measurement show that the device resistance of the TJ LED was significantly reduced compared to the reference LED without the TJ due to enhanced hole injection. The electroluminescence measurement manifested that the emission and the external quantum efficiency of the TJ LED were greatly enhanced by ~70% compared with the reference LED. This work demonstrates that the TJ devices can be realized amid N-polarity that is promising for high-performance devices operating at various wavelength.



(a) The schematic diagram of the TJ LED under EL operation. (b) The I-V curves of the TJ LEDs and the reference LED. (c)The EL spectra of the TJ LED under current density ranging from 7.5 to 20 A/cm2. (d) The integrated EL intensity and the relative EQE of the TJ LED and the reference LED as a function of current density.

Nanostructure-assisted quantitative regulation of energy transfer and conversion dynamics of phosphors

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Quantitatively disentangling the microscopic energy transfer and conversion dynamics in lanthanide ions doped phosphors and implementing functional design thereon are a key and long-standing challenge, which is mainly due to the entanglement of various factors, such as random doping pattern of the activator and/or sensitizer, influence of other impurities/defects, *et al*. which are often impossible to be seperated in most bulk materials. Advance of nanotechnology not only brings new functions of the phosphors which are otherwise hard to achieve, but also make it possible to untie these factors and explore concretly the microscopic interactions between the elements, resulting in quantitative understanding and control of the photon energy transfer and conversion dynamics of the phosphors.

In these years, we are committed to understanding the energy transfer and conversion dynamics in functional luminescent materials with the aid of nanotechnology. One example is how energy migration path affects the luminescence. Employing sandwich nanostrcuture to adjust the energy migration paths the relationship between the excitation energy migration path and the upconversion luminescence is successfully established for lanthanide ions doped crystals from experiments and corresponding model simulation. With the upgraded understanding we have demonstrated how to precisely tailor the upconversion lumiescence dynamics from nanostrutures. Another highlight of our recent efforts is to reveal the actual role of OH^- impurity in the popular Yb, Er co-doped $NaYF_4$ phosphor. With nanostructure and isotope effect the influence of the internal OH^- impurities is quantitatively determined, without the interference of the surface OH^-, which enables us to model the interaction of the internal OH^- with sensitizers and activators in detail. Exponential dependence of the nonlinear upconversion luminescence intensity on the internal OH^- content is confirmed. The OH^- relevant microscopic interaction picture is unraveled quantitatively with the interaction parameters.

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Unusual thermal stability and high Eu^{3+} quantum yield in double-perovskite molybdenites

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Four double perovskite hosts – Ba_2MgMoO_6, Sr_2MgMoO_6, Ba_2ZnMoO_6 and Sr_2ZnMoO_6 (BMM, SMM, BZM and SZM) doped with Eu^{3+} (0%, 2%) were synthesized by the co-precipitation method. The hosts crystalize in a high-symmetry elpasolite structure with space group *Fm-3m*. The Eu^{3+} emission is characteristic for the high-symmetry site with dominant $^5D_0$ – $^7F_1$ line and very wear electric-dipole-type lines.

The Eu^{3+} ions can be excited indirectly by the host absorption bands in the UV (>27 000 cm^{-1}). The quantum yield of Eu^{3+} emission in those hosts ranges from 1.2% for SMM to over 20% for BMM.

All samples exhibit extraordinarily long luminescence decay times amounting to 44 ms for BZM, as well as unusually stable host luminescence – at 600 ºC the samples (except SZM) seem to conserve over 50% of its emission intensity at 77 K.

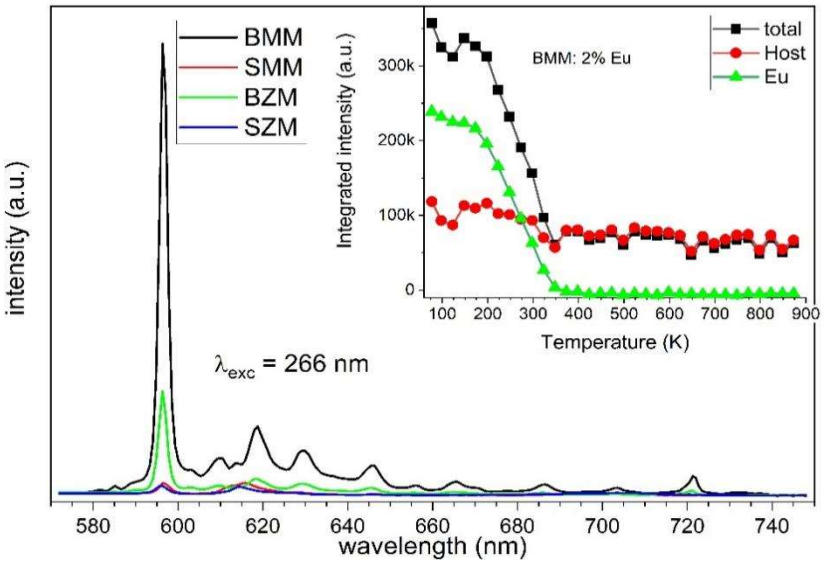


Figure 1. Emission spectra of Eu^{3+} - doped double perovskite molybdenites. Inset: Thermal profile of luminescence intensity of BMM: 2% Eu^{3+}.

Acknowledgments: This study was supported by "The National Science Centre" under Grant No. 2017/25/B/ST5/02670, which is gratefully acknowledged.

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Temperature dependent emission of Holmium (II) in the NIR range

First investigation of Ho^{2+}-Luminescence by direct doping with divalent Holmium

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Due to the low stability of Ho^{2+} ions their luminescent properties are very rarely investigated. Especially direct doping with Holmium in the divalent state was never presented before. In the past, samples doped with Ho^{3+}-ions are presented which were reduced by X-rays or γ-rays [1-3]. In these cases it can be assumed, that numerous defects are produced, that will lead to additional emission bands. Moreover, the coordination sphere of Ho^{2+}-ions will be distorted, so that the performance of high resolution spectra and ensured assignments of the bands observed in the spectra might not possible or, at least, questionable. Here, we present the luminescent investigations of samples directly doped with Ho^{2+} ions for the first time. SrCl and SrFCl were doped with the mixed valent compound Ho_5Cl_{11}. Although some trivalent Holmium is present in the starting materials, it can be assumed that only Ho^{2+} ions are substituted in the host lattices. In the emission spectra of both materials a sharp emission band at around 5465 cm^{-1} was observed, which can be assigned to the parity forbidden f-f- transition $^4I_{13/2} \rightarrow {}^4I_{15/2}$. For SrFCl, a further additional narrow band at about 8650 cm^{-1} was detected at room temperature as well as at 10 K, this can be assigned to $^4I_{11/2} \rightarrow {}^4I_{15/2}$. The low-energy band ($^4I_{13/2} \rightarrow {}^4I_{15/2}$) is much more intense at room temperature, whereby the high-energy band ($^4I_{11/2} \rightarrow {}^4I_{15/2}$) is more dominant at low temperatures. Thus, a very strong temperature dependent transition of the $^4I_{11/2}$ state into the $^4I_{15/2}$ ground state between 180 K and 300 K can be observed. In addition, reflectance and temperature dependent lifetime measurements are presented, which provide further inside of the electronic situation of Ho^{2+}-ions.

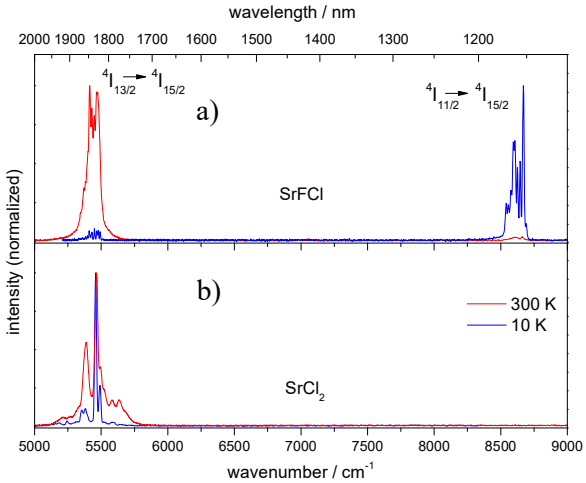


Figure: Emission spectra of Ho^{2+} in a) SrFCl and b) $SrCl_2$ at room temperature (red) and 10 K (blue)

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Spectral broadening and temperature quenching of Cr^{3+} in $LiSc(Si,Ge)_2O_6$ and $NaSc(Si,Ge)_2O_6$ solid solutions

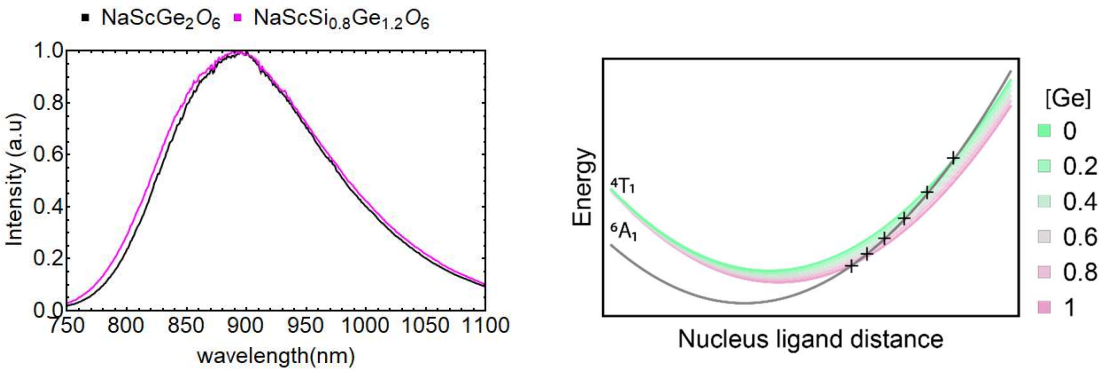
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Near infrared spectroscopy is a powerful tool for chemical sensing and bio imaging. For these applications, broadband NIR emission is necessary, preferably between 700 and 1000nm. Compact blue LEDs exciting Cr^{3+} phosphors have shown to be excellent candidates for miniaturization of NIR spectroscopy. Creating a solid solution is a promising way to broaden the emission band while keeping control over the peak position. For the NIR phosphors in pcLEDS a high quenching temperature is desirable, as the local temperature around the chip easily exceeds 100ºC. The quenching mechanism for broadband $^4T_2$ emission from Cr^{3+} is thermal crossover and correlates with the crystal field strength. Here we investigate the influence of Si-Ge disorder on the spectral broadening and thermal quenching behaviour of a promising Cr^{3+}-based NIR phosphor.

In this research we synthesized $LiSc(Si_{1-x}Ge_x)_2O_6$: Cr^{3+} and $NaSc(Si_{1-x}Ge_x)_2O_6$: Cr^{3+} (1% Cr^{3+}). We measured the PL, PLE, and lifetime as a function of Ge concentration. In addition, extensive temperature dependent lifetime measurements were done to accurately determine the quenching temperature. The solid solution allows for a 5% larger FWHM and a clear redshift is seen with increasing Ge content. Also, with increasing Ge content the quenching temperature drops the mixed local environment around each Cr^{3+} ion reduces the quenching temperature. The results show that optimization of these phosphors for efficient broadband NIR sources require a careful balancing of the Si/Ge ratio and disorder to provide a broader NIR emission range while keeping the quenching temperature high.



Left: *Emission spectra of Cr^{3+} emission in $NaScGe_2O_6$ and $NaScSi_{0.8}Ge_{1.2}O_6$ showing the broadening when between the germinate and the solid solution.* ***Right****: Schematic configuration coordinate diagram for $NaSc(Si_{1-x}Ge_x)_2O_6$:Cr^{3+} showing how increasing the Ge concentration reduces the energy necessary for thermal crossover, thus lowering the quenching temperature*

Temperature-dependent photoluminescence saturation effects in K_2TiF_4: Mn^{4+}

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Blue light emitting diodes (LED) based on InGaN are increasingly used in team with phosphor powders to generate artificial light of varying colours. In warm white LED architectures the optically active Eu^{2+} ion is often used to emit red light. However, this ion has the drawback that a typical emission spectrum extends into the infrared, where human eyes cannot observe it anymore. An alternative is to use a red phosphor that has sharp emission lines around 600nm, such as optically active Mn^{4+} incorporated in K_2SiF_4.

K_2SiF_4:Mn^{4+} is well-known for its applications in display technology, but has found limited applications in consumer lighting. The problem is that if blue light with excitation intensities typical for blue LEDs is used, the efficiency of the red light emission drops. It has already been shown that the loss of efficiency is primarily caused by ground state depletion (GSD) due to strong absorption, slow ms decay and thermal quenching.[1] However, the temperature-dependent emission mechanism of Mn^{4+} in this host material allows for the modulation of the luminescence decay time.

Here we show measurements on the highly similar K_2TiF_4:Mn^{4+} that capture the interplay between GSD and temperature by varying the temperature as a function of excitation density. Because of the temperature dependent emission mechanism in KTF:Mn^{4+} material we are able to integrally study saturation and laser-induced heating effects.

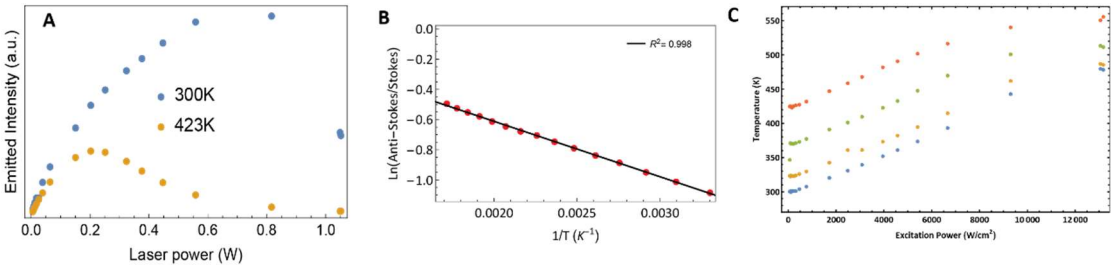


Figure 1. Laser induced heating and *in-situ* analysis of the heating process. (A) Emission saturation and subsequent thermal quenching due to laser heating as observed from different temperature starting points. (B) Shows the calibration curve for the ration between the temperature-dependent Stokes and Anti-Stokes emission, because of which it can be used as a thermometer. (C) Different temperature set-points from which the laser-induced heating is visible. The set-points are 300K (blue), 323K (orange), 375K (green) and 425K (red).

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Spectroscopy and modelling of rare-earth doped Y_2SiO_5

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Quantum-information applications, such as encryption and computation, rely on quantum coherence. Quantum coherence may be stored by making use of the nuclear spins of rare-earth (lanthanide) ions, which are coupled to the electronic states via the hyperfine interaction. Storage of coherencefor over six hours using magnetic-hyperfine levels of Eu^{3+} ions in Y_2SiO_5 (YSO) has been achieved [1], and more recent work includes single-ion measurements.

Accurate modelling of hyperfine and magnetic interactions for rare-earth ions in YSO is challenging, due to a lack of symmetry for the Y^{3+} sites. However, magnetic and hyperfine data may be used to remove ambiguities, making crystal-field modelling of rare-earth ions in YSO practical.

Our initial work was on Er^{3+}[2]. We have now extended measurements and modelling to a number of other ions, including Nd^{3+} and Ce^{3+}[3]. Energy levels for the two different crystallographic sites have been identified using laser spectroscopy, and in the case of Sm^{3+} Raman heterodyne techniques were used to measure magnetic splittings [4]. High-resolution FTIR neasurements of magnetic splittings and polarization behaviour provide further information. For Ho^{3+}, hyperfine splitting may be directly observed by FTIR absorption spectroscopy [5], giving the opportunity to extensively test our modelling of magnetic-hyperfine interactions.

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Developing and understanding inorganic phosphors with the help of theoretical calculation

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Density Functional Theory (DFT) is a powerful tool for materials research, becoming more and more popular in developing luminescent materials recently. For example, the local structure, affecting the luminescent properties of phosphors like the coordinate environment of dopants can be analyzed using the structure optimization and total energy from DFT calculation. This report focuses on the application of DFT calculation in studying the internal structure and interpreting the properties of luminescent materials. We found a special phenomenon that the blue-emitting $K_2BaCa(PO_4)_2:Eu^{2+}$ gave extra red emission after the partial substitution of $[PO_4]^{3-}$ by $[BO_3]^{3-}$. The formation energy and local space revealed the substitution of $[PO_4]^{3-}$ by $[BO_3]^{3-}$ opens a path for Eu^{2+} to occupy Ca sites, emitting red color. Another example is the thermal stabilities of $Ba_{3-x}Sr_xSiO_5:Eu^{2+}$ increase and decrease when the content of Sr increase. The Debye temperatures and electronic band structure demonstrated the rigid structure and large bandgap of $BaSr_2SiO_5$ are advantageous to high thermal stability and high efficiency. The $Sr_2Al_3Si_7ON_{13}:Ce^{3+}$ was discovered to be a high chemical stable phosphor. We interpreted the high stability is a result of electronic three dimension framework by difference electron densities (Figure 1).

It is expected DFT will not be limited to analyze the structural parameters and electronic properties. More properties, like Raman scattering and IR vibrations, will be interpreted by DFT calculation.

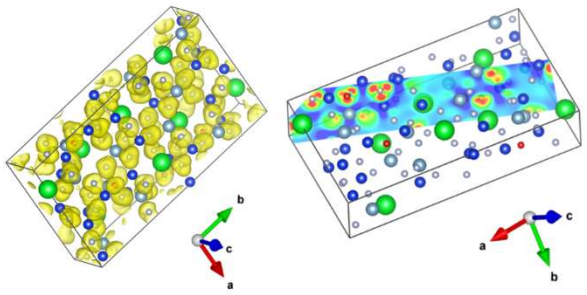


Figure 1. Three dimension (left) and two dimension slice (right) difference electron density of $Sr_2Al_3Si_7ON_{13}$.

The devil is in the details: Foundations of and pitfalls in luminescence thermometry

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Luminescence thermometry is an emerging technique with great potential in next-generation remote temperature sensing, especially on the micro- and nanoscale. Despite numerous efforts and suggestions for potential candidates, particularly among the lanthanide-doped phosphors, the founding theoretical guidelines and control parameters have been essentially not developed so far. In this contribution, an overview of the recently developed guidelines for the simplest class of ratiometric thermometers, the single ion Boltzmann thermometers, will be given [1]. A special focus will be given to the impact of the doping concentration of a potential activator and how it can affect the excited state dynamics that is crucial for the performance of a luminescent thermometer [2].

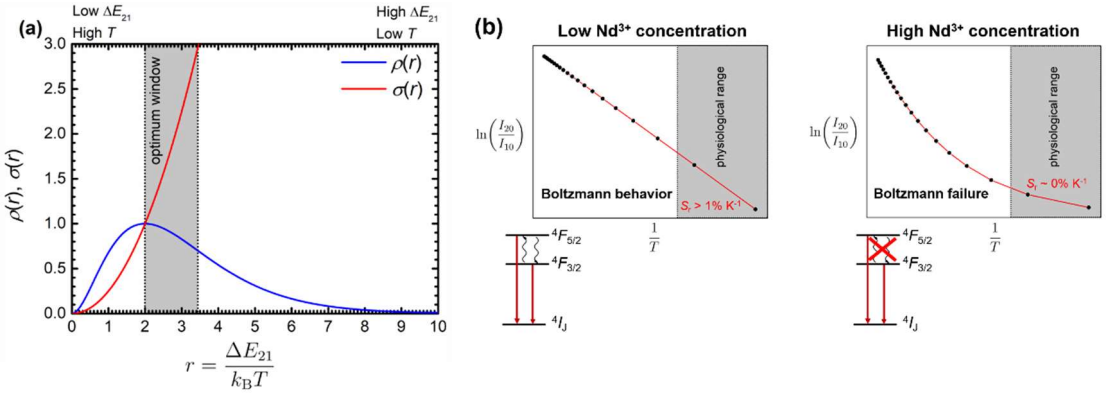


Figure 1. (a) Universal normalized function of the thermal response, $\rho(r)$, and relative sensitivity, $\sigma(r)$, of a Boltzmann thermometer indicating the optimum performance within a narrow temperature window (in grey) for a given energy gap, ΔE_{21}, between the two excited levels [1]. **(b)** Schematic depiction of the influence of doping concentration on the performance of Nd^{3+}-activated luminescent thermometers [2].

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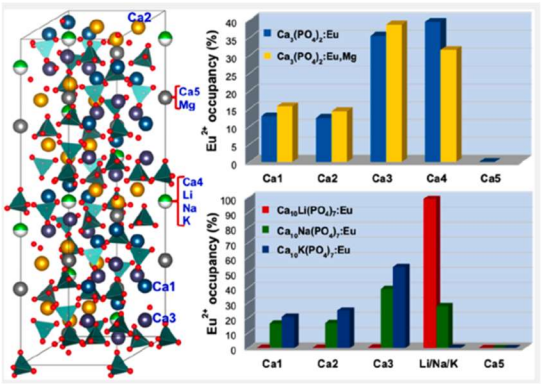
Computational insights into spectral properties of Eu^{2+}-activated β-$Ca_3(PO_4)_2$-type phosphors

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Eu^{2+}-activated complex phosphors have attracted significant experimental interests for applications in solid state lighting due to presence of multiple cation sites that is highly desirable for site-engineering of activator emission. However, the site occupation and associated spectral assignment of dopants Eu^{2+}, and hence the mechanism behind the site-regulated emission-tuning, are usually elusive. We have performed a systematic first-principles study on Eu^{2+}-activated β-$Ca_3(PO_4)_2$-type phophors by combining DFT and multi-configurational ab initio calculations. The results show that, among the isovalent Eu_{Ca} substitutions, the occurrence probability correlates positively with the size of the substituted site, which is, nevertheless, weaken by incorporation of codopant Mg^{2+} ions. In the presence of aliovalent Eu_M substitutions as in $Ca_{10}M(PO_4)_7$, the site-size-controlled preference is neutralized by the requirement for charge-compensation, and the effect becomes more pronounced with the increase of the M^+ ionic size. On this basis, the emission spectra of the phosphors are interpreted with respect to the substituted sites and the mechanism behind the composition-dependence of emission color is consistently elucidated, as is also verified by comparison between calculated 4f→5d transition energies and experimental excitation spectra. Our results provide a new perspective on the site preference of Eu^{2+} in β-$Ca_3(PO_4)_2$-type compounds and may also serve as a theoretical guideline on structure-property relationship for the design of other Eu^{2+}-activated phosphors.



Crystal structure the Ca3(PO4)2 crystal and the relative occurrence probabilities of Eu^{2+} site occupations.

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Facet Modulation and Heterostructure of Lead Halide Perovskite Nanocrystals

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$CsPbX_3$ (X = Cl, Br, and I) perovskite nanocrystals have recently emerged as one of the most efficient optical materials for various optoelectronic applications. However, the widely adopted method for synthesizing these highly emissive nanocrystals involved the ice-cooled harvesting procedure which makes it challenging to monitor the growth process and design the new nanostructure. Here, we proposed a perovskite cluster-based synthesis protocol that allows us to obtain two kinds of new nanostructures of perovskite including 26 facets polyhedron and arm-structured hexapods. Detailed investigations have shown that they are thermally controlled facets growth, and in specifically, the 26 facets polyhedron is formed under a halide-deficient condition, but enriching the system with halides again dissolved new facets and led to hexapod structures. DFT study on the surface energy calculation also supported the possibility of formation and evolution of these nanostructures. Moreover, based on this new method, a series of $CsPbX_3$-$Pb_4S_3Br_2$ heterostructures are successfully prepared, which providing an example of a sharp and atomically resolved epitaxial interface between a metal halide perovskite and a non-perovskite lattice. Besides, the growth mechanisms, the structural and optical features, and the overall electronic structure of these heterostructures have been also studied in detail.

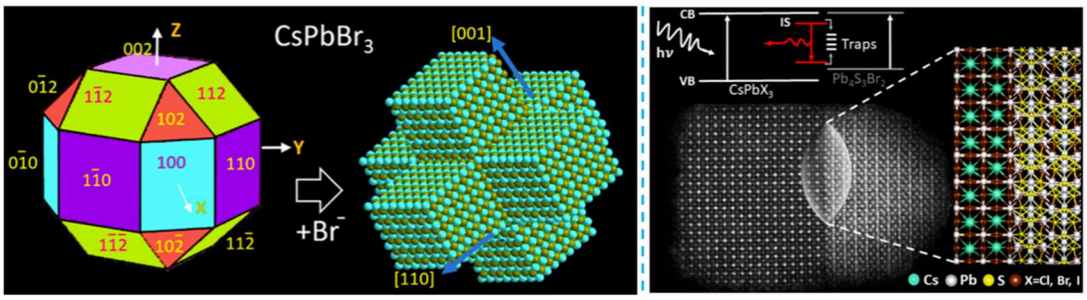


Figure 1. The arm growth and facet modulation of $CsPbBr_3$ perovskite nanocrystal (left). The HAADF-STEM image and the schematic depiction of the energy levels of $CsPbBr_3$-$Pb_4S_3Br_2$ nanocrystal heterostructure (right).

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Monazite $LaPO_4:Eu^{3+}$ nanorods as strongly polarized nano-emitters

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Orientation analyses of macromolecules or artificial labels are vital for many issues in fundamental research or for practical bio-applications.[1] We recently demonstrated that lanthanide-doped nanocrystals are extremely interesting systems due to the intense polarized emission of some crystalline compounds.[2,3] However, practical applications have been limited by the development of optimal nanocrystal dispersions in term of the particle size, colloidal stability, and the degree of polarization of the luminescence. In the present study, we focus on $LaPO_4:Eu^{3+}$ nanocrystals exhibiting an anisotropic rod-like shape. Investigation was made on the experimental conditions allowing to produce targetted $LaPO_4$ polymorph, the monazite phase, which was found to exhibit superior polarized emission properties.[4] While the rabdophane phase of $LaPO_4$ is kinetically favored during normal hydrothermal synthesis, we found that microwave heating with an excess of phosphate precursor invokes a rapid phase transition into monazite. Careful adjustment of synthesis conditions permitted to obtain outstanding colloidal stability, which is confirmed by the liquid crystalline behavior of the nanorods. The limited defects in the monazite nanorods resulted in a luminescence efficiency as good as the monazite phase obatained by high-temperature annealing. The emission spectrum of Eu^{3+} consists of well-defined lines with high degrees of polarization for both the forced electric dipole transitions and the magnetic dipole transitions. Due to the promising optical and colloidal qualities, these monazite $LaPO_4:Eu^{3+}$ nanorods can be used as accurate probes in orientation analyses and potential applications, such as in microfluidics and biological detections.[3]

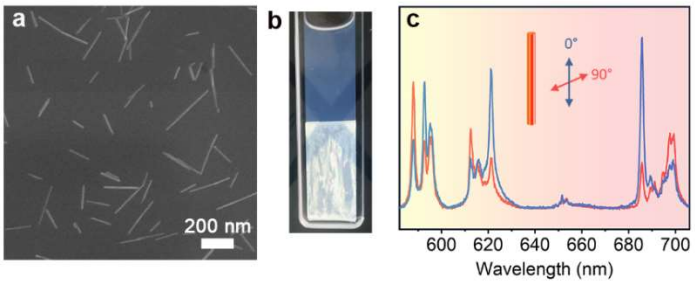


Figure. (a) SEM image of nanorods. (b) Birefringence for the bottom nematic phase under crossed polarizers. (c) Polarized Eu^{3+} emission spectra under excitation of 394 nm laser. The angles of 0° and 90° denote the polarizer parallel and perpendicular to the orientation of the nanorods.

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Multiexciton emission in colloidal spherical quantum wells under ionizing radiation

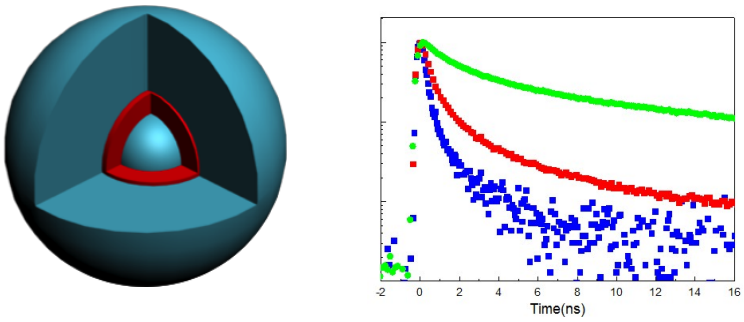
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Continuous research on the suppression of Auger non-radiative recombination in nanocrystals(NCs) provides an excellent opportunity to exploit multiexciton in numerous fields. Previous studies mostly focused on the intense pulsed and moderate energy photons excitation[1-2]. To date, the extremely energetic excitation - such as X-rays and gamma rays - has also attracted widespread attention to develop the potential new generation NCs-based radiation detector [3-4]. In this work, we thus investigate the underlying physics under ionizing radiation on a large scale of NCs sizes. Instead of conventional core/shell quantum dots in which the capability of Auger effect suppression has been hampered by the intrinsic lattice mismatch of the materials when ultrathick shell is considered, we utilize spherical quantum well(SQW, CdS/CdSe/CdS) to overcome the limitation of shell thickness through the strain epitaxial growth of emissive layer CdSe sandwiched between the two CdS domains[5].

In this subject, following the simulation of energy deposition and multiexciton generation under high energetic irradiation in nanocrystals, we analyze the spectral and dynamical properties of multiexciton under X-rays excitation by comparing the time-resolved results under UV and X-rays pulsed excitation. This approach enables the identification and quantitation of excitation species, then giving an insight to this complex energy relaxation process. This will provide a better understanding of the mechanism of nanoparticles scintillation properties and hopefully develop new and highly efficient radiation detector materials.



SQW schematic representation and radioluminescence decay of multiexciton.

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Photoluminescence imaging of a ferroelectrically driven lateral p-n junction in monolayer MoS_2

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Layered transition metal dichalcogenides (TMDs) represent an interesting class of atomically thin materials in which d-electrons' interaction give rise to unique physical phenomena with relevant implications in a variety of fields such as electronics, spintronics or optoelectronics. In particular, monolayer (1L) MoS_2 is currently attracting an intense attention due to its electronic and optoelectronic properties as direct bandgap semiconducting 2D material.

Different techniques such as strain,[1] electrical bias,[2] and chemical doping [3] have been used to control the physical properties of TMDs and to enable applications in optoelectronics. Alternatively, the atomic thickness nature of the 1L 2D materials also offers a unique opportunity to engineer their properties by means of the surrounding environment. In this context, ferroelectric crystals as substrates for TMDs provide a means for electrostatic doping of these systems due to their remnant polarization.[4]

Here, we analyze the photoluminescence response of 1L MoS_2 deposited on antiparallel ferroelectric domain structures. By means of high-resolution confocal microfluorescence, the spatial evolution of the emission spectra and photoluminescence mapping of the 1L MoS_2 is studied. Tunable exciton and trion emission is observed due to different electrostatic doping by the orientation of the ferroelectric domains. Moreover, the presence of a periodical array of lateral p-n junctions on the ferroelectric domain wall regions is evidenced, as well as the depletion region associated with the built-in potential. A photovoltaic response across the p-n region is identified, which is a promising result for the design of simple and cost-effective optoelectronic devices based on atomic p-n junctions.

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Nature-based molecules for luminescent solar concentrators

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Luminescent solar concentrators (LSCs) are a solution to facilitate the integration of photovoltaic (PV) devices into the urban environment, since they can be incorporated in building façades and windows. LSCs consist of a transparent waveguide doped with optically active centres able to absorb sunlight and re-emit it at a longer wavelength. The emitted photons are guided by total internal reflection to the PV cells coupled to LSC edges [1]. Current challenges include the search for environmentally friendly optically active materials with chemical and optical stabilities.

The most common natural dyes used in LSCs are based on phycobilisomes from which R-phycoerythrin (R-PE) can be extracted. Aqueous solutions of R-PE, extracted from *Gracilaria sp.* algae, with absorption in the UV/visible spectral range and red emission with a maximum absolute quantum yield of ~0.39, were used to fabricate LSCs by filling a glass container and cylindrical hollow-core plastic optical fibres assembled in bundles. In this work, LSCs with optical conversion efficiency (η_{opt}) and power conversion efficiency (PCE) values up to 6.88% and 0.27%, respectively, were obtained. Nevertheless, these devices presented poor photostability [2].

In order to find a natural optically active center with enhanced photostability, the green fluorescent protein (GFP) was selected. GFP is naturally expressed in the jellyfish *Aequorea victoria*, and presents spontaneous and natural emission of green light, when excited by UV radiation. GFP aqueous solutions with maximum absolute quantum yield of ~0.50 were used to fabricate planar LSCs, with η_{opt} and PCE values up to 3.7% and 0.35%, respectively, without showing photo-induced degradation. These results are ~30% higher than the current figures of merit for natural fluorescent proteins in aqueous media [3].

These results show the potential of nature-based molecules in the development of LSCs as reliable, sustainable and competitive energy systems.

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ICL 2020

A full thermal model for acoustically induced (thermo)luminescence

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Acoustically Produced Luminescence (APL) is the phenomenon where luminescent emission is triggered by irradiation with ultrasound waves.[1] Although some reseach into this topic was performed in the past[2-3], recent work has shown that the driving mechanism behind APL is not mechanoluminescence, as was commonly believed, but rather thermoluminescence (TL).[4] The acoustic energy of the ultrasound wave is absorbed by a polymer sensor membrane containing an energy storage phosphor, $BaSi_2O_2N_2:Eu^{2+}$ in this study. This causes a temperature increase which results in TL emission (see **Figure 1**). Since this emission occurs very locally, a precise cross sectional image of the US radiation field can be obtained, which is beneficial for applications relying on a precise knowledge of the ultrasound beam. Here we present a recently developed model to explain and predict APL emission resulting from any given ultrasound source. Furthermore, this model can be inverted to quantify the acoustic pressure distribution by analyzing an APL measurement where the light emission is monitored. This validated TL model can aid the development of related TL techniques, such as luminescent thermometry based on persistent phosphors.

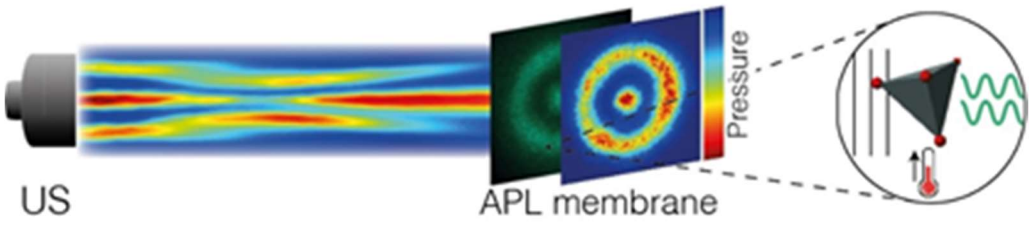


Figure 1: Schematic representation of the APL phenomenon. Ultrasound waves cause a temperature increase in the phosphor containing membrane, which results in local TL emission.

References

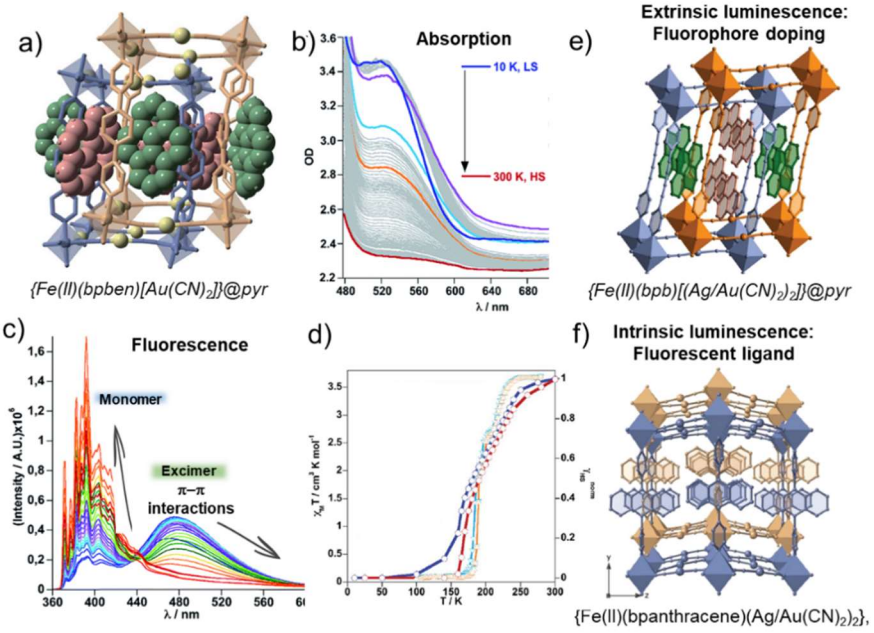
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Luminescent spin crossover MOFs

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Bifunctional materials showing synergies between spin crossover (SCO) and luminescence are promising platforms for new switching electronic and optical technologies, hence they have recently attracted substantial interest. We present here the first 3D Fe(II) Hofmann-type coordination polymer exhibiting SCO properties and luminescence. The complex {FeII(bpben)[Au(CN)$_2$]}@pyr (bpben = 1,4-bis(4-pyridyl)benzene) (Fig. a) functionalized with pyrene guests undergoes a cooperative multi-step SCO. The fluorescence from pyrene and exciplex emissions are controlled by the thermal and light irradiation dependence of the high/low-spin state population of FeII. Conversely, the SCO can be tracked by monitoring the fluorescence emission.[1] Strong π–π interactions between pyrene and the pillars result in exciplex emission (Fig. c). While heating, the emission intensity of the excimer increases due to the weaker overlapping with the absorption band (Fig. b), which is maximum at 10 K and minimum at room temperature. The normalized relative intensities of the excimer and monomer emission as a function of the temperature follow almost the same profile as the thermal spin transition obtained by magnetism (Fig. d). This was the first SCO-MOF implemented with luminescence properties and further studies focused on the luminescence mechanism of SCO-MOFs have followed (Figs. e/f).[2]



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Energy traps redistributions in the YAGG:Ce^{3+},Cr^{3+},Nd^{3+} ceramics and their effect on persistent luminescence

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From the time of the first publications to the present day, persistent luminescence (PersL) materials have been of interest both from the point of view of fundamental science (trapping and de-trapping mechanisms, traps effect on the decay time) and from the application point in various fields such as sensing, additive manufacturing, medicine [1,2]. Recently, ceramics with PersL in the NIR region have been of interest for use in optical storage applications [1]. In particular, ceramics based on $Y_3Al_2Ga_3O_{12}$ (YAGG) matrix doped with rare-earth ions and co-doped with transition metal ions. Eventually, the YAGG:Ce^{3+},Cr^{3+},Nd^{3+} nano-phosphors exhibit PersL originating from the $4f^3 \rightarrow 4f^3$ transitions of Nd^{3+} which matches well to the first ($^4F_{3/2} \rightarrow {}^4I_{9/2}$) and second ($^4F_{3/2} \rightarrow {}^4I_{11/2}$) biological window to be used also in bioimaging applications [3-4]. However, the preparation of ceramics from relatively narrow particle-size distributed starting powders is a good approach to obtaining high-quality ceramics [5].

In the present work, the PersL ceramics based on YAGG:Ce,Cr co-doped with Nd were fabricated by Hot Isostatic Pressing method. The starting powders were synthesized by using the Pechini method and then annealed at 900 °C. The microstructure of the ceramics was characterised by XRD and TEM analyses. The optical properties were measured and analysed by photoluminescence and thermoluminescence methods.. As a result, the intrinsic relationship between composition, microstructure, spectral properties and ceramic quality were determined. In particular, the effect of doped ions on the traps creation and their effect on the PersL properties were also studied.

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Extracting trap depth distributions in persistent phosphors with a thermal barrier for charging

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The trap depth distribution (denoted as $N(E_t)$) in persistent phosphors determines the performance of these phosphors. Extracting the trap depth distribution is however hindered by an often present thermal barrier ΔE for optical excitation (i.e., charging), which leads to temperature-dependent filling of traps. In this talk, we demonstrate a method to extract the trap depth from thermoluminescence (TL) curves which were aquired at a wide range of charging temperatures (T_{ch}) but with fixed charging irradiance I_e and charging duration t_{ch} [1]. The filling function $f(E_t, \Delta E, q, t)$ relates the trap depth distribution $N(E_t)$ to the electron population function $n(E_t, t)$ via,

$$n(E_t, t) = f(E_t, \Delta E, q, t)N(E_t),$$

in which q is the vector containing all the charging parameters (T_{ch}, I_e, t_{ch}). With the local model for trapping and recombination, we manage to simulate the behavior of $f(E_t, \Delta E, q, t)$ under different T_{ch}. The obtained TL curves can then be transformed into $n(E_t, t)$ via the Tikhonov regularization in the framework of first-order kinetics. Afterwards, the magnitude of $f(E_t, \Delta E, q, t)$, which is denoted as $\tilde{R}(E_i)$, can be estimated from $n(E_t, t)$. After constructing the envelope of all $n(E_t, t)$ at the designed T_{ch}, i.e. $n(E_t)_{env}$, the trap depth distribution can be calculated by,

$$N(E_t) = n(E_t)_{env}/\tilde{R}(E_i)\ .$$

The method was validated for $BaSi_2O_2N_2:Eu^{2+}$ as a model phosphor. It provides a solid mathematical background, and offers improved precision and resolution than methods that were reported previously [2,3]. This is a step forward in acquiring a deeper understanding of the (de)trapping behavior of persistent and storage phosphors.

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Persistent luminescence ceramics

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Persistent luminescence materials are able to emit light a few minutes, or even hours after ceasing the irradiation. Materials exhibiting persistent luminescence have been widely studied because of their potential applications. For this reason series of garnet and aluminate nanopowders were prepared using different methods. The powders were used for nanoceramic sintering by High Pressure Low Temperature technique. The impact of sintering pressure on the conventional and persistent luminescence in the ceramics is presented. Spectroscopic properties were characterized by the photo and thermoluminescence as well as measurements of luminescence kinetic. The difference between powders and ceramics was studied also under optical stimulation. It was found that sintering pressure decreases the grain size, change the type and filling and releasing time of the traps. Based on the results of structural and spectroscopic measurements an energy transfer diagram is proposed and discussed.

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Persistent luminescence at extremely low temperature

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Phosphors exhibiting persistent luminescence have received substantial attention and have been widely used in night-vision applications and *in vivo* bio-imaging. Traps associated with various defects inside host matrices, store excitation energy and then slowly release it to the emitters. The nature of these traps together with the ambient environment is responsible for the trapping and detrapping processes, corresponding to energy storage and liberation of charge carriers[1]. Room-temperature persistent phosphors and deep-trap materials have witnessed a great success, however, the design and development of low-temperature persistent phosphors with strong afterglow emission remains challenging thus far.

Herein, we demonstrate the design of trivalent chromium activated magnesium gallogermanates ($Mg_{1+x}Ga_{2-2x}Ge_xO_4:Cr^{3+}$) exhibiting strong near-infrared afterglow emission at low temperature, e.g., −80 ℃. Notably, this new persistent phosphor can be efficiently activated even at these low temperatures. A combination of experimental characterizations together with simulations has identified its novel low-temperature persistent luminescence and good capacity of stabilizing a large number of very shallow traps[2]. Our finding of this low-temperature near-infrared afterglow property provides an opportunity for novel applications at extreme conditions, such as cryopreservation of biological samples.

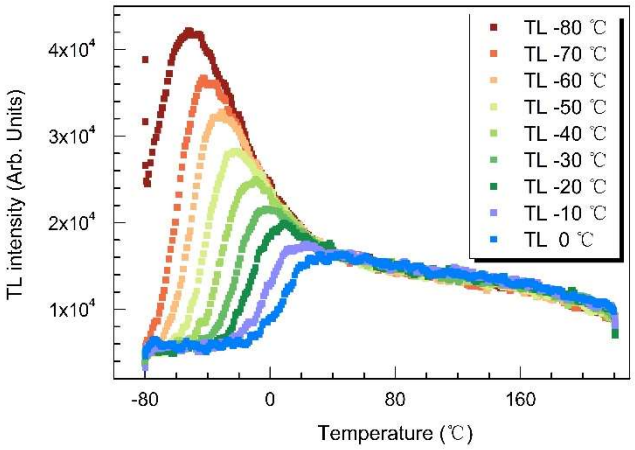


Figure 1. TL profile of $Mg_{1+x}Ga_{2-2x}Ge_xO_4:Cr^{3+}$ phosphor.

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Regulation of the structure and luminescence properties of rare earth doped micro/nano system

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Single crystal nanomaterials are very important for the fundamental investigation and application of luminescence. Here, an easy and rapid in situ achievement of a single crystal luminescent material is realized even at a very low temperature, which is impossible with conventional approaches, by taking advantage of plasmon-induced thermal and catalysis effects. And a heat-trapping system of self-assembled gold nanoislands with a thin Al_2O_3 layer is designed to significantly enhance the photothermal effect. It is found that the thermal effect plays a dominant role in plasmon catalyzed material transformation, and hot electrons can promote the oxidation reaction by facilitating the generation of active oxygen. Such a convenient and efficient plasmon assisted scheme provides a new technology for the rapid achievement of single crystal materials and extends the application of surface plasmon to a much broader field.

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Tuning the energy transfer efficiency by doping Ce^{3+} ions on $NaYF_4$: Yb, Tm nanocrystals

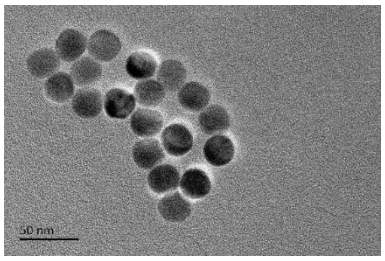
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Introduction: Luminescence nanothermometry is gaining great interest, and different excitation and readout schemes have been sought to improve temperature sensitivity and sensing range, or to simplify the readout. In this presentation, we report the temperature dependent luminescence properties of $NaYF_4$: Yb, Tm, Ce nanocrystals.

Resluts and Conclusion: Blue upconversion luminescence(UCL) is selectively enhanced by 6 times via Ce^{3+} ions doped $NaYF_4$: Yb, Tm nanocrystalline lattice. $NaYF_4$ nanoparticles with different Ce^{3+} contents were prepared by solvothermal method. It was found that the upconversion luminescence from UV to visible increased first and then decreased with the increase of Ce^{3+} concentration when the mole fraction of Ce^{3+} increased from 0% to 0.5%, the maximum fluorescence is obtained at 0.2%, which is about 5 times stronger than that without Ce^{3+}. It was found that the cross-relaxation processes between Tm^{3+} ($^3F_3$,$^3H_4$) and Ce^{3+} ($^2F_{7/2}$,$^2F_{5/2}$) had been employed to enhanced blue emission. After doping Ce^{3+}, it was effectively to prevent the electron transition back to the ground state and resulting in the overall fluorescence enhancement. On the other hand, after Ce^{3+} is doped, the （Yb^{3+}- Yb^{3+}- Ce^{3+}） trimers transfer energy to $^1G_4$ level and emit 475 nm blue light, which leads to strong blue light. It is applied to FIR temperature measurement, the sensitivity is as high as 3.5%.

Figure 1: Transmission electron microscope of $NaYF_4$: 18% Yb, 0.5% Tm, Ce



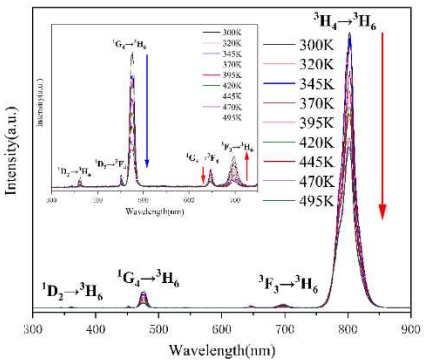


Figure 2：Fluorescence spectra of $NaYF_4$: Yb, Tm, Ce nanocrystals at different temperatures, the illustration shows the amplified fluorescence spectra with emission wavelengths ranging from 300 nm to 750 nm(laser: 980 nm, power density: 4 W/cm^{-2}

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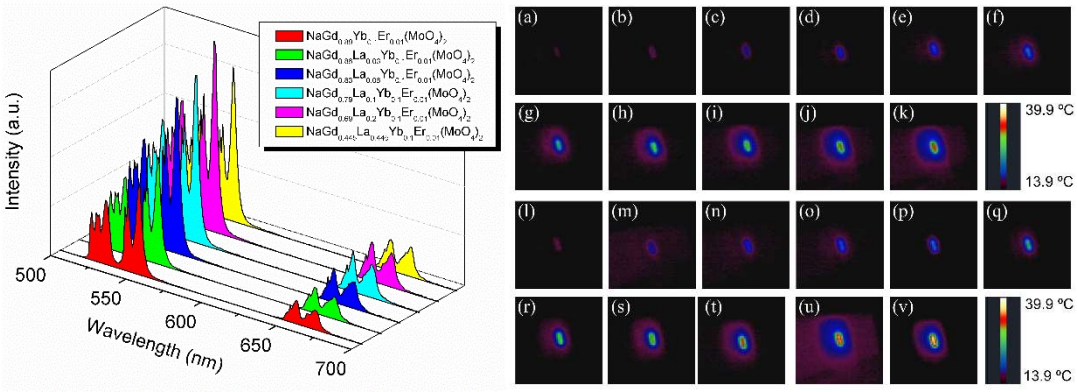
Solid solution $Na(Gd/La)(MoO_4)_2:Yb^{3+}/Er^{3+}$ upconversion nanocrystals with simultaneously enhanced photothermal conversion efficiency and luminescence Intensity

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Solid solution $Na(Gd_xLa_{1-x})(MoO_4)_2$ nanocrystals are synthesized. Due to lower lanthanide site symmetry and augmented odd-parity crystal field interactions after La^{3+} doping, the 4*f*-4*f* transition probabilities of the lanthanide ions are effectively increased. $Na(Gd/La)(MoO_4)_2$ solid solution hosts exhibit enhanced upconversion luminescence from Er^{3+}/Yb^{3+} activators, compared with single-component $NaGd(MoO_4)_2$ counterparts. What's more, enhanced photothermal conversion efficiency in solid solution $Na(Gd_xLa_{1-x})(MoO_4)_2$:Yb/Er nanocrystals is further confirmed from thermographic images recorded by a thermographic camera. The underling mechanisms of simultaneously enhanced photothermal effects and luminescence intensity in $Na(Gd_xLa_{1-x})(MoO_4)_2$ solid solution nanocrystals are elucidated. Modulation of composition in solid solution hosts may be an effective method for regulating photothermal effects and lanthanide upconversion luminescence intensity simultaneously. Multifunctional solid solution upconversion nanocrystals could be potential for photoluminescent and photothermal applications.



Upconversion Luminescence and Thermographic Images of the Solid solution nanocrystals

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Study of the spectral properties of Er-Yb-doped high-phosphorus silica glass

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Rare earth (RE)-doped silica glass fibers are widely employed, such as Er-doped fiber amplifiers for optical communications and Yb-doped fiber lasers for laser processing[1,2]. Phosphorus (P) is normally co-doped in RE-doped silica glass fibers for various applications. Since the doping of phosphorus has many effects; changing the refractive index of the fiber core, avoiding the clustering of RE ions, suppressing photodarkening, and improving the energy transfer efficiency between RE ions (e.g., from Yb^{3+} to Er^{3+} in Yb–Er-doped fiber amplifiers).

In this work, Yb-P double-doped (YP) and Er-Yb-P triple-doped (EYP) silica glass was successfully prepared by a novel sol-gel method combined with nano-powder sintering technology. Effects of Yb/Er doping ratio on the spectral properties of glass were systematically investigated, and the energy transfer efficiency from Yb to Er was systematically analyzed by the ratio of fluorescence intensity (I_{1530nm}/I_{975nm}) and fluorescence lifetime as well as the change of glass structure. Above work provides certain guidance for the next step of preparing high performance optical fiber.

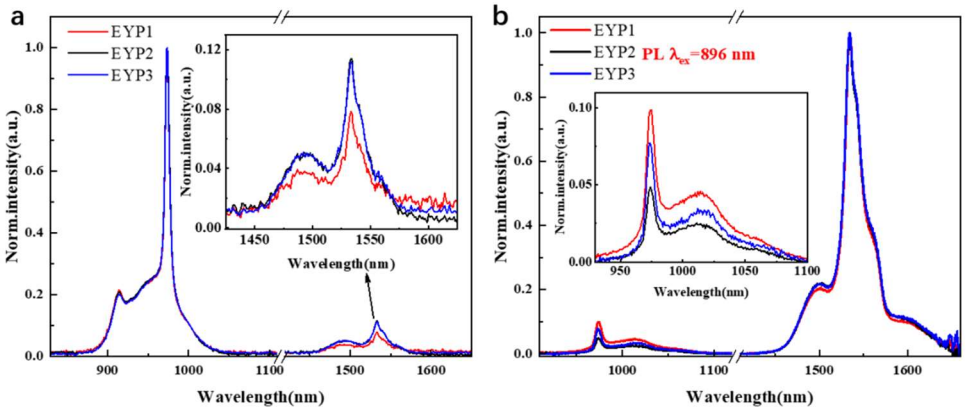


Fig. 1 Normalized absorption (a) and fluorescence (b) spectra of EYP series samples

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In vitro assays and nanothermometry investigations of infrared-to-visible upconversion of nanocrystalline Y_2O_3: Er^{3+}/Yb^{3+} nanoparticles for biological applications

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In the last few years, the application of luminescent lanthanide doped nanoparticles has played a fundamental role as fluorescent nanoprobes for *in vivo* and *in vitro* imaging [1] besides their use as energy converters to induce photochemical processes in biological medium. This multifunctionality makes them interesting platforms for theranostic applications. In this way, Er^{3+} and Yb^{3+} co-doped materials can exhibit an interesting near infrared to visible upconversion process, which makes them promising for biological applications such as bioimaging combined to photodynamic therapy. Moreover, the intensities of their emissions can be used to determine the local temperature [2]. Luminescent spherical, and monodisperse Er^{3+}, Yb^{3+} co-doped Y_2O_3 nanoparticles with an average diameter size of 100 nm were synthesized by the homogenous precipitation method followed by thermal annealing. Single-phase body-centered cubic Y_2O_3 nanoparticles presented high colloidal stability in water and biological medium. The cell viability was performed by colorimetric test MTT and 90% cell viability toward glioblastoma multiforme cell lines were obtained. Cellular sub-localization (T98G and U87MG cells) of Y_2O_3 nanoparticles was evaluated by confocal microscopy coupled to luminescent probes. Efficient visible emission by upconversion luminescence, was observed from Er^{3+},Yb^{3+} co-doped Y_2O_3 nanoparticles, upon direct excitation at 980 nm. The upconversion dynamic processs were determined by the measurement of the number of photons, which evidenced a dominant energy transfer by upconversion mechanism. As a result of luminescence nanothermometry investigations, the nanoparticles exhibited behavior of a primary thermometer with high relative thermal sensitivity (1.27 ± 0.05 % K^{-1} at 303 K) and considerable repeatability (> 97%), ensuring also its use as a contactless optical thermal sensor. Based on these studies, Er^{3+}/Yb^{3+} co-doped Y_2O_3 nanoparticles are promising materials for biological applications, specifically as a nanothermometer, bioprobe, and photodynamic therapy agent, demonstrating their potentials applications as a multifunctional theranostic platform for cancer therapy.

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Quantum cutting emission and local optical field control for Yb^{3+} ions

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Quantum cutting (QC) is a luminescent process, in which a high frequency photon is absorbed, while two low frequency photons are generated in the same time. The theoretical photoluminescence quamtum yield for the QC phosphors is 200 %. As a luminescent converter which can convert light from ultravoilet to blue into 980 nm, Yb^{3+} based QC phosphors demonstrate potential application on improving power conversion efficiency of silicon solar cells. However, in the past several ten years, the searching for Yb^{3+}**QC** phosphors is only confined in Yb^{3+} and other rare earth ions (such as Pr^{3+}, Er^{3+}, Tm^{3+}) pairs doped into different fluoride and oxide hosts. Limited by the smaller absorption cross section, unperfect spectral matching, and lower practical luminescent efficiency due to the large nonradiative transition rate for these ions, it is still a challenge for the application of QC phosphors in the silicon solar cells. .In 2017, we achieved breakthrough through doping Yb^{3+} ions into the $CsPbCl(Br)_3$ quantum dots, which had large absorption cross section in the blue and ultraviolet region, .broad excitation wavelength range of 300-450 nm, emission line at about 980 nm and practical luminescent quantum efficiency of 146 %. Surprisingly, as a luminescent converter, it improved the power conversion efficiency of silicon solar cells from 18.1 % to 21.5 %, with relative improvement of 18.8 %. This result was aslo followed by the other authors, such as Gamelin's group in Washington University. On April 22, 2019, Science highlighted this work as "perfect matching" , "This is one of the most exciting works I have seen for a long time." Herein, we present recent progresses in this interesting field.

Manipulation of luminescence properties of two-dimensional transition metal dichalcogenides

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Two-dimensional transition metal chalcogenides (TMDs), have shown considerable potential in future optoelectronic devices due to their large exciton binding energy, strong spin-orbit coupling and giant nonlinear optical responses. However, the main disadvantage of TMDs for practical applications is their extremely low quantum yield (QY), which is attributed to defect-mediated nonradiative recombination and weak optical absorption of atomically thin nature. Thus, exploring the carrier dynamics to restrict the adverse exciton relaxation process and enhance the light absorption capacity is critical to improve the QY of TMDs-based light-harvesting devices.

Herein, we studied the ultrafast dynamics of defect-assisted Auger process in a multilayer WSe_2 film by using transient absorption (TA) spectroscopy, and the Auger rates of 6.69 (±0.05) × 10^{-2} cm^2 s^{-1} and 1.22 (±0.04) × 10^{-3} cm^2 s^{-1} are quantitatively calculated.[1] Concurrently, high-energy C exciton without fluorescence activity exhibits two different relaxation process at picosecond level, instead of previous reported ultrafast cooling (sub-picosecond) process in monolayer MoS_2. From TA spectroscopy, the experimental results confirmed that the relatively slow cooling of C exciton is mainly limited by the rates of intervalley transfer rather than Pauli blocking effect from band-edge excitons. Then, intervalley transfer time are quantitatively estimated with two processes of 5.1 ± 0.6 ps and 69.5 ± 8.4 ps.[2] Based on a full understanding of the non-radiative process, we proposed that the concentration of charged excitons with low recombination efficiency can be manipulated via thermal dissociation effect, and a ~4-fold PL enhancement of monolayer MoS_2 can be achieved when the temperature increases to 420 K.[3] As for improving the photon absorption of monolayer counterparts, multilayer TMDs are experimentally demonstrated similar fluorescence enhancement of the K-K direct emission via the inter-valley transfer process of photocarriers rather than thermal-expansion-induced interlayer decoupling by heat engineering.[4-7]

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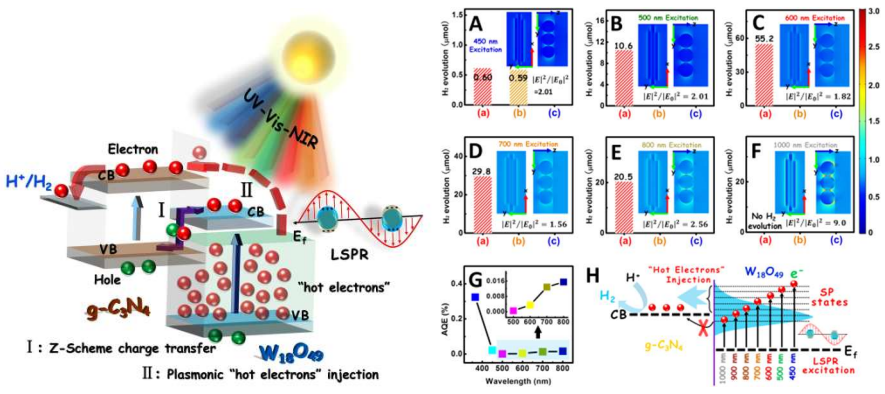
Plasmonic nano-heterostructure photocatalysts

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Plasmonic nanostructures have drawn considerable interest in the research field of solar energy conversion due to their fascinating localized surface plasmon resonance (LSPR). One successful paradigm in this regard is the integration of plasmonic metal nanostructures, such as Au or Ag, with appropriate semiconductors to extend light-absorption range and promote charge-carrier generation based on the transfer of plasmon-induced hot electron from metals to semiconductors. However, the actual manipulation of plasmonic metals into anisotropic nanostructures for the IR absorption often needs a tough multistep route. Moreover, the obtained anisotropic-nanostructured metals are difficult to attach directly to the semiconductors, leading to an impeded transfer of plasmonic hot electron from the metals to the semiconductors. With the rapid development of semiconductor-related nanoscience, the LSPR phenomenon has also been found in the heavily-doped semiconductor nanostructures. Unlike the plasmonic metals, the LSPR in semiconductors originates from the collective oscillations of excess free carriers associated with ion doping or lattice vacancies, resulting in broad and robust IR-light absorption. These advanced techniques enable plasmonic semiconductors to be combined with photoactive semiconductors, thereby obtaining a highly-efficient hot-electron-driven photocatalysis and avoiding the drawbacks associated with traditional plasmonic metal-semiconductor systems.



Energy band configuration, photocatalytic H_2 evolution, and near-field effect simulations of the $W_{18}O_{49}$/g-C_3N_4 heterostructure.

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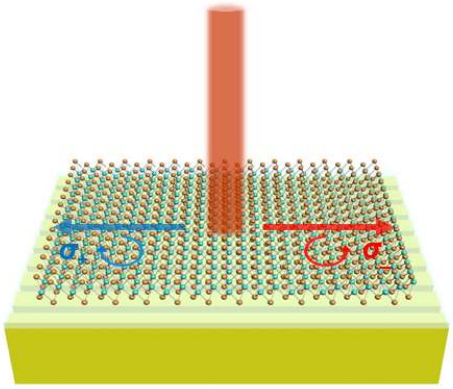
Room temperature valley hall effect enabled by directional surface plasmon propagation

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Transient metal dichalcogenides (TMDs) is not only important in the fundamental research, but also hold great potential in the appliction of optoelectronic devices. Valley degree freedom is an significant feature of TMDs, which is originated from the broken inversion symmetry, spin-orbit coupling and time reverse symmetry. Analogous to spin and charge, valley is capable of storing and processing information. In order to realize the practice application of valley freedom, it is desired to distuiguish valey carriers or excitons from different valleys. Spin valley hall effect is an effective way to seperate the valley cariers, however, it has to operate at low temperature. Recently, it has beem demonstrated valley exciton seperation can be achieved by coupling with directional SPP. Herein, we design a symmetric metallic greating and we observed seperation of SPP with simulation, which is attributed to the strong spin-orbit coupling of light in the evanescent field. Futhermore, bu coupling monolayer WSe_2 with this greating, we achieve directional propagation of valley exciton at room temperature.



Schematic of directional valley exciton proparation.

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Improving the near-infrared Yb^{3+} emission in carbon-silica systems

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One of the main challenges in the optical properties of materials doped with rare-earth ions (RE^{3+}) is to overcome the low efficiency of their direct intra-4f-shells excitation. Hence, the search for suitable indirect excitation mechanisms of RE ions is an active area of research. Previous work on silicon oxide glasses has reported that the inclusion of carbon in their composition could lead to an increase in the RE^{3+} ion photoluminescence at room temperature [1]. Moreover, reduction of the RE clustering phenomenon has been reported in carbon-doped materials compared to the silicon oxide matrix [2]. On the other hand, the ytterbium ion (Yb^{3+}) has attracted great interest for its simple energy level scheme, which could avoid detrimental luminescence processes such as cross-relaxation, excited-state absorption, and cooperative upconversion, as well as acting as a good sensitizer for other RE^{3+} ions.

In this work, we study the effect of C and Tb doping on the Yb^{3+} NIR emission in silica-based glasses thin films. Samples were grown on silicon substrates using RF-magnetron sputtering. In order to investigate the chemical composition of the samples, EDX, FT-IR, and Raman spectroscopy were carried out. The carbon composition was varied from ~6.0 to 40.0 at.% (carbon doping map). The Tb and Yb doping were varied from 0.8 to 2.6 at.% and 1.8 to 6.0 at.%, respectively. The excitation and emission spectra were investigated by photoluminescence excitation (PLE) and steady-state photoluminescence (PL) measurements. Transient PL measurements were also performed to study the Yb excited state lifetime. Sequential post-deposition annealing treatments up to 600 °C revealed the Yb^{3+} photoluminescence behavior. Optimization of the luminescence by carbon concentration and annealing temperature led to a region of maximum Yb emission intensity identified in the carbon-doped samples map. The Tb doping led to an important improvement in the Yb lifetime compared with the Yb single-doped case. The effect of the annealing temperature, carbon composition, and Tb doping on the Yb excitation mechanisms have also been investigated.

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Research progress on whitlockite-type mineral phosphors towards high-efficiency luminescent materials evolution

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Minerals are precious wealth left to humankind after long-term evolution and screening of nature. In recent years, taking the structure of mineral materials as the initial model has become an essential inspiration for the development of rare-earth phosphors. However, low luminous intensity and quantum efficiency are still the "shackles" that most phosphors are challenging to break through. Nowadays, several strategies have been proposed to discover new host materials. Unfortunately, there is no universal method to improve the luminescent properties of those materials which have been developed but have poor performance. Therefore, we try to modify the structure of a complex phosphate mineral material and explore the mystery of its structure-activity relationship combined with mineral crystallography, to reveal the law of the influence of the composition and structure of the material on its luminescent properties and put forward a comprehensive development strategy to improve the performance of phosphors towards high-efficiency luminescent materials evolution. By enhancing the structural rigidity and reducing the defect level, the designed phosphorite mineral fluorescent material can effectively improve PL intensity (more than 2 times), thermal stability (more than 80%, 150 ℃), CL intensity (more than 30 times) and quantum efficiency (more than 95%); Combining with DFT calculation, Special Aberration Corrected Transmission Electron Microscope, X-ray Absorption Fine Structure and Positron Annihilation Lifetime Spectrum, we obtained the lattice occupation of ions with low doping concentration, as well as revealed the mechanism of improving luminescence performance. In addition, this work explored and tried the development of multi-functional devices in LED lighting, anti-counterfeiting and other fields.

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Regulation of spectral properties of Nd-doped silica glass

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Nd-doped silica glass has many important application prospects. Recently, we introduced Nd:YAG nanocrystals into silica glass, greatly enhancing the emission cross section of ~1060 nm, which is expected to be used in high energy and high refrequency laser. In addition, the introduction of I, Br, S and other non-oxygen anions into Nd-doped silica glass can greatly improve the relative fluorescence intensity of ~900 nm, which provides a new idea for the development of high energy ~900 nm fiber laser.

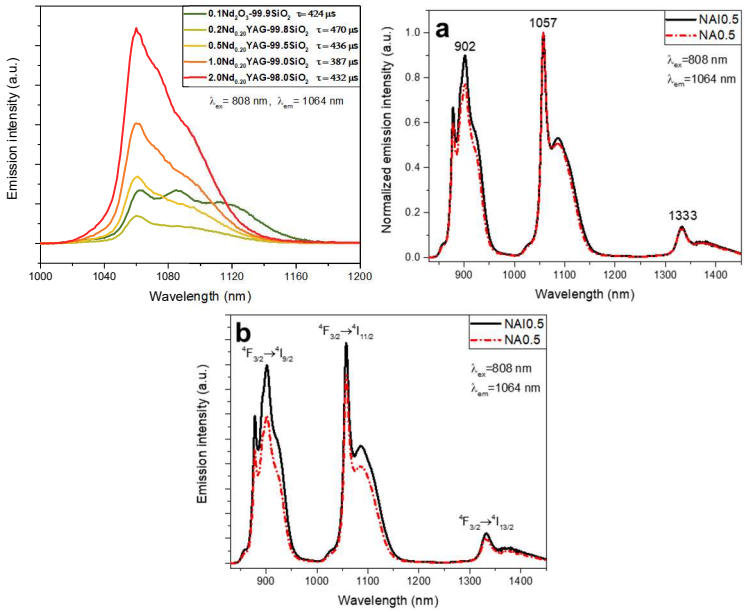


Figure 1 (a)Fluorescence spectra of silica glass doped with different content of $Nd_{0.2}YAG$, (b) fluorescence spectra of Al-Nd co-doped and I-Al-Nd co-doped silica glass, (c) the normalized emission spectrum, NAI0.5: I-Al-Nd co-doped silica glass, NA: Al-Nd co-doped silica glass

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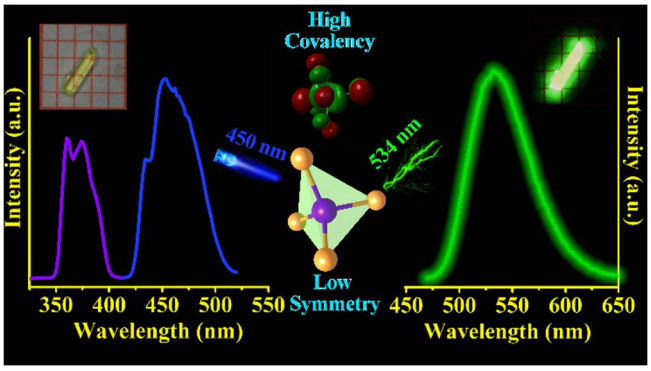
Structural design enables highly-efficient green emission with preferable blue light excitation from zero-dimensional manganese (II) hybrids

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Manganese (II) compounds are promising luminescent candidates for white light-emitting diodes (WLEDs) applications. However, the forbidden d-d transition of Mn^{2+} ion makes the absorption of blue light and emission relatively weak without a sensitizer. The strategy of isolating MnX_n (X is the ligand) with some ionic liquids is used to design two new hybrid compounds in this study, focusing on the orbital hybridization to relax the parity selection rule of the d-d transition. A large hindrance of the organic cations in the two new Manganese (II) hybrids enables a large Mn-Mn distance (up to ~10 Å) to form zero-dimensional (0D) structures, and the Mn sites in both compounds have a low site symmetry (C2 or C1). The 0D structure of MnX_n polyhedral is beneficial to isolatedly investigate the orbital hybridization of the ligand and Mn^{2+} ion. A higher orbital hybridization extent for Mn-Br bond is evidenced by Density Functional Theory (DFT) simulation. This conclusion leads to the strong and stable green light emissions under preferable blue light (460 nm) excitations, giving photoluminescence quantum yields (PLQYs) as high as 76%. The WLEDs fabricated with these compounds have presented high luminous efficiency up to ~130 lm/W and survived multiple stability tests. The research favors the discovery of ideal Mn compounds for displays and lighting applications.



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Near-unity red Mn^{2+} photoluminescence quantum yield of doped cspbcl$_3$ nanocrystals with mg incorporation

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The quantum yield of Mn-doped $CsPbCl_3$ perovskite nanocrystals (NCs) is up to 62% [1]. The Mn-doped $CsPbCl_3$ perovskite nanocrystals (NCs) were post-processed using the $MgCl_2$ precursor solution with stirring at room temperature to realize the Mg and Mn co-doped $CsPbCl_3$ perovskite nanocrystals (NCs). The luminous efficiency has been increased from 62% to 98%, the stability has been enhanced, and the toxicity has been reduced. The temperature dependence ofsteady-state and time-resolved PL spectra reveals that the $MgCl_2$ post-treatment significantly reduces the nonradiative defect states and enhances the energy transfer from host to Mn^{2+} ions[2]. White LEDs with color rendering index up to 80 and lumen efficiency up to 90% were prepared by using double-doped $CsPbCl_3$ perovskite quantum dots combined with commercial green phosphor at 365nm excited GaN chip.

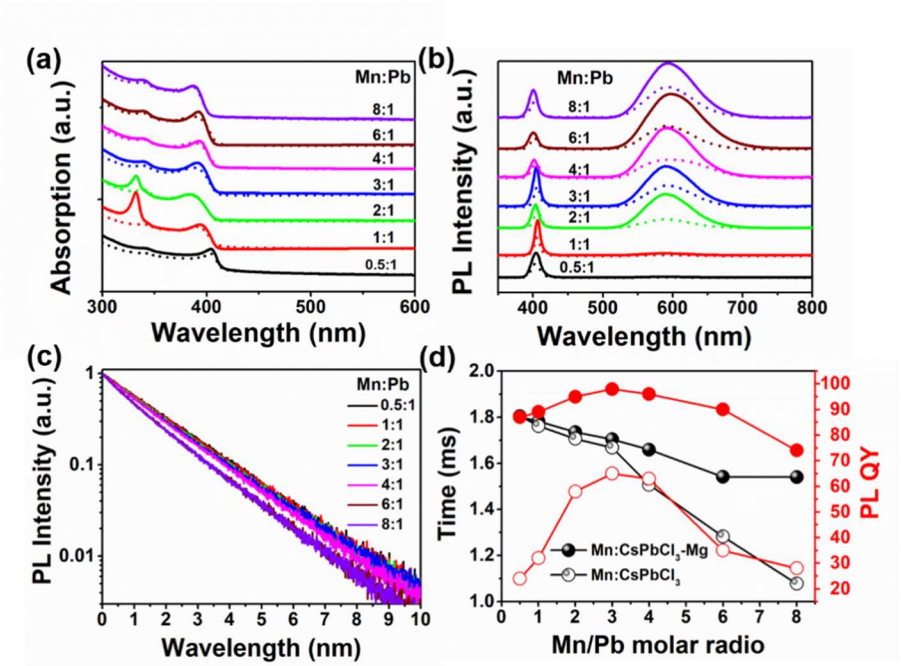


Figure 1 (a) UV-Vis absorption spectra of perovskite nanocrystals before and after $MgCl_2$ modification, (b) The luminescence spectra of perovskite nanocrystals before and after $MgCl_2$ modification, (c)the lifetime of Mn in perovskite nanocrystals modified by $MgCl_2$, (d) The single exponential fitting of Mn lifetime value and perovskite nanocrystalline efficiency value before and after $MgCl_2$ modification.

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Fabrication of the hybrid layered rare earth hydroxides with enhanced luminescence and photofunctional performances

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In this abstract, the novel hybrid composite based on the layered rare earth hydroxides was successfully fabricated through ion-exchange and intercalation chemical process. The rare earth elements contained Gd and Eu (Tb) and the molar ratio of Gd to Eu(Tb) was kept constant at 1.9 : 0.10. The organic anions (sodium dodecyl sulfonate and dye molecule) as supporting agent and light-harvesting antenna were simultaneously incorporated into the layered rare earth hydroxides (Fig. 1). The resulting hybrid layered rare earth hydroxides exhibited the enlarged interlayer distance, and the chemical composition was confirmed by the X-ray diffraction patterns, CHN elemental analysis, infrared spectroscopy, and thermogravimetric analysis. The layered solid compound showed the characteristic red (green) emission corresponding to the $^5D_0 \rightarrow {}^7F_2$ ($^5D_4 \rightarrow {}^7F_5$) transition of Eu^{3+} (Tb^{3+}) ion, and the luminescence intensity of the optimized compound was greatly enhanced as compared to its corresponding nitrate and the hybrid composite without the introduction of dye molecule. The hybrid layered rare earth hydroxides could be exfoliated into bright colloidal solution, which showed superior recognition capability to Cu^{2+} ion with the distinct luminescence quenching. implying a "turn-off" fluorescent sensor for Cu^{2+} detection. Moreover, a transparent film was prepared based on the colloidal solution and displayed the typical red (green) emission in folded shape. The fabricated hybrid compound with enhanced luminescence and excellent photofunctional performances is expected to apply in the fields of fluorescent sensing and flexible optical devices.

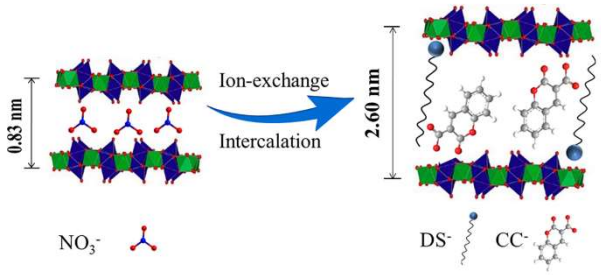


Fig.1. Schematic diagram for the fabrication of hybrid layered rare earth hydroxides through ion-exchange and intercalation reaction.

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Study of the dependence of photoluminescence on the crystallinity in solvated fullerenes

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Since scientists successfully prepared C_{60} and separated large carbon cage fullerenes such as C_{70} and C_{90}, these molecules have attracted extensive attention due to their unique carbon cage structure and three-dimensional conjugated π electronic structure[1][2][3]. In this paper, we mainly studied the depandence of the fluorescence properties on the crystallinity of solvated fullerenes (C_{60}/C_{70} derivatives). By analyzing the Raman, XRD and PL spectra of solvated fullerenes (C_{60} and C_{70}), it is found that the C_{60} molecules still maintain the original face-centric cubic structure under solvation. The fluorescence effect is obviously enhanced and the peak blue shifted. On the contrary, the crystal structure of C_{70} is obviously amorphous due to solvation, and its luminescence intensity is obviously weakened, the position of luminescence peak exhibits red shift, which indicates that there is a positive correlation between the crystallinity and the fluorescence intensity of the composite materials. That means, in addition to the interaction of the solvent and the fullerene in previous research, the crystallinity of the solvated fullerene is also an important factor that can affect its fluorescence properties[4][5]. We offer a new research perspective for the novel fullerene-based luminescent materials.

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Surface Chemistry of Phosphonate capped CsPbBr3 nanocrystals

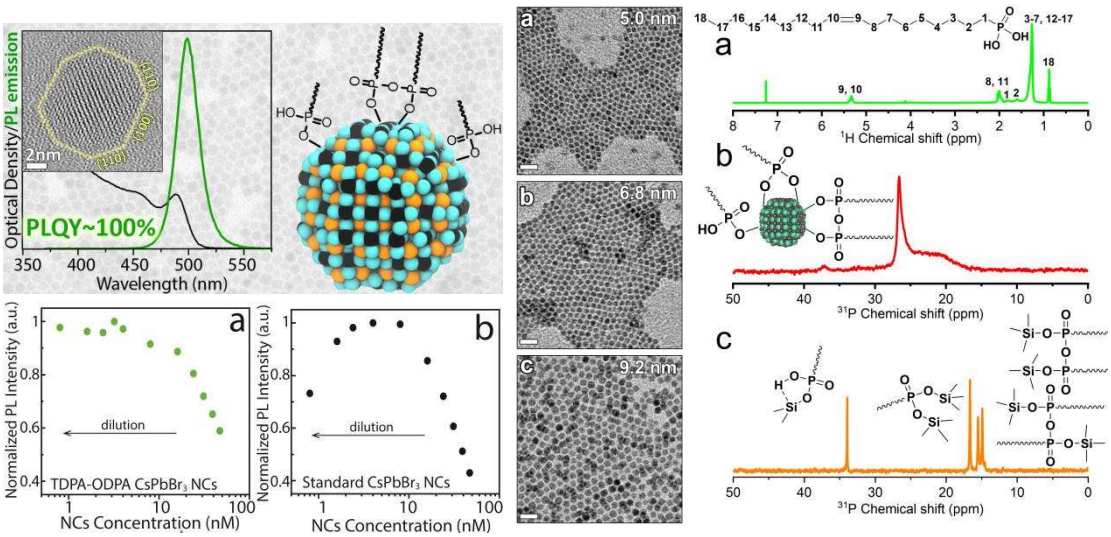
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We devised a colloidal approach for the synthesis of CsPbBr3 nanocrystals (NCs) in which the only ligands employed are phosphonic acids (alkyl phosphonic acid or oleyphosphonic acid). Determined by NMR, the surface was capped by phophonated and derivitad phosphonate ligands only. Compared to more traditional syntheses of CsPbBr3 NCs, the present scheme delivers NCs with the following distinctive features: (i) The NCs do not have cubic but truncated octahedron shape enclosed by Pb-terminated facets. (ii) The NCs have near unity photoluminescence quantum yields (PLQYs). (iii) Unlike NCs coated with alkylammonium or carboxylate ligands, the PLQY of phosphonate coated NCs remains constant upon dilution, suggesting that the ligands are tightly bound to the surface. Specially, oleyphosphonic acid with lower melting point, could extend the injection temperature to low range (ie, 100 °C), and thus we can obtain the phosphonate stablized small size (< 5nm) CsPbBr3 nanocrystals which show strong quantum confinemnet effect here.



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Dot−wire−platelet−cube: step growth and structural transformations in perovskite nanocrystals

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In comparison to the well-developed classical growth mechanism of chalcogenide nanocrystals, growth patterns for perovskite crystals in a reaction flask have been little explored. Here, we proposed a new synthetic approach of a single reaction leading to successive changes in dimensions of $CsPbBr_3$ nanocrystals. Using smaller nanoclusters as monomers and restricting the ligand concentration in the reaction medium, a sequential step growth of ~0.6 nm starting from the unit cell dimension to beyond the quantum confinements (>25 nm) was achieved. This growth process was also observed with the shape transformation of wire-to-platelet-to-cube shapes of $CsPbBr_3$ nanostructures, but all in one reaction. The entire process was monitored optically and microscopically, and the intermaterial transfer-induced successive change in size or shape was established as the major driving mechanism. Moreover, based on these results, we measured the extinction coefficient of the perovskite nanocrystals through Lambert-Beer law to establish the curves of concentration versus absorbance, which can help us to quickly and accurately quantify the concentration of the solution.

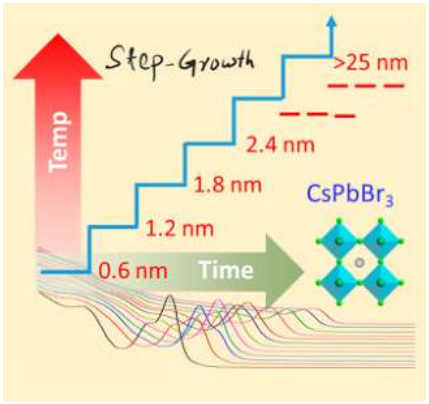


Figure 1. Schematic presentation of coupled and decoupling step-rise of reaction temperature and reaction time leading to size-defocusing and size-focusing of $CsPbBr_3$ nanostructures.

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Laser induced emission and photocurrent of Yb^{3+}:$Y_2Si_2O_7$ nanocrystalline ceramics

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The laser induced white emission (LIWE) was investigated for Yb^{3+}:$Y_2Si_2O_7$ nanocrystalline ceramics upon excitation with CW infrared laser diode. The broadband white emission has increased exponentially with excitation power density and was assisted by laser induced photocurrent (LIPC) generation. It was found that both white emission intensity and photocurrent the increased exponentially with the laser excitation power for high Yb^{3+} concentration much intensively in comparison to the laser induced light emission. In particular the influence of Yb^{3+} concentration on LIWE and LIPC processes was studied. The mechanism of laser induced white light emission and photocurrent is discussed in terms of multiphoton ionization of trivalent Yb^{3+} ion assisted by free electron emission, formation of divalent Yb^{2+} ion and the intervalence charge transfer $(Yb^{3+},Yb^{2+})\rightarrow(Yb^{2+},Yb^{3+})$ transitions responsible for the broadband white emission

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Luminescent smart labels unclonability and authentication through Physical Unclonable Functions

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Internet of Things has been widely explored on nowadays society in areas as healthcare or industry. Since it can create a massive network of interactions, factors as security and authentication have been more and more a concern[1]. In this scope, Physical Unclonable Functions (PUFs) have been recently investigated, making use of the unique and unclonable variations introduced on the manufacturing of a device to authenticate it[2].

Here, the PUF concept is implemented to produce unclonable smart labels based on luminescent QR Codes and their authentication procedures are developed based on adapted Hash Functions. Two authentication procedures are proposed, suited for different types of labels and consequently different applications. The first proposed procedure is suited for luminescent labels with no variability detectable at the naked eye, being demonstrated using QR Codes based on organic-inorganic inks modified by Eu^{3+}. To implement these labels as PUFs, structural and optical information that is obtained and combined to include geometrical error correction and consequently increase the effectiveness of the authentication methodology. This procedure makes use of expensive and complex techniques and so, is spontaneously restricted to certain entities such as legal entities of the States. Potential applications include authentication of private documentation or valuable objects, avoiding their counterfeit. The second proposed procedure explores the unclonability and authentication of smart labels based on QR Codes, where the analyzed PUF output is detectable by a smartphone. The PUF concept arises because of a luminescent that is airbrushed on the top of a non-luminescent QR Code[3] stamped on a flexible substrate. The Eu^{3+}-based luminescent QR code displays emission visible at the naked and detected by smartphone. The intra-4f6 transitions provides the required pure red color emission, enabling the analysis acquired images by the smartphone using the RGB colour model. Potential applications include their inclusion on smart sensing labels, protection masks or professional clothing, being useful for fast authentication, identification or for example, for covid - 19 triages.

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Luminescent smart labels based on QR Codes for temperature sensing and authentication

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Sensors play a major role on the Internet of Things (IoT) providing monitoring inside and outside the network. Challenges towards IoT lie in the lack of affordable strategies able to convert optical into an electronic signal cost-effectively and sustainably. The coupling of optical sensors to smartphones appears as an exciting strategy for the new generation of optical sensing.[1] Among optical properties, luminescence stands out as a non-invasive spectroscopic method based on the dependence of the phosphor emission on the measurand, often resulting in a color variation able to be quantified by an unchanged smartphone camera.[2] Lanthanide ions (Ln^{3+}) provide the required color purity and tuneability for image-based sensing, enabling the design of smart labels for authenticity, sensing, and traceability with applications ranging from smart cities to *e*-health. Also, the possibility to excite emission with LEDs combines well with the use of a smartphone.

Here, we propose the use of *super*-modules QR codes to combine Ln^{3+}-based materials with smartphones.[3] Color and spatially multiplexed luminescent QR codes were created with two single Ln^{3+}-doped luminescent inks. Exploring the color thermal dependence (294-314 K), two ratiometric thermometers based on RGB color coordinates were designed, increasing the reliability in temperature readout. This concept was demonstrated by processing the QR codes in medical adhesives, for *e*-healthcare purposes. Besides temperature sensing, exploring the airbrushing methodology to process the QR codes allows to design physical unclonable functions (PUF).[4] The PUF is based on a luminescent random pattern created by the airbrush stamped on the position detection pattern of a non-luminescent QR code, being detectable by a smartphone, under UV illumination. The image *responses* of the PUFs are evaluated through the adapted use of hash functions (for example Discrete Cosine Fourier Transform) that convert them on bit strings that can be compared using the Hamming Distance.[5] Combining temperature sensing and PUFs, a smart unclonable label for IoT is produced, with double storage capacity, double temperature sensing guaranteeing authenticity and traceability to the object, person, or document it is attached to.

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Luminescence pressure sensing in the vacuum and high-pressure ranges using lanthanide-based luminescent thermometers-manometers

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Pressure is a fundamental physical parameter, so its monitoring is crucial for various industrial and scientific purposes. However, the available optical sensors allow monitoring either low pressure or high pressure ranges.[1]

Here we show combination of different concepts of pressure sensing, and the development of first luminescent pressure sensor working within 9-orders of magnitude (from 10^{-4} to 10^{5} bar), allowing alike low (vacuum) and high pressure sensing.[1-3] This sensor is based on the inorganic, upconverting material (YPO_4:Yb^{3+}-Er^{3+}) emitting in the visible and near-infrared (NIR) ranges. For vacuum detection, the recently discovered sensing method is applied, which is based on the luminescent thermometer conversion into the pressure sensor. This is thanks to the effect of enhanced light-to-heat conversion, which is greatly enhanced under vacuum conditions. Whereas, for high-pressure sensing, the emission line shift of Er^{3+} (induced with material compression), located in the NIR spectral range is used.

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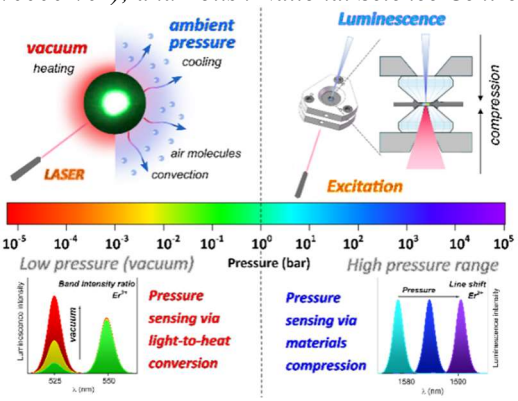


Fig. 1 Luminescent thermometer-manometer working as a low (vacuum) and high pressure sensor

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A new Ho^{3+}-based thermometer for sensitive sensing over a wide temperature Range

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Luminescent materials are promising for temperature sensing, but their operation range is often limited. Inorganic crystals doped with lanthanide ions can solve this issue, since the nature and the concentration of the dopant(s) offers fine control over the luminescence and its temperature dependence. However, selecting the concentration of the dopant(s) for optimum thermometer performance is still mainly based on trial-and-error. This hinders the targeted design of luminescent thermometers optimised for specific applications and temperature regimes.

Here we present and quantitatively model a Ho^{3+}-based thermometer with sustained low uncertainty from room temperature up to 873 K[1]. Our thermometer shows bright green and red luminescence with a strong and opposite dependence on temperature and Ho^{3+} concentration (Figure 1). This is the result of temperature-dependent competition between multi-phonon relaxation and energy transfer, feeding green- and red-emitting levels, respectively, following excitation with blue light. Our model quantifies this competition and correctly predicts the output spectrum over a wide range of temperatures and Ho^{3+} concentrations and serves to determine the optimum Ho^{3+} concentration for a temperature range of interest.

Quantitative modelling as presented here is crucial to optimally benefit from the potential of energy transfer thermometers for low measurement uncertainties over a wide temperature range. It helps to understand the impact of doping concentration on the performance of the energy transfer-based luminescent thermometers.

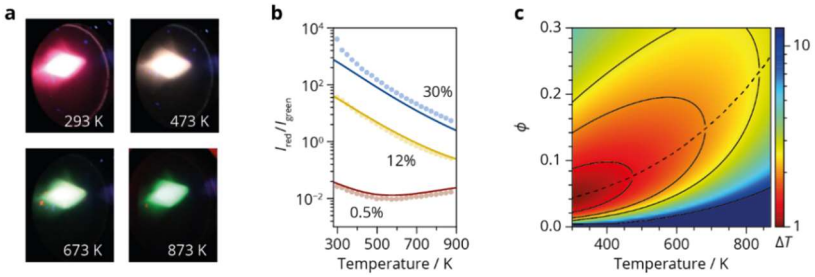


Figure 1 | A colourful thermometer with tunable temperature uncertainty. (**a**) Photographs of the Ho^{3+}-based thermometer at various temperatures (λ_{exc} = 450 nm). (**b**) Temperature dependence of the experimentally measured (dots) and the calculated (lines) red-to-green ratio for different concentrations. (**c**) 3D plot of the normalized temperature uncertainty for Ho^{3+} doping fractions ϕ and temperatures within the range of this study.

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Photon avalanching in Tm^{3+}-doped $LiYF_4$ nano-, micro- and bulk crystals

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Lantanides trivalent ions (Ln^{3+}), due to their unique properties, such as high photostability, complex structure of energy levels, long lifetimes of excited states and relatively efficient anti-Stokes multicolour emissions, in particular in ranges corresponding to transmission windows of biological tissues, have found broad applications in optoelectronics, sensorics and biomedical research [1,2]. Moreover, Ln^{3+} ions can be incorporated into crystal matrices characterized by various sizes, tailored for particular needs of given utilization. However, a list of Ln^{3+} applications can be succesfully extended by using highly non-linear pumping scheme known as photon avalanche (PA), where slight changes of illumination power lead to rapid growth of the luminescence intensity by even 2 or 3 orders of magnitude. Although PA has been known and studied in single crystals from 1979, just recently a full demonstration of photon avalanche emission was presented in colloidal Tm^{3+}-doped $NaYF_4$ nanocrystals in room temperature with high non-linearity (power law order exceeding 30) [3] which enabled to confirm previous predictions of suitability of PA nanomaterials for a new type of single excitation beam superresolution imaging [4].

We continue this work and present systematic studies comparing PA performance of the $LiYF_4$: Tm^{3+} structures of varying scale, from bulk monocrystal, through microcrystals of c.a.40-60 μm, to nanocrystals with various architectures. Each of the structures, even composed of the same host doped with the same concentration of Tm^{3+}, exhibited PA emission, however its characteristics significantly varied between them. We show size dependencies of essential PA parameters, such as order of the nonlinearity of power dependence and power dependent luminescence rise time slowing down. The presented results confirm high potential of such structures for applications in bioimaging and sensorics.

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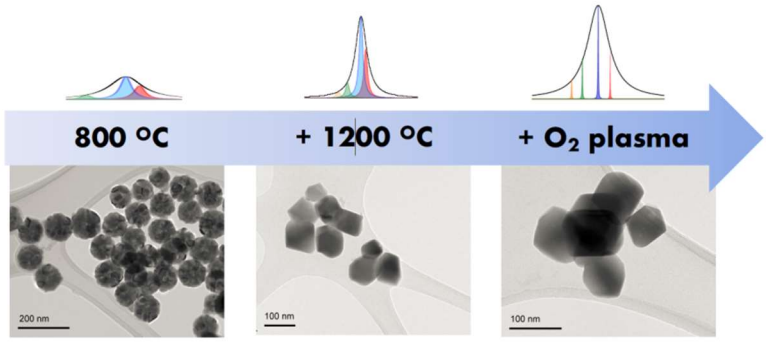
Defect engineering of Eu:Y_2O_3 nanocrystals for optical quantum technologies

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Nanostructured systems that combine optical and spin transitions offer new functionalities for quantum technologies by providing efficient quantum light-matter interfaces. Rare-earth (RE) ion-doped nanocrystals are promising in this field as they show long lived optical and spin quantum states [1, 2]. However, further development of their use in highly demanding applications, such as scalable single ion based quantum processors, requires controlling defects that currently limit coherence lifetimes. In this work, we show that a post-treatment process that includes multistep high-temperature annealing followed by high-power microwave oxygen plasma processing advantageously improves key properties for quantum technologies. We obtain single crystalline Eu^{3+}:Y_2O_3 nanoparticles (NPs) of 100 nm diameter, presenting bulk-like inhomogeneous line widths (Γ_{inh}) and population lifetimes (T_1). Furthermore, a significant coherence lifetime (T_2) extension, up to a factor of 5, is successfully achieved by modifying the defects in the NPs by the oxygen plasma treatment. These promising results confirm the potential of engineered RE NPs to integrate devices such as cavity-based single-photon sources, quantum memories, and processors. In addition, our strategy could be applied to a large variety of oxides to obtain outstanding crystalline quality NPs for a broad range of applications.



Structual and spectroscopic evolution of Eu^{3+}:Y_2O_3 NPs along the different post-treatments.

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Ultrafast photocarrier dynamics competition in surface and bulk region of $CsPbBr_3$ microplates

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Quantitatively elucidating trap-mediated photocarrier dynamics is crucial for deep understanding of structure-performance relation in perovskites. In this work, ultrafast spectroscopy technique is adopted to resolve photocarrier dynamics mediated by trap states in surface and bulk region of perovskite. Firstly, by using time-resolved photoluminescense (TRPL) measurement, it is find that the fast and slow PL lifetimes are originated from band-edge excitons radiative recombination in surface and bulk region of perovskite, respectively. Then, we qualitative analysis the relationship between trap density and sample's thickness by thickness-dependent TRPL measurements. Furthermore, to establish a quantitative relationship between the spatial distribution of trap states and energy relaxation process of photocarrier, photocarrier dynamics competition in surface and bulk region of pervoskite has been studied by pump power-dependent TRPL and femtosecond laser transient absorption measurements. Results show that trap density in surface region is an order of magnitude higher than that of the bulk region of $CsPbBr_3$ microplate. Subsequently, the interface between the surface and the bulk region forms a spatial gradient distribution of trap density. When the trap states in surface region are completely filled, the non-radiative recombination channel produces the Pauli blocking effect, which will induce the polaron-assisted ultrafast energy transfer from surface to bulk region with 20 ps. Hence, this process will improve exciton concentration and remarkably enhance PL emission in bulk region of $CsPbBr_3$ microplate. Our results provide new insights into dynamical photocarriers energy relaxations and interfacial energy transport for inorganic perovskites.

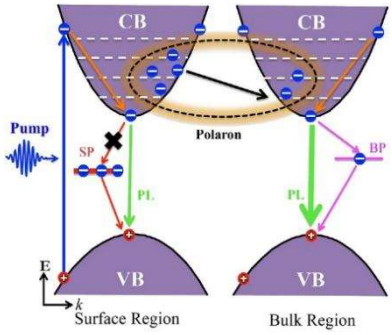


Figure 1. Schematic illustration of polarons dominated inter-region energy transfer and following trap-state-mediated exciton energy relaxations in surface and bulk regions.

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In-situ, quantitative and gradient of perovskite composition regulation

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Abstracts: In recent years, perovskite materials have received extensive attention. By adjusting the composition of the perovskite, the optical and electrical properties can be adjusted. As a typical post-synthesis method, anion exchange reaction can quantitatively adjust the composition in situ. However, because the anion exchange reaction rate is too fast to adjust the perovskite halogen ratio flexibly and quantitatively. Although there are some reports trying to control the anion exchange in the liquid phase and try to carry out anion exchange in the vapor/solid reaction, there is no relevant research on the quantitative regulation of the perovskite composition in situ.

Herein, we reported a facile and gentle vapor/solid anion exchange strategy to control a composition *in-situ* and quantitatively for adjust the properties of $MAPbI_{3-x}Br_x$ (x = 0 to 3) films continuously. Simply by controlling a reaction time, the optical properties of the film can be continuously adjusted in situ. More importantly, an empirical formula that can quantitatively control the composition in situ was put forward which supported by theoretically and simulation on anion exchange process. The anion exchange strategy and empirical formula are appropriate not only for perovskite but also for anion exchange and evaporation experiments of other related materials. This work is expected to be used as a reference for further applications, such as *in-situ* quantitative reversible composition-tunable perovskite, solar cells, white LEDs and lasers.

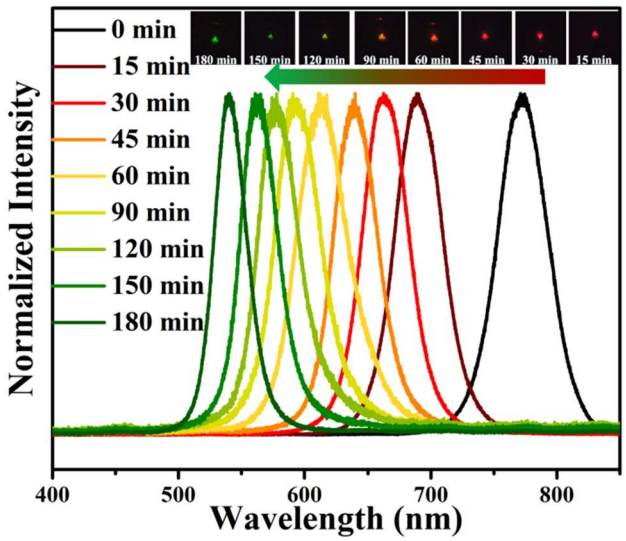


Figure Luminescence photographs for $MAPbI_{3-x}Br_x$ films.[1]

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Photophysics and microlasers developed from metal-halide perovskite nanocrytals

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In the past few years, the all-inorganic cesium lead halide perovskite nanocrystals (IPNCs) ($CsPbX_3$, X = Cl, Br, I) have emerging as the fantastic optoelectronic materials due to the high photoluminescence quantum yield, facile emission color tunability and solution processibility. More importantly, they are found to be much more stable than its close relative-the hybrid organic-inorganic perovskites. Very recently, these novel nanocrystals were discovered to possess superior optical gain properties appealing for solution-processed cost-effective lasers by our group and Kovalenko's group. However, the potential of such materials has not been exploited for practical laser devices, rendering the prospect as effective laser media elusive.

In this work, we realized for the first time the challenging but practically desirable vertical cavity surface emitting lasers (VCSELs) based on the $CsPbX_3$ IPNCs. These solution-processed VCSELs exhibit notably high performance including low threshold (9 $\mu J/cm^2$), unidirectional output (beam divergence of ~3.6º) and favorable stability. The lasing wavelength can be manipulated to span across red, green and blue region with comparable pump thresholds, which is appealing for developing single source-pumped full-color visible lasers.

It is fully demonstrated that the characteristics of the VCSELs can be versatilely engineered by independent adjustment of the cavity and solution processable nanocrystals. Our results represent a significant leap towards practical laser sources leveraging on the advantageous CsPbX3 IPNCs.

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The regulation strategy for Surface Enhanced Raman Spectrum

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Quantitative identification of trace molecules in complex systems is an important part of laser spectroscopy. Raman spectroscopy, as a typical laser spectroscopy technology, can provide rapid, simple and nondestructive qualitative analysis, but with weak intensity and poor signal-to-noise ratio. Surface Enhanced Raman Spectroscopy (SERS) can achieve the breakthrough of detection limit by virtue of surface plasmon effect, which has profound significance in plasmon spectroscopy, condensed matter physics and surface interface science. SERS doesn't have widespread application yet since its discovery of more than 40 years especially in the field of biomedical science duo to complex interactions among light, surface plasmon nanomaterials and detection molecules leading to poor reliability and universality, which seriously restricts its practical application. The main potential factor that interferes the reliability and universality of SERS detection is the signal fluctuation caused by the substrate and low sensitivity for molecules with poor Raman activity. In order to fundamentally solve the above problem, we systematically analyzed the mechanism of plasmon coupling, constructed homogeneous hot spots, and then accurately manipulated molecules to effectively correlate molecular orientation with enhancement performance, which can realize trace analysis of complex systems, and promote SERS to be the next generation of advanced spectroscopy technology.

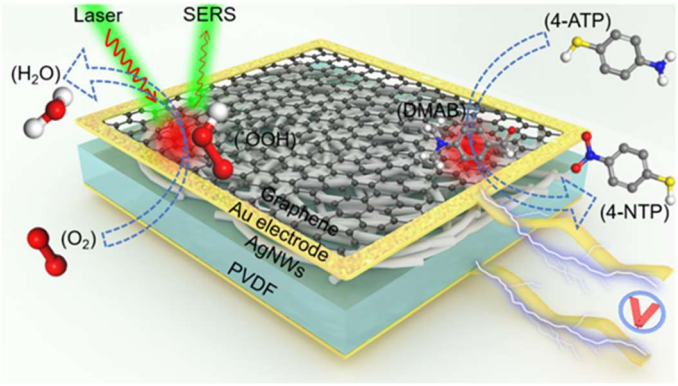


Figure. the schematic illustration of the pyroelectric regulation.

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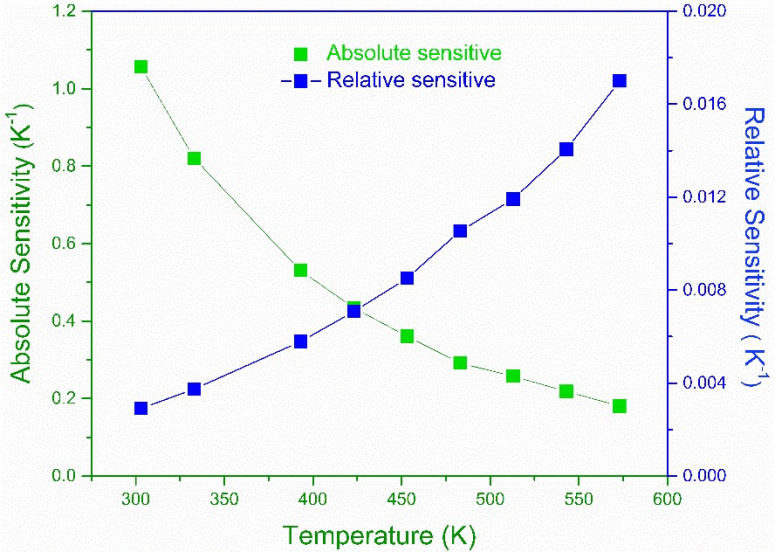
Yb,Ho:$(La_{0.1}Y_{0.9})_2O_3$ ceramics for thermometric applications based on the upconversion emission

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A series of Yb^{3+}, Ho^{3+}:$(La_{0.1}Y_{0.9})_2O_3$ green-emitting upconversion (UC) ceramics were fabricated by spark plasma sintering. Under the 980 nm excitation, the samples exhibited strong green, weak red and negligible near infrared (NIR) UC emissions, corresponding to the transitions $^5F_4/^5S_2 \rightarrow {}^5I_8$, $^5F_5 \rightarrow {}^5I_8$ and $^5F_4/^5S_2 \rightarrow {}^5I_7$ of Ho^{3+} ions, respectively. The UC emission intensity of Yb^{3+}, Ho^{3+}:$(La_{0.1}Y_{0.9})_2O_3$ ceramics can be improved by optimizing the concentration of Yb^{3+}. In addition, optical temperature sensing properties of Yb^{3+}, Ho^{3+}:$(La_{0.1}Y_{0.9})_2O_3$ ceramics were investigated in the range of 303-573 K, presenting a maximum relative sensitivity of about 0.017 K^{-1} at 573 K. The results demonstrate the Yb^{3+}, Ho^{3+}:$(La_{0.1}Y_{0.9})_2O_3$ ceramic can be a potential candidate for temperature sensors.



Relative sensitivity and absolute sensitivity of the Yb^{3+}, Ho^{3+}:$(La_{0.1}Y_{0.9})_2O_3$ ceramic at various temperatures.

Influence of Ce^{3+} ion on optical properties and radiation resistance in Ce^{3+}/Tm^{3+}-co-doped alumino-silicate glasses

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Owing to their reduced weight, size and high conversion efficiency, rare earth (RE) doped active fibers are crucial in space-based applications, such as space laser communication, laser radar and space waste disposal[1]. However, the radiation induced attenuation of the active RE-doped fibers is approximately 1000 times larger than that of passive RE-free fibers under the same radiation condition, which poses a severe challenge to the long-term stability of active fiber lasers or amplifiers in space[2].

In this work, Ce^{3+}/Tm^{3+}-co-doped alumino-silicate glasses with various Ce^{3+}/Tm^{3+} ratio were prepared by sol-gel method combined with vacuum sintering. To check their radiation resistance, the glasses were exposed to 1 KGy and 100 KGy gamma rays. The effect of Ce^{3+}/Tm^{3+} ratio on the absorption, emission and fluorescence lifetime of glasses under investigation, before and after irradiation, were examined in detail. Ce^{4+} and Ce^{3+} cations were detected. The nature of Si-E' and AlOHC color centers caused by irradiation was identified by radiation-induced absorption (RIA) and electron paramagnetic resonance (EPR) spectroscopies. It was found that co-doping with Ce^{3+} ions can significantly improve the radiation resistance of the glass, but it can also deteriorate the spectral properties of Tm^{3+} ions. The related influence mechanisms were discussed. The obtained results indicated that Ce^{3+}/Tm^{3+}-co-doped alumino-silicate glasses with optimized Ce^{3+} ion concentration, so that Ce^{3+}/Tm^{3+} molar ratio less than 0.3, can be used as an active medium for radiation resistant materials in harsh radiation environments.

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Eu^{2+}-doped nitride and oxynitride phosphors with persistent and photostimulated luminescence

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Persistent luminescence (PersL) is the phenomenon that radiant energy can last for a period of time after ceasing the excitation source. [1] Different from PersL, photostimulated luminescence (PSL) which needs optical energy stimulation is very promising to be applied in information storage area. [2] We show that both PersL and PSL can be realized in Eu^{2+}-doped narrow-band (oxy)nitride phosphors, $SrLiAl_3N_4:Eu^{2+}$ and Sr-Sialon:Eu^{2+} after 254 nm light pre-irradiation. [3,4] Their PersL can last for 395 and 1690 s, respectively. Both of them show photostimulated signals even after 15 days decay. By analyzing the thermoluminescence (TL) spectra, the internal mechanism is revealed. Both of them have broad range spanning TL spectra, which means multiple electron traps with different depth exist in these two materials. We confirm that the PersL is strongly dependent on shallower traps while the PSL relies on deeper traps. We can roughly define 0.8 eV as the boundary energy between shallow and deep traps if we use $T_m/500$ to estimate the trap depth. [5] The DFT calculation of $SrLiAl_3N_4$ indicates that N vacancies may contribute to the electron traps. In the end, the electronic structure diagram of $SrLiAl_3N_4$ and Sr-Sialon with traps are constructed to illustrate the overall process of PersL and PSL.

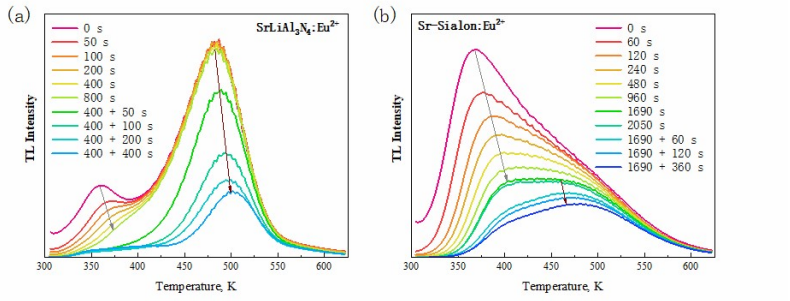


Figure 1 TL spectra of (a) $SrLiAl_3N_4:Eu^{2+}$ and (b) Sr-Sialon:Eu^{2+} after pre-treatment with darkness for different time plus 980 nm photostimulation for different time.

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Tunable near-infrared emission without intensity loss in high efficiency $Ga_4GeO_8:Cr^{3+}$ phosphor

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Near-infrared (NIR) phosphors serving as the core component of NIR phosphor-converted light-emitting diode (pc-LED) have received increasing attentions and vast investigations very recently. While the challenging issue of weak emission in the longer NIR waveband (especially for the wavelength above 850 nm) is still remained and extremely restrains the practical applications of NIR pc-LED. Herein, novel NIR $Ga_4GeO_8:Cr^{3+}$ ($GGO:Cr^{3+}$) phosphors are developed. A high internal quantum yield (IQY) is obtained to be 60% for $GGO:0.02Cr^{3+}$, which shows a NIR emission band peaking at 850 nm with a FWHM (full width at half maximum) ~215 nm upon 430 nm excitation. A new strategy of tunable emissions is presented in $GGO:Cr^{3+}$ phosphors via varying the Cr^{3+} concentration. The $GGO:Cr^{3+}$ phosphors display tunable emission bands peaking from 835 to 980 nm with increased FWFM from 210 to 270 nm with increasing Cr^{3+} concentration from 0.01 to 1.00. Moreover, the emissions present no intensity loss for $GGO:xCr^{3+}$ ($x = 0.02-0.10$) peaking from 850 to 900 nm. In addition, a NIR pc-LED is fabricated by integrating representative $GGO:0.02Cr^{3+}$ onto blue LED chip, exhibiting a maximum NIR output power of ~56 mW at 400 mA drive current, and the applications on night vision and food analysis are achieved basing on the as-fabricated NIR pc-LED. The results suggest that the $GGO:Cr^{3+}$ would be a promising NIR emission to overcome the weak emission in the longer NIR waveband, and this work further provides a new strategy of tunable NIR emission which can inspire the exploration on controlling emission.

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Emission from ultraviolet phosphor $LuAl_3B_4O_{12}:Bi^{3+},Gd^{3+}$ stimulated by ambient temperature and ambient lighting

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Ultraviolet persistent luminescence technology holds promising potential in some new application fields. However, not much is known about such luminescence [1]. To date, investigations on ultraviolet persistent phosphors has focused primarily on their luminescence properties in ambient dark. It is the requirement for ambient dark that is hindering the further development of persistent phosphors under different ambient conditions [2]. In this presentation, we introduce a novel phosphor $LuAl_3B_4O_{12}:Bi^{3+},Gd^{3+}$, which exhibits long-lasting ultraviolet emission peaking at 312 nm after x-ray charging. Interestingly, the initial intensity of the long-lasting emission recorded in ambient lighting condition is more intense than that recorded in dark environment. We carry out spectroscopic investigations on the material, revealing that both ambient temperature and ambient lighting simultaneously play the role of stimulants in the emission process. We hope the work brings different insight to luminescence research and offers approach to further learn about ultraviolet persistent phosphors.

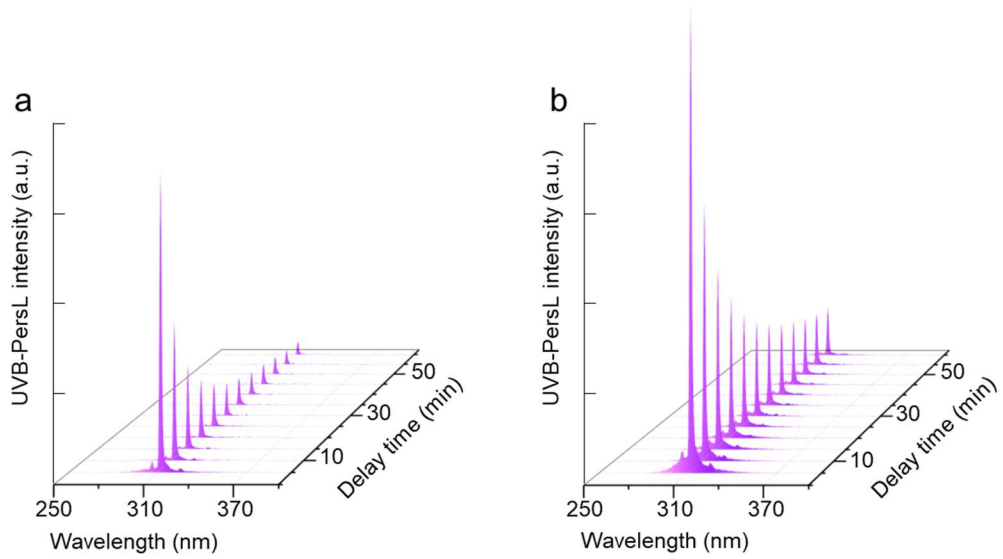


Figure 1. Emission spectra of $LuAl_3B_4O_{12}:Bi^{3+},Gd^{3+}$ phosphor recorded in dark (a) and bright (b) environments, respectively.

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Strategies to approach true quasi-point light source for high-luminance phosphor-converted laser lighting

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To obtain a true quasi-point light source with high-luminance light emission, the emitting area of the device needs to be as small as possible. In phosphor-converted laser lighting systems, a blue (pump) laser can, in fact, be focused into a very small spot. However, after excitation of the phosphor, this white-light-emitting area usually increases considerably, which reduces the characteristic benefits of laser lighting substantially. To solve this problem, we design and investigate a highly scattering YAG:Ce/glass composite film with a porous microstructure. Both the glass/phosphor interfaces and the introduced pores act as scattering centers, which can confine the emission area effectively. The relationship between the spot size and the microstructure (porosity, phosphor-particle size, thickness) is studied. Furthermore, by using a typical composite-film, the luminescent spot diameter (603 μm) is only 24 % larger than the laser spot diameter (485 μm). Furthermore, it was found that the spot-expansion ratio (rate of the spot-diameter increment) decreases, with increasing laser spot diameter. Whereas, the spot expansion (the spot-diameter increment) is generally constant. Under excitation with blue laser, the composite films can operate efficiently and are robust, showing a uniform white-light emission, a high luminous efficacy (176 lm/W), and a saturation-threshold that exceeds 29.7 W. A maximum luminous flux of 4941 lm for a correlated color-temperature of 4486 K is thus achieved. These excellent photometric and colorimetric properties of the designed composite films, together with the capability to confine the emission area, make them ideal color-converter candidates for the production of high-luminance, high-directionality, laser-driven white lighting.

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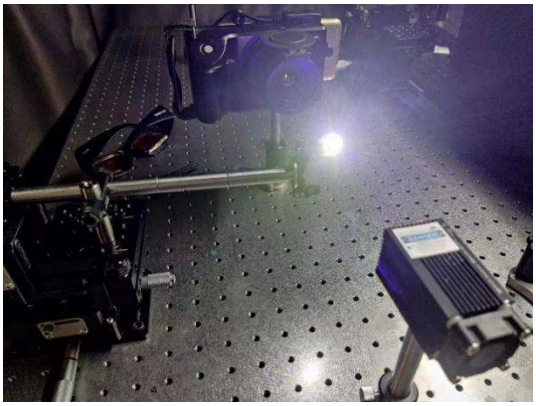
Ion-exchanged LTA zeolite derived nepheline-phase $NaAlSiO_4:Eu^{2+}$ ceramic phosphor for laser illumination

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A reliable yellow phosphor converter for laser illumination applications that can be efficiently excited by a 405 nm bluish violet laser is in high demand. A $NaAlSiO_4:Eu^{2+}$ phosphor with a quantum efficiency reaching 92% was obtained using LTA zeolite as the raw material. $NaAlSiO_4:Eu^{2+}$ ceramics with suitable porosities were prepared from the phosphor powders via spark plasma sintering. The ceramics lost only 2% of the quantum efficiency compared to the powders, maintained good thermal quenching properties (30% drop at 150 ℃), and showed good thermal conductivity (2.02 $W \cdot m^{-1} \cdot K^{-1}$). The $NaAlSiO_4:Eu^{2+}$ ceramic showed increasing luminous flux (23.83–70.26 lm) and stable luminous efficacy (47.7–46.8 lm/W) with the bluish violet driving laser powder density up to 9.15 W/mm^2. The temperature distribution of the ceramic remained uniform and stable under long-time laser irradiation. This indicates that the nepheline-phase $NaAlSiO_4:Eu^{2+}$ ceramic is a promising material for laser illumination.



A picture of the nepheline $NaAlSiO_4$：Eu^{2+} ceramic illuminated by a 1.5 W 405 nm laser.

ICL 2020

On the temperature dependence of Judd-Ofelt parameters in the luminescence of trivalent europium complexes

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Lanthanide-based complexes and materials are sources and versatile platforms for a wide range of technological developments, mostly because of their unique luminescent properties [1]. One of these features is the quantitative description of the emission intensities of lanthanide ions by only three quantities known as intensity parameters according to the Judd-Ofelt theory [2]. These parameters are relevant to explain, determine and predict luminescent properties such as, radiative lifetimes, energy-transfer rates and oscillator strengths. Eu^{3+} ions are particularly interesting because the intensity parameters Ω_λ $(\lambda = 2, 4, 6)$ can be obtained from the $^5D_0 \longrightarrow {}^7F_\lambda$ $(\lambda = 2, 4, 6)$ transition intensities relative to the $^5D_0 \longrightarrow {}^7F_1$ transition intensity. These parameters depend on coordination polyhedron, which varies with the temperature and their modeling should take into consideration thermal effects. In this context, we propose to investigate the temperature dependence of photophysical properties of $[Eu(hfa)_3(bpyO_2)]$ and $[Eu(bpyO_2)_4]^{3+}$ complexes, and to model these thermal effects on the intensity parameters using a new approach to calculate these parameters. Our results indicate that the dependence of the intensity parameters on structural changes of coordination polyhedron, which simulate the thermal effects, is larger for the Ω_4 parameter, while Ω_2 also varies significantly because the $^5D_0 \longrightarrow {}^7F_2$ transition is hypersensitive [3]. These results are corroborated by the experimental data and can contribute to develop a quantitative model of luminescence of these systems and their role in proposing new thermometric parameters.

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Tunable super-broad NIR luminescence in Cr-doped olivine phosphors towards multifunctional applications

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Near-infrared (NIR) phosphors have developed a lot in virtue of the increasing demands towards NIR smart devices. Previously, we have developed a series of Cr^{3+}-doped olivine phosphors, $(Mg_{1-x}Li_x)(Mg_{1-x}Sc_x)GeO_4:Cr^{3+}$, with tunable luminescence from NIR-I to NIR II based on crystallographic site engineering.[1] The NIR luminescence can be largely tuned from 940 nm to 1110 nm, and the corresponding FWHM can be modified from 236 to ~300 nm. Their potential applications as light sources for nondestructive food analysis were also demonstrated. In general, Cr^{3+} strongly prefers to occupy octahedral sites and produces NIR-I luminescence, while Cr^{4+} tends to occupy tetrahedral sites and results in NIR-II luminescence. It is highly desirable if chromium in a single composition host has mixed valence so that we can control the ratio of Cr^{3+}/Cr^{4+} to liberally tune the luminescent properties. In this work, we choose Mg_2GeO_4 as the host material to design chromium-valence-controllable phosphor, since six-coordinated Mg sites and four-coordinated Ge sites are very promising to accommodate Cr^{3+} and Cr^{4+}, respectively. High Li content charge compensators can stabilize the trivalent state while high temperature sintering tends to facilitate the formation of Cr^{4+}. By carefully adjusting the synthesis conditions, pure Cr^{3+} or Cr^{4+} luminescence can be obtained with peak emission locating at 935 and 1190 nm, respectively. Dual emission spanning from 650 to 1600 nm is also realized in the Cr^{3+} and Cr^{4+} co-existed sample. This study may initiate a new perspective for designing chromium-valence-controllable phosphors.

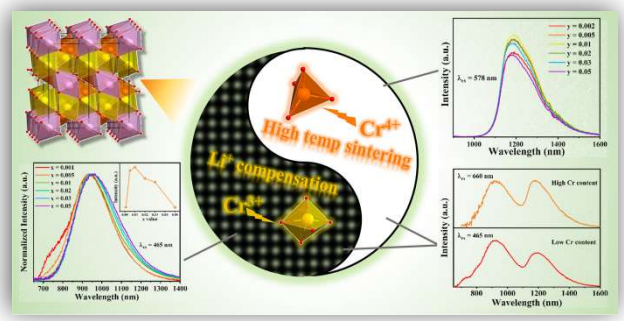


Illustration of tailored NIR luminescence in Cr-doped Mg_2GeO_4

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NIR-NIR Yb^{3+} luminescence decay based thermometry in $REPO_4$:Yb,Nd nanocrystals

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Luminescent nanothermometry (LTh) is an interesting tool to study in real time the behaviour of temperature dependent proccesses (e.g. thermogenesis, cancerogenesis, etc.) occuring in living organisms. I*n vivo* temperature sensors are also suitable to diagnose diseases (e.g. heart infarcts) or feedback control the progress of phtoto-thermal-therapy (PTT). Despite great progress in the field, the accuracy of the temperature readout using LTh may be however hampered by the physical interaction of the light emitted by the LTh with the biological medium, which owes to light reabsorption and scattering. Therefore, one of the most promising approaches to LTh which circumvent the above mentioned issues, is luminescent thermometry based on the kinetics of the luminescence which occurs at single excitation and single emission wavelengths, and only the relative shape of kinetic curve reports on temperature changes. Hence, intensive research is currently underway around the world which aim to finding new lifetime based LTh operating in the optical windows of biological tissues spectral range. [1]

In this study, we investigate the thermometric properties of LTh based on the luminescence kinetics of the excited states of the Yb^{3+} ions in biocompatible $Nd_{0.5}RE_{0.5}PO_4$ (RE-Y^{3+}, Lu^{3+}, La^{3+}, Gd^{3+}) nanoparticles. The Yb^{3+} emission is excited through phonon assisted energy transfer form Nd^{3+} ions upon λ_{exc}=808 nm. At elevated temperatures, back $Yb^{3+}\rightarrow Nd^{3+}$ energy transfer is activated which shortens the $^2F_{5/2}$ lifetime proportionally to temperature. The studies confirmed that the lifetime of $^2F_{5/2}$ state of the Yb^{3+} can be successfully used as a thermometric parameter and its thermal response including relative sensitivity and the operating temperature range can be further tuned by the modification of the host material composition.

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Acknowledgement

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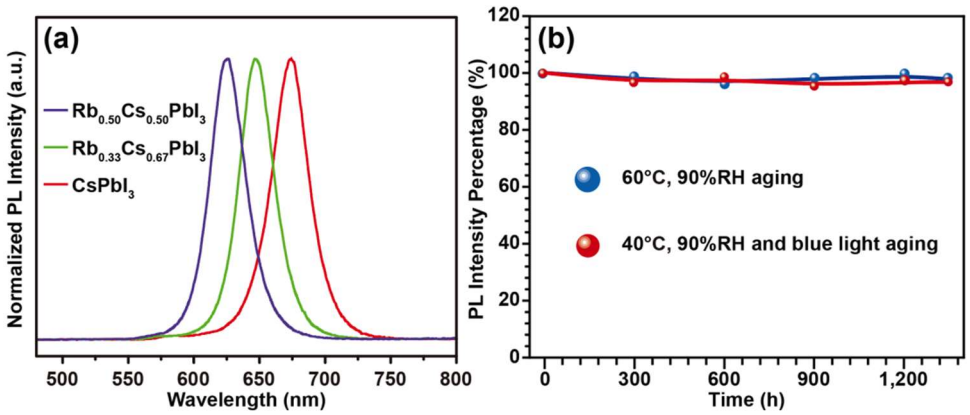
Highly Stable and Spectrally Tunable γ-$Rb_xCs_{1-x}PbI_3$ Gradient-Alloyed Quantum Dots in PMMA Matrix through A Sites Engineering

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Perovskite quantum dots are emerging as new generation functional materials for display applications. The issue of perovskite "red wall" has been an obstacle for their use in display technology. Therefore, we developed the fabrication of γ-$Rb_xCs_{1-x}PbI_3$ gradient-alloyed quantum dots in polymeric matrix through a rational designed in situ fabrication process. The formation of γ-$Rb_xCs_{1-x}PbI_3$ gradient-alloyed structure can be explained by considering the lattice mismatch and solubility difference between γ-$CsPbI_3$ and $RbPbI_3$. The photoluminescence emission of γ-$Rb_xCs_{1-x}PbI_3$ gradient-alloyed quantum dots can be tuned from 675 nm to 620 nm with full width at half maximum of 31 nm and maximum quantum yields up to 91%. Importantly, the packaged films retained about 95% of its original photoluminescence intensity after 1000 hours aging at the test conditions of 60°C, 90% RH and 40°C, 90% RH with 3 mW/cm^2 455 nm blue light irradiation, respectively. By integrating a red and green dual emissive film with blue Mini LEDs, a LCD backlight of a color space of ~130% of NTSC 1931 standard was achieved with matching rate of 100%.



(a) PL spectra of the composite films with a set of Cs:Rb ratio. (b) The stability of packaged γ-$Rb_{0.5}Cs_{0.5}PbI_3$ gradient-alloyed QDs composite film.

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Two hybrid metal halide nonlinear optical crystals of (TMEDA)MI_5 (M = Sb, Bi) with high stability

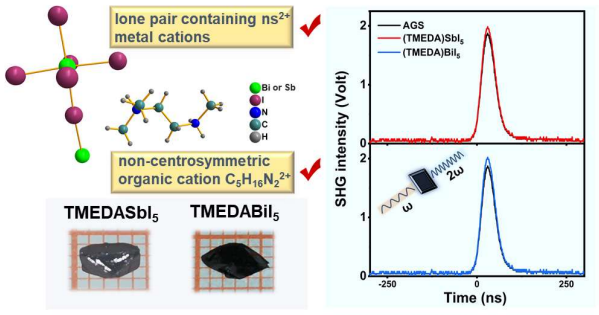
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Organic–inorganic metal halides (OIMHs) with unique structural flexibility possess excellent photoelectric properties, which is regarded as next-generation photovoltaic materials, phosphors, semiconductors and ferroelectrics.[1] The metal-halide units in OIMHs are believed to be good microscopic building blocks of nonlinear optical crystal for laser wavelength conversion.[2] Here, we synthesized two new lead-free OIMHs (TMEDA)SbI_5 and (TMEDA)BiI_5 ($TMEDA^{2+}$ is the N,N,N'-trimethylethylenediammonium) using the concept of non-central organic matter and ns^{2+} electronic unit, both of which have a one-dimensional structure crystallizing in the orthorhombic system with a non-centrosymmetric $P2_12_12_1$ space group. Remarkably, both compounds possess strong nonlinear optical response in the same magnitude with $AgGaS_2$, a benchmark semiconductor-type nonlinear optical crystal. In addition, under the excitation of ultraviolet light and visible light, both (TMEDA)SbI_5 and (TMEDA)BiI_5 produced self-trapped exciton induced red light emission at 695 and 805 nm, respectively. First-principles electronic structure calculations revealed that their optical properties originated from the electronic transition within the inorganic metal halides group. These findings indicate that (TMEDA)SbI_5 and (TMEDA)BiI_5 are potential photoelectric materials for laser frequency conversion and fluorescence, and the discovery of remarkable NLO effect in these two compounds verified that OIMHs are also good candidate of NLO crystals.



Crystal and SHG intensity of (TMEDA)SbI_5 and (TMEDA)BiI_5.

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Photophysical characterization of YVO_4: Yb^{3+}, Er^{3+} nanoluminophores under variable pressure conditions

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YVO_4 nanomaterials doped with Yb^{3+} and Er^{3+} ions exhibit visible up-conversion luminescence with a narrow emission band after excitation by near-infrared (NIR). Up-conversion (UC) is a phenomenon where two or more low-energy photons are converted into one photon with higher-energy (Vis) [1]. Additionally, the luminescence of Er^{3+} ions is temperature-dependent due to the thermally-coupled levels.

Ln^{3+} -doped materials can be applied as LED, bioimaging materials, photovoltaics, security markers and sensors. The properties of materials are strongly dependent on external conditions. In this work, well-defined luminescent inorganic nanoparticles (YVO_4) were successfully synthesized by a hydrothermal method. The structure, morphology and luminescence properties of the obtained products were investigated.

Measurements of the up-conversion luminescence were carried out under high-pressure and ultra-low pressure conditions in order to investigate the influence of pressure on the properties of materials [2,3]. The obtained materials exhibit a red-shift of the emitted light as the pressure increases due to increased interactions between ions and decreasing differences between their ground and excited energy states. The enhancement of the laser-induced heating of the sample observed under low-pressure conditions was used to convert the luminescent thermometer into a contactless low-pressure sensor. The research of YVO_4:Yb^{3+}, Er^{3+} nanoparticles in low- and high-pressure allows it to be used as a sensor with a wide pressure range.

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Luminescent nanothermometer operating at very high temperature - sensing up to 1000 K with upconverting nanoparticles (Yb^{3+}/Tm^{3+})

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Temperature is a fundamental parameter of many industrial processes, such as sintering, catalytic reactions, metal alloying, creation new materials under extreme conditions, etc. Therefore, rapid, accurate, and real-time monitoring of this phenomenon is a challenge for many specialists in various scientific fields, industrial researchers, and material engineers.[1,2]

We show how to overcome these limitations and monitor very high-temperature values, with high sensitivity and good thermal resolution at around 1000 K, using upconverting Yb^{3+}–Tm^{3+} codoped YVO_4 nanoparticles. For ratiometric sensing in the low-temperature range, we used the relative intensities of the Tm^{3+} emissions (associated with the $^3F_{2,3}$ and $^3H_4$ thermally coupled levels) 700/800 nm band intensity ratio. In order to improve the sensitivity and resolution in the high-temperature range, we used the 940/800 nm band intensity ratio of the nonthermally coupled levels of Yb^{3+} ($^2F_{5/2} \rightarrow {}^2F_{7/2}$) and Tm^{3+} ($^3H_4 \rightarrow {}^3H_6$). These NIR bands are very intense, even at extreme temperature values, and their intensity ratio changes significantly, allowing accurate temperature sensing with high thermal and spatial resolutions.[3]

The optical thermometer we obtained could enable a highly sensitive method to accurately monitoring high temperatures. This nanothermometer can be used in industrial applications, in processes requiring very high temperature conditions as well as submicron-size resolution.[3,4]

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Improved ligand-free modification strategy of core/shell $NaYF_4:Yb^{3+},Er^{3+}/NaYF_4$ up-converting nanoparticles

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Nowadays, research groups have paid special attention to the synthesis of up-converting nanoparticles (UCNPs) doped with Ln^{3+} ions, which show visible emission under near-infrared radiation [1]. The high-quality UCNPs with a particular size, shape, and phase can be synthesized using precipitation reaction in high-boiling-point solvents [2]. Unfortunately, the synthesized oleate-capped UCNPs cannot be used in biomedical experiments because of their insolubility in water [3]. Therefore, it is advantageous to modify their surface. The ligand-free modification strategy allows the preparation of NPs which are stable in aqueous solutions and ready for further surface conjugation with biomolecules [4]. Unfortunatelly, the mentioned method can be associated with difficulties, such as the tendency of NPs to agglomerate and low reaction effiiency [5].

The main goal of our study was to improve the ligand-free modification strategy to obtain water-stable UCNPs with bright emission and high reaction yield. Different combinations of hydrochloric acid molarities and mixing times were selected to remove the organic ligand from the NPs' surface and to discover the most promising modification approach. In the described study, the stability of colloids, hydrodynamic diameter of nanoparticles and emission spectra upon continuous-wave excitation at 980 nm were presented (confirmed by zeta potential measurement, dynamic light scattering and spectrometer with CCD camera, respectively) and measured directly after surface modification and additionally after 6 months. Furthermore, the sizes of both oleate-capped and ligand-free NPs were determined by TEM images. The effects of the changing modification conditions on the reaction yield, UCNP morphology, and spectroscopic properties were demonstrated.

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Microstructural properties of ceramics doped with rare earth ions for use as scintillators

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In recent years, polycrystalline materials with a double perovskite structure, including ceramics, have gained great interest due to their physicochemical properties. As a result, they find many different applications - they are used as laser materials, phosphors for WLEDs, optical filters, optoelectronics, biomedical materials, aviation, and military materials, etc. The transparent ceramics obtained in this work are intended to be used as detectors of high-energy ionizing radiation. The requirements for scintillators are above all a high absorption coefficient of ionizing radiation, which is related to the high density of the material and the rapid decay time of the scintillation signal. The investigated hosts are very promising because they are characterized by a high density greater than 6 g/cm^3.

Ba_2MgWO_6 (BMW), $Ba_2Mg_{0.99}Eu_{0.01}WO_6$ (BMW-Eu) and $Ba_2Mg_{0.99}Nd_{0.01}WO_6$ (BMW-Nd) phosphors were prepared by conventional high-temperature solid-state reaction method. The obtained powder were then sintered by using Spark plasma sintering (SPS) method. After sintering the samples were annealed at 1000 °C for 10 h in air for reoxidation and graphite burnout. The last stage of the process was machining and polishing.

Ceramic materials obtained by the SPS method on the basis of BMW, BMW-Eu and BMW-Nd polycrystalline powders were microstructurally analyzed. For this purpose, XRD, SEM and density measurement by the Archimedes method were performed. Overall, the obtained results confirm the obtaining of well-dense double perovskite ceramics.

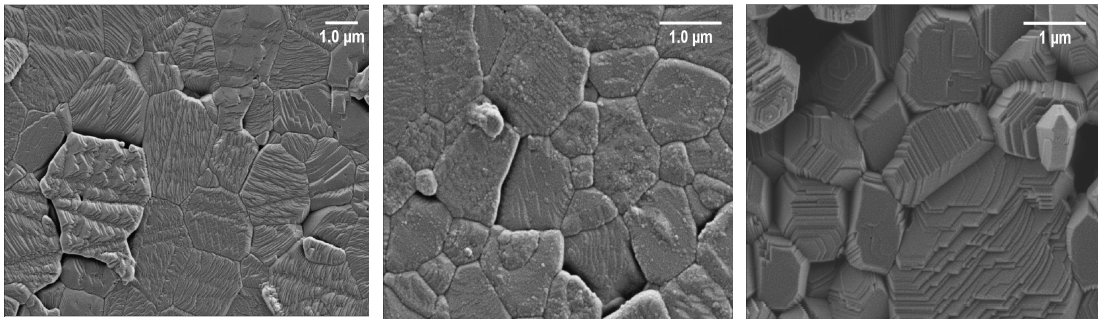


Fig. 1. The microstructure of ceramics sintered at 1350°C by SPS method: a – BMW-host (left), b – BMW-Eu (center), c – BMW-Nd (right).

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A novel fluorescence emission mechanism for CdZnS solid solution defect anti-electron doping through oxygen adsorption of sulfur vacancies

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Defect engineering has been widely used in many fields as a strategy by designing semiconductor defects, such as catalysis, photovoltaics, etc. However, it is often necessary to eliminate defects as much as possible, due to defects in conventional semiconductors substantially lower the photoluminescence quantum yield (PLQY) in the field of fluorescent materials. We report a CdZnS solid solution-based oxygen adsorbed sulfur vacancy defect complex with an emission mechanism of anti-electron doping, which removes the electron-phonon coupling of the defect and converts the defects sites of fluorescence annihilation into a strong fluorescence emission center. Through cathodoluminescence, we can estimate that the local defect PLQY can reach more than 75%, which lays the foundation for development of new defect-enhanced fluorescent materials.

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Enhanced photostability and photoluminescence of PbI_2 via constructing Type-I heterostructure with ZnO

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Improving the stability of lead iodide (PbI_2), especially photostability, is in crucial demand for the realization of application-level optoelectronic devices. In this regard, deposition of organic polymers on PbI_2 as a protective layer is a common strategy to improve its stability, but polymers with low thermal conductivity generally cannot produce the desired effect. Herein, a novel strategy is proposed for improving the photostability of PbI_2 at different excitation wavelengths, including 320, 405, and 532 nm, via constructing type-I heterostructure with ZnO with high thermal conductivity. In addition, due to the type-I band alignment between PbI_2 and ZnO, the photogenerated carriers in ZnO can be transferred to PbI_2, resulting in a nearly eightfold photoluminescence enhancement of PbI_2under 320 nm laser excitation. The ZnO as a protective layer forming type-I heterostructure is evidenced as a feasible strategy for enhancing the photostability and photoluminescence of PbI_2, facilitating the development of practical applications.

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Fabrication and luminescence investigation on ZnO nanorod array/GaN heterojunction

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ZnO nanorod arrays (NRA) were fabricated by solution method on p-GaN substrate, and highly vertical-oriented ZnO NRA were obtained with ZnO or MgZnO seed layer. The temperature-dependent photoluminescence (PL) showed that the near band-edge (NBE) of ZnO NRA made red shift as ambient temperature increased, and the NBE peak experienced decrease-increase tendency, presenting a transformation process between bound excition to free excition emission. Such transformation decreased the radiative recombination efficiency of defecet emission (DE) in visible region, causing a domination of NBE PL at room temperature.

For ZnO NRA/GaN heterojunction device, an obvious bule light could be observed after current injection, and the luminescence at NBE was originated from ZnO exciton emission, ZnO/GaN interfacial luminescence and GaN accepter recombination. By increasing the injection current, the luminescence could be enhanced and red-shifted, but vanished under high injection current (over 30 mA), showing a thermal effect influenced on the performance of the device. Compared with heterojunction with ZnO seed layer, devices using MgZnO seed layer could enhance the carrirer recombination on ZnO side due to the large band gap of MgZnO which limited the electron injection of ZnO on conductive band toward GaN side. Meanwhile, the luminous intensity could be increased by 2.5 times under the injection current of 30 mA due to the existence of MgZnO barrier layer which lowered the influence of the interfacial state on the luminous performance of ZnO.

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Enhanced emission intensity in lanthanide-based materials co-doped with Li^+ ions

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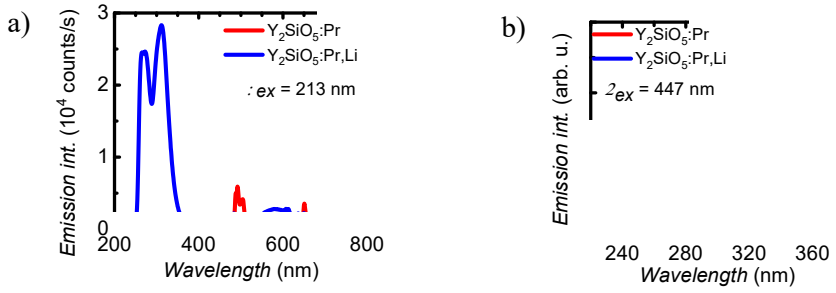
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Lathanides, which are well-known for their extraordinary energy level structure allowing $4f^N \rightarrow 4f^N$ electronic transitions, are utilized for a plethora of photonic and optical applications. [1] Since there is a possibility to precisely manipulate the ratio of excited photons to emitted photons, some optical processes can be realized, such as up-conversion (UC) or quantum cutting (QC). [2]

Emission intensity of rare earth ions cannot be plotted as a simple linear function of dopant concentration. What significantly influences on emission intensity is concentration quenching and other processes of undesirable energy migration. It is often observed that despite the optimal concentration of lanthanide dopant in material, emission intensity is still low. Therefore, a few ways to allow intra-*4f* transitions to be more probable have been widely exploited, including addition of another non-lanthanide element to host matrix, such as Li^+, Fe^{3+}, etc. [3, 4]

In this work our main focus is on spectroscopic mesurements performed on Pr^{3+} and Li^+ co-doped materials (e.g. Y_2SiO_5). Preliminary results show that addition of Li^+ significantly increases Stokes emission intensity under 213 nm pulsed laser excitation. Similar trend can be observed in some materials when excited with 447 nm diode laser for anti-Stokes up-conversion from visible to UV-C region. The results are of considerable importance for the further research to employ such materials in antibacterial applications not only at macroscale, but also at micro- and nanoscale.



Emission intensity comparison of Y_2SiO_5 ceramics after a) 213 nm, b) 447 nm laser excitation

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Ionic liquid assisted synthesis routes for fabrication of fine nano-crystalline Nd^{3+}-doped $LuPO_4$ optical material

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The aim of this study was to obtain fine nanoparticles of Nd^{3+}-doped $LuPO_4$ zircon-(xenotime)-type orthophosphates (0.5–15 mol%) with using simple lanthanide precursors such as lanthanide nitrates and task-specific ionic liquid (IL) of choline dihydrogen phosphate as the reactant and in-situ nanoparticle stabilizer. The compounds were prepared by hydrothermal method and microwave treatments. These synthesis routes possess many advantages as they are fast and facile preparation methods of the desired well-crystallized single phase phosphate nanomaterials of good quality, as we present in this work.

In frame of this work the structural, morphological and spectroscopic investigations of the fabricated powders were performed. The XRD and microscopic (SEM/TEM) analysis revealed some influence of synthesis conditions on morphology and nanoparticles size, what is reflected in their spectroscopic properties. As the high-temperature solid-state reaction is known as an efficient way to obtain a very pure well-crystallized orthophosphates, for comparative studies the micro-powdered Nd^{3+}-doped $LuPO_4$ obtained in such way, recently studied by us, were used [1].

Nd^{3+} ion can be used as structural probe and by applying the low-temperature high-resolution techniques like absorption spectroscopy at 4.2K and laser site selective spectroscopy at 77K, detailed structural and spectroscopic studies of Nd^{3+}-doped $LuPO_4$ micro-powders were performed. Abnormal temporal behavior of photoluminescence in Nd^{3+} doped $LuPO_4$ nano/micro-powders were also studied.

In addition, we have focused on the possible application of this material as a thermometer by analysing the thermal dependence of the intensity of emission lines under λ_{ex}=532 nm excitation in the temperature range between 293 and 613 K. Especially, we note that the $^4F_{5/2}$ level is populated by a thermal excitation from the $^4F_{3/2}$ level due to a small energy gap between these levels.

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Localized surface plasmon enhanced electroluminescence from n-ZnCdO/MgO/p-GaN via decoration of Ag nanoparticles

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In this work, the heterostructure of n-$Zn_{0.85}Cd_{0.15}O$/I-MgO was fabricated on p-GaN/c-Al_2O_3 substrate via palsed laser deposition (PLD) method, and a layer of Ag thin films with different thickness was evaporated on MgO and annealed in vacuum to form Ag nanoparticules (NPs). A typical heterojunction diode of n-$Zn_{0.85}Cd_{0.15}O$/MgO/p-GaN with the decoration of Ag NPs was constructed by evaporating a Ni/Au electrode on p-GaN surface and vacuum sintering an In electrode on n-ZnCdO surface, as shown in Fig. 1(a). Fig.1(b) exhibits electroluminescence (EL) spectra of the heterojunctions with different thicknesses of Ag NPs at room temperature. When the thickness of Ag film is 6 nm, the dipole formant peak of obtained Ag NPs centered at 444 nm matching the luminescent peak of p-GaN, which could enhance EL intensity of p-GaN layer. When the thickness of Ag film reaches 20 nm, the dipole formant overlaps with the emission peak of the n-$Zn_{0.85}Cd_{0.15}O$ film, which also improves the intensity of EL peak at 495nm from n-ZnCdO layer. These results indicate that dual mode enhancement of pn heterostructure can be achieved by adjusting the thickness of the Ag film when it located between n-$Zn_{0.85}Cd_{0.15}O$ and p-GaN.

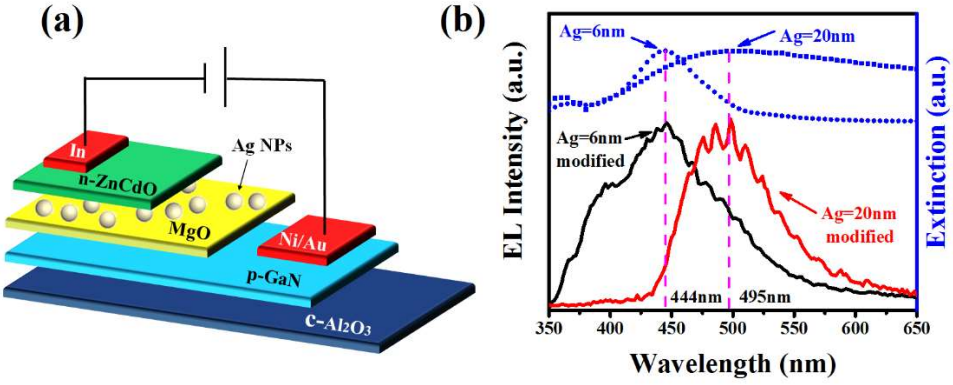


Figure 1.(a) The structure of n-$Zn_{0.85}Cd_{0.15}O$/MgO/p-GaN heterojunction device modified by Ag nanoparticles; (b) EL spectra of devices modified by 6 nm and 12 nm Ag film with 10 mA forward injection current, and corresponding extinction spectra of Ag nanoparticles.

Spectroscopic properties and color-tunable emission based on the layered gadolinium terbium/europium hydroxides

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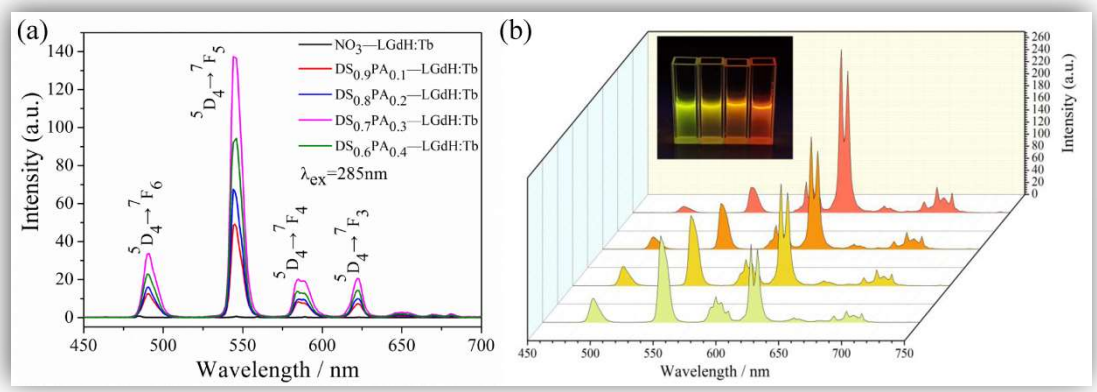
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Layered rare earth hydroxides (LREHs) are a new class of two-dimensional layered materials. Their interlayer anions can be flexibly adjusted to produce synergistic effect with the rare earth ions in the host layer. As a result, the optical properties of layered assemblies are regulated.

In this work, the dodecyl sulfonate (DS^-) and phthalate (PA^-) were co-inserted into the LGdH:Eu/Tb matrix binding with NO_3^- through the ion exchange and intercalation chemistry means, and the samples were peeled off with *n*-butanol to achieve colloidal solution. The results show that the anion PA^- matches well with the energy levels of Eu^{3+} and Tb^{3+}, which can significantly enhance the luminescence of the layered compound, and exhibits characteristic emission of Eu^{3+} (red) and Tb^{3+} (green). By changing the relative content of the two colloidal solution of LGdH:Tb and LGdH:Eu, the emission color variations from green to yellow, orange, and red can be precisely controlled. Additionally, DS^- and PA^- intercalated LGdH:Tb colloidal solution is suitable to detect metal ions in aqueous solutions, especially for Fe^{3+} ion. This organic-inorganic hybrid system provides new ideas for the development of new multifunctional luminescent materials.

Fig.1 (a) Emission spectra of organic anions and NO_3^- intercalated LGdH:Tb solid samples;



(b) Emission spectra of colloidal solutions in different ratios

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Unraveling structure origin of oxygen ion conduction upon cations co-doping by photoluminescence

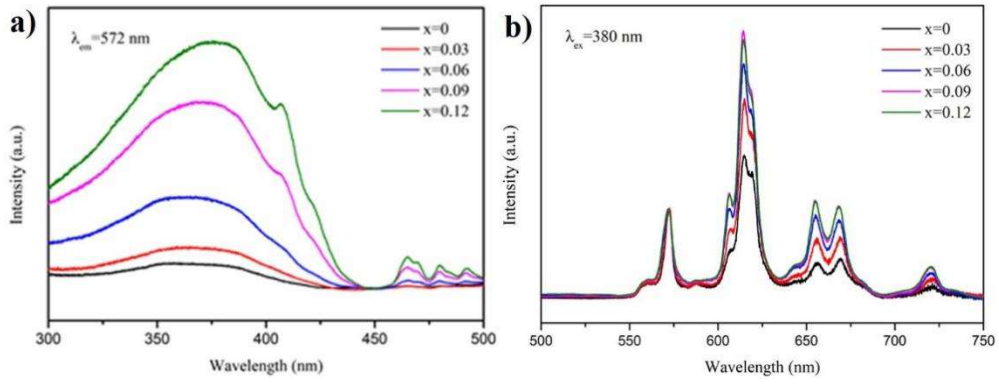
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Doping or co-doping is the universal and most effective strategy to enhance ion conductivities by modulating the coordination surroundings of oxygen vacancy in oxygen ion conductors. Herein, the structure origin of bulk conduction upon cations doping, exemplified in $Ce_{1-x}Sm_xO_{2-\delta}$ (x=0~0.2) and $Ce_{0.85}Sm_{0.15-x}La_xO_{2-\delta}$ (x=0~0.15) polycrystalline oxygen ion conductors, has been unraveled by employing the structure-sensitive photoluminescence properties of Sm^{3+} ions.

It was found that, for $Ce_{0.85}Sm_{0.15-x}La_xO_{2-\delta}$ (x=0~0.15) system, oxygen vacancies prefer to exist at the nearest neighbor (NN) position of Sm^{3+} ions not Ce^{4+} ions in SDC, but oxygen vacancies in LDC prefer to exist at the nearest neighbor (NN) position of Ce^{4+} ions rather than La^{3+} ions. For $Ce_{1-x}Sm_xO_{2-\delta}$ (x=0~0.2) system, oxygen vacancies prefer to exist at the nearest neighbor (NN) position of Ce^{4+} ions for x lower than 0.05, but oxygen vacancies prefer to exist at the nearest neighbor (NN) position of Sm^{3+} ions for x higher than 0.05. The strategy to reveal the relationship between doping and electrical conduction by photoluminescence may be very helpful to understand the changes on coordination surroundings of oxygen vacancy and construct reliable empirical formula in choosing suitable dopants to optimize electrical properties for various ion conductors.



Excitation (a) and emission (b) spectra of $Ce_{0.85}Sm_{0.15-x}La_xO_{2-\delta}$ pellets

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Multiplasmons-pumped excited-state absorption and energy transfer upconversion of rare-earth-doped luminescence beyond the diffraction limit

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Rare-earth-doped upconversion luminescence has attracted extensive attention due to its narrow-band and wide-range emission spectra, which cover biological and optical communication windows. For direct laser excitation, the photoluminescence of upconversion nanoparticles is inevitably involved in the excitation laser signals to luminescence, limiting its application due to high background noise, heating, and the low quantum yield of rare-earthdoped upconversion photoluminescence. Here, multiplasmons-excited upconversion luminescence was investigated by employing propagating surface plasmons polaritons on a monocrystalline silver microplate: pure plasmon near-field excitation without background photoluminescence. Due to near-field excitation, multisurface plasmons upconversion luminescence exhibit strong excited-state absorption and energy transfer upconversion, and more than 97-fold luminescence enhancement was obtained without background noise. It was found that multiplasmons-excited luminescence can be easily controlled by surface plasmons polaritons propagation and excitation modes and laser polarization directions, and a super-resolution luminescence of upconversion nanoparticles was achieved beyond the diffraction limit. The characterization of multiplasmon-excited luminescence helps not only enhance the understanding of light−matter interactions between rare-earth ions and plasmons in the near-field, but also benefits the development of bioimaging and the super-resolution of micro light sources.

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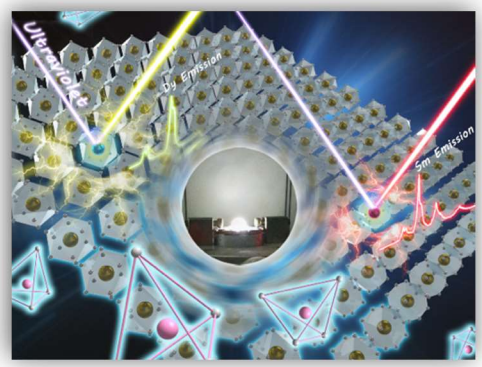
A novel multi-center activated single-component white light-emitting phosphor for deep UV chip-based high color-rendering WLEDs

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Single-component white light-emitting phosphors for pc-WLEDs are a hot spot of solid-state lighting field. Here, a novel multi-center activated single-component white light-emitting phosphor, $Sr_2LaGaO_5:Dy^{3+},Sm^{3+}$, has been designed and synthesized. It is surprisingly found that there is no evident energy transfer between the host and dopants even though they satisfy the rule of spectral overlap, which can be explained from the special structure of the phosphor. The co-excitation of the host and the dopants would be a facile strategy to finely tune the luminescent spectra of phosphors. By adjusting the doping concentrations of Dy^{3+} and Sm^{3+}, we can control the relative intensities of the emissions from Dy^{3+}, Sm^{3+} and the host. Therefore, the emission color of the co-doped phosphors can be tuned from white light to orangish red region with CCT decreasing from 5708 K to 1971 K. A WLED device with extremely high Ra up to 91.4 was fabricated by coating the synthesized phosphor with a deep UV LED chip. And it is the first time to use a single-component white light-emitting phosphor co-activated with Dy^{3+} and Sm^{3+} in deep UV chip excited WLEDs with high Ra.



The schematic diagram of as-fabricated WLED device

Acknowledgements

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Surface-related laser induced white emission phenomenon in transparent Cr:YAG ceramics

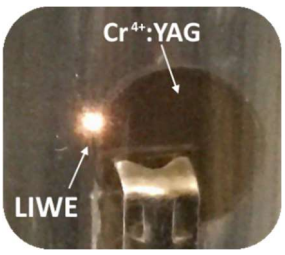
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Recently, a considerable scientific interest has been devoted to studies of the Laser Induced White Emission (LIWE). This phenomenon has been observed in different materials including inorganic materials, hybrid nanostructures, organometallics, etc. Reported spectra covers whole Vis and NIR part of spectrum and its intensity can be regulated both by the excitation power and ambient pressure [1]. Up to the present, the proposed mechanisms for LIWE include black body radiation, charge transfer luminescence, thermal avalanche, etc. Therefore, a general understanding has not yet been established amongst scientists on the LIWE mechanism.

The aim of this work is understanding the mechanism behind of Laser-stimulated white light emission. So far, most of the work has focused on opaque nanopowder materials, in contrast to this work, which used transparent Cr:YAG ceramics. The samples were synthetized by solid-state reaction sintering in vacuum ambient at 1750 °C for 10 h. 1064 nm laser diode was used as excitation source (3.4 W). The samples were placed in vacuum ambient at 10^{-4} mbar [2,3].



The photo of LIWE from Cr:YAG sample.

It was shown that LIWE can be generated only at the surface of the samples. Due to the fact that the sample is transparent, the laser beam penetrated the entire volume of the sample, but white light was emitted only from the surface [3]. It's impressive that the white emission was detected at the output of the laser beam from samples volume. This is surprising since the power of the laser beam decreased towards the exit due to absorption by Cr^{4+} as well as Cr^{3+} ions. The interaction of the laser beam with the surface leads to ionization with simultaneous emission of photons and free photoelectrons. The ionization process occurs due to the process of multiphoton absorption in a Cr^{3+}/Cr^{4+} mixed valence pair with the ejection of electrons and subsequent recombination, leading to the transfer of electron with the emission of photons.

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Synthesis and luminescent properties investigation of Cr^{3+}-doped $YX_3(BO_3)_4$ borates ($X=Al^{3+}$, Ga^{3+})

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Cr^{3+}-doped $YX_3(BO_3)_4$ borates exhibit intensive luminescence in the near infrared (NIR) spectral range from 680 nm up to 800 nm, which enables their application for NIR laser devices or NIR light sources [1–4]. Recently, it was shown that by appropriate adjustment of the host matrix stoichiometry as well as the concentration of Cr^{3+} dopant ions, the ratio of luminescence intensity of narrowband $^2E \rightarrow {}^4A_2$ emission to the $^4T_2 \rightarrow {}^4A_2$ broadband emission could be intentionally modulated [5,6]. The gradual enlargement of the metal to oxygen (M^{3+}-O^{2-}) distance in the matrix structure, contributes to lowering the crystal field strength. In consequence, the splitting of Cr^{3+} energy states becomes smaller, which is exemplified by lowering the energy of the $^4T_2$ state parabola and thus decreasing the activation energy of nonradiative depopulation of the ^2E state. This phenomenon is especially favorable for sensitive non-contact luminescent thermometers. Therefore, in this work, a detailed analysis of the influence of the host matrix composition, type of the synthesis method and their conditions on the spectroscopic properties of Cr^{3+} ions will be performed. Additionally, the effect of the Cr^{3+} concentration on the luminescence of Cr^{3+}-doped $YX_3(BO_3)_4$ will be investigated.

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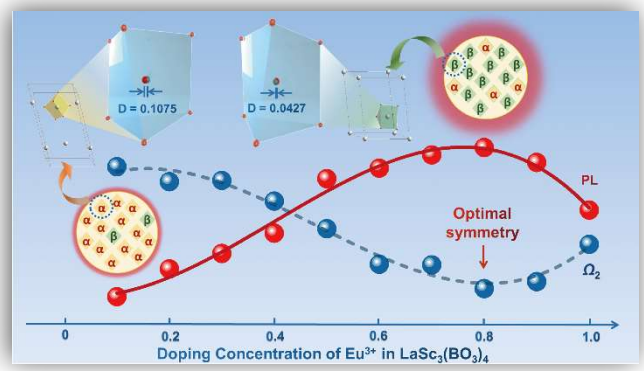
Delayed concentration quenching of luminescence caused by Eu^{3+}-induced phase transition in $LaSc_3(BO_3)_4$

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In order to explore the influence of phase transition on luminescent properties, a series of Eu^{3+} doped phosphors were prepared via a high-temperature solid-state reaction. A monoclinic α-phase and a trigonal β-phase were found coexisting and constantly changing with various doping concentration of Eu^{3+}. The phase transition induced by the doping concentration of activators and the changes of luminescent properties caused by the transition were then studied in detail. A delayed concentration quenching effect was surprisingly discovered in the materials and it is evidenced to closely connect with the structure transitions triggered by phase transitions. Besides, the high quantum efficiency and the good thermal stability of the as-prepared phosphor suggest its promising application prospect in solid-state lighting. This kind of activator-induced phase transitions contributing to the enhanced luminescence and the delayed quenching concentration may provide a new and effective way for improving luminescent properties of phosphors.



Phase transition and the changes of luminescent properties with increasing doping concentration of Eu^{3+}

Acknowledgements

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Structure, luminescence and potential applications of $LiSr_4(BO_3)_3$: Ln (Ce^{3+},Eu^{2+})

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In order to further develop lanthanide-activated inorganic materials in anti-counterfeiting with wide color tunability, we select Ce^{3+}, Eu^{2+} ions with adjustable 5d-4f emission as activators, and $LiSr_4(BO_3)_3$ with different crystallographic sites as host compound. The compound $LiSr_4(BO_3)_3$ crystallizes in the cubic space group $Ia\bar{3}d$, in which Sr^{2+} ions occupy two diverse lattice sites [1]. $Sr^{2+}(1)$ ions are six-fold coordinated to form distorted octahedral [$Sr(1)O_6$], while $Sr^{2+}(2)$ ions are eight-coordinated in two-capped trigonal prisms [$Sr(2)O_8$], which may endow Ce^{3+} and Eu^{2+} with different emission colors. In our work, a series of $LiSr_4(BO_3)_3$:Ln (Ln = Ce^{3+},Eu^{2+}) samples were prepared via a high-temperature solid-state reaction method. X-ray diffraction techniques along with Rietveld refinement, UV−vis photoluminescence a ） nd fluorescence decay measurements were utilized to investigate the site occupancy, luminescence and energy transfer dynamics of Ce^{3+} and Eu^{2+}. Then the color variation of Ce^{3+}, Eu^{2+} co-doped $LiSr_4(BO_3)_3$ sample at 300 K – 420 K were displayed by screen printing technology. The wide color tunability of the sample indicates its potential application in the field of anti-counterfeiting.

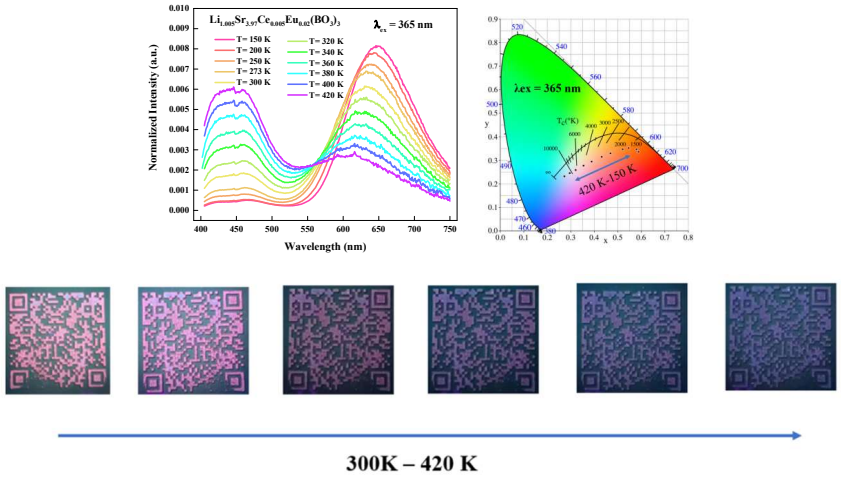


Figure 1. The emission spectra and CIE chromaticity diagram at 150 K – 420 K and the display of screen printing technology at 300K – 420 K of $Li_{1.005}Sr_{3.97}Ce_{0.005}Eu_{0.02}(BO_3)_3$.

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Temperature-dependent emission color variation of Ce^{3+}, Eu^{2+} co-doped $Sr_3B_2O_6$ phosphors

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Recently, lanthanide-activated luminescent materials have aroused great attentions in the applications of information storage and security.[1] The manipulations of their luminescence properties including emission color and thermal stability under different external fields (temperature, pressure, etc.) provide new opportunities to develop the information storage and security applications with multi-responsive features. In this work, series of Ce^{3+}, Eu^{2+} singly/doubly doped $Sr_3B_2O_6$ (SBO) samples were synthesized via conventional high-temperature solid-state method. The crystal, vibrational structure as well as luminescence properties of Ce^{3+}, Eu^{2+} doped samples including 4f-5d transition energies, emission bandwidth and luminescence thermal stabilities were studied in detail with the aid of some techniques like XRD, TEM, synchrontron radiation Far-IR and VUV-UV spectroscopy and so on. Vacuum referred binding energy (VRBE) scheme of lanthanide ions in the $Sr_3B_2O_6$ host is constructed to analyze the thermal stability of Ce^{3+} and Eu^{2+} emission.[2] Their great differences in emission color and thermal stability may endow them with potential applications in thermal-induced information storage and security.[3]

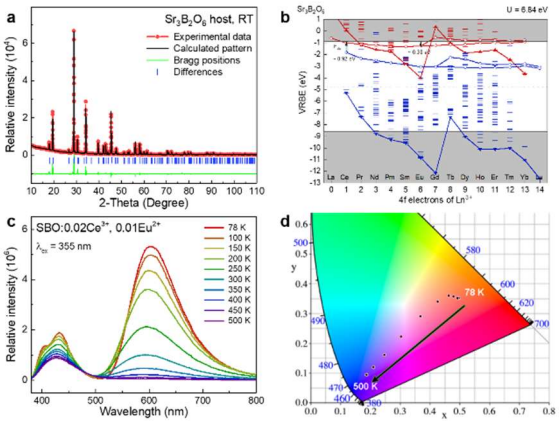


Figure 1. (a) Rietveld refinement of XRD pattern of SBO host; (b) VRBE scheme of lanthanide ions in SBO host; (c) Temperature-dependent emission spectra of SBO:0.02Ce^{3+}, 0.01Eu^{2+} in the range of 78-500 K (λ_{ex} = 355 nm) and (d) their corresponding CIE chromaticity coordinates.

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Pr^{3+}/Yb^{3+} co-doped yttrium tantalates: from tunable white light generation to near-infrared ultra-broadband emission

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Given that the Covid-19 pandemic has required the adoption of social isolation measures, meeting the growing demand for more efficient and reliable telecommunication networks to carry larger data volume is currently one of the major and most urgent technological challenges [1]. Furthermore, the development of light sources with high luminous efficiency, reliability, significant reductions in power consumption and pollution from fossil fuel, such as the white light-emitting diodes (*w*-LEDs), is another contemporary challenge [2]. In both cases referred, rare earth (RE)-doped materials become a clever alternative to potentialize the characteristics of the commercial *w*-LEDs and optical amplifiers. In the present work, we report the structural and spectroscopic characterization of a multifunctional material: the xPr^{3+}/yYb^{3+} co-doped yttrium tantalate (x = 0.5 mol%; y = 0.05, 0.15, 0.25, 0.5, 1, 2, 3 and 4 mol%) designed by an attractive sol-gel methodology. The samples were annealed at 900 or 1100 °C for 2 h and exhibited the Y_3TaO_7 and the M'-$YTaO_4$ phases. Photoluminescence measurements revealed a noteworthy intensity variation for the emissions arising from the $^3P_0$ (blue) and $^1D_2$ (red) states with the increment on the Yb^{3+} concentration. The light-emitting color was adjusted from rich orange/red to bright white, achieving all the Color Correlated Temperature ranges, from ultra-warm white (1000 K) to cool white (6938 K). A wide color tunability, from the blue up to the green region, could be observed as well within the Yb^{3+} concentration raise, upon excitation at 980 nm (Yb^{3+}:$^2F_{7/2}\rightarrow{}^2F_{5/2}$), for both annealing temperature systems. Dual simultaneous excitation measurements in the UV (or visible) and NIR ranges were performed and outstanding broadband from 1.3 to 1.7 µm was obtained with a FWHM larger than 220 nm, covering several bands in the third telecommunication window. Nevertheless, owing to the detector limitation, the total region occupied by this broadband has not been entirely investigated, especially for the Pr^{3+} transition $^3F_2\rightarrow{}^3H_4$, at 1.7 µm, therefore, the total bandwidth ought to be even broader. All the abovementioned structural and luminescent properties make these yttrium tantalates potential candidates for Photonic applications.

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White light emission based on GeO_2-Nb_2O_5 rare earth doped under excitation at 980 nm and ultraviolet

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GeO_2-Nb_2O_5:0.3%Ho^{3+}/1.2%Yb^{3+}/0.5%Tm^{3+} nanocomposites were produced using the sol-gel method. The main objective of this work is the preparation and structural and spectroscopic characterizations of these luminescent materials for white light emission. X-ray diffraction measurements were performed on nanocomposites calcined at 900 and 1100 ºC. The trigonal phase of germanium oxide GeO_2 was confirmed in both heat treatments. For the sample calcined at 1100 ºC, the coexistence of the tetragonal mixed oxide $GeO_2.9Nb_2O_5$ was observed. Under infrared excitation, at 980 nm, the sample calcined at 900 °C showed luminescence upconversion processes, with red, green and blue emissions, which are the three colors responsible for the emission of white light. The band at approximately 470 nm (blue) refers to the $^1G_4 \rightarrow {}^3H_6$ and/or $^5F_3 \rightarrow {}^5I_8$ transitions of Tm^{3+} and Ho^{3+} ions, respectively. The green emission around 546 nm is attributed only to the Ho^{3+} ion transitions ($^5S_2$,$^5F_4 \rightarrow {}^3H_6$). In the red region at 658 nm, the transitions attributed to the ions Ho^{3+} ($^5F_5 \rightarrow {}^5I_8$) and Tm^{3+} ($^1G_4 \rightarrow {}^3H_4$) occur in all fluorescence spectra.[1, 2] For the sample treated at 1100 °C under ultraviolet excitation (245 to 280 nm), were observed in addition to the emission band of the host lattic, the emissions of Ho^{3+} ions in 540, 590, 613, 623 and 653 nm, assigned to $^5S_2$, $_5F_4 \rightarrow {}^5I_8$, $^5G_6 \rightarrow {}^5I_7$, $^5F_2 \rightarrow {}^5I_7$, $^5F_3 \rightarrow {}^5I_7$ and $^5F_5 \rightarrow {}^5I_8$ transitions, respectively.[3,4] Emissions of Tm^{3+} ions referring to transitions $^1G_4 \rightarrow {}^3F_4$ (653 nm) and $^3F_3 \rightarrow {}^3H_6$ (704 nm).[1] Thus, the sample calcined at 900 ºC under excitation at 980 nm and the calcined at 1100 °C under excitation at UV showed emission in the white light region. Such preliminary results demonstrate the relevant potential of these rare earth doped materials in several photonic applications, in solid-state lighting.

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Luminescence of $Eu_xLa_{1-x}Fe_3(BO_3)_4$ mixed crystals

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Huntite-like iron borates $RFe_3(BO_3)_4$ (R – rare-earth ion) are widely known materials that combine interesting magnetic, magnetoelectric, optical, and structural properties. These compounds are the second type multiferroics, they order magnetically at a temperature of about 30K, and some of them exhibit a giant magnetoelectric effect [1]. Iron borates can be found in two crystal structures, a high-temperature trigonal with the space group $R32$ and a low-temperature, also trigonal, $P3_121$. The structural phase transition temperature can vary over a wide temperature range, from 450 K for $YFe_3(BO_3)_4$ to 90 K for $EuFe_3(BO_3)_4$ [2]. We have shown that solid solutions of rare-earth iron borates make it possible to obtain any required phase transition temperature, including temperatures below the magnetic phase transition (<30K). At the same time, a composition-dependent temperature hysteresis (up to 5K) is observed in the system, which can be used for practical applications [3,4].

Here, we study the luminescent properties of the series of $Eu_{1-x}La_xFe_3(BO_3)_4$ mixed crystals with x from $x = 0$ to $x = 0.12$. The La^{3+} ion, which is larger in ionic radius and is optically inactive, was chosen as the diluting ion to obtain a desired temperature of the $R32 \rightarrow P3_121$ structural phase transition in the range from 87 to 12 K. Simultaneously, the width of an almost rectangular hysteresis loop varied from 0.29 K to 4.7 K, respectively. The luminescence of the Eu^{3+} ion was detected under various excitations. We show that the luminescent properties of the $Eu_{1-x}La_xFe_3(BO_3)_4$ crystals strongly differ for the $R32$ and $P3_121$ structural phases. This can be used to implement luminescence-based optical storage devices and switches operating at any chosen temperature between 87 and 12 K. Such devices can be in demand in modern quantum information technologies dealing with low temperatures.

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Specific features of synthesis and luminescence for lithium-aluminum spinels doped with manganese ions

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Ceramic samples of lithium-aluminum spinels doped with manganese ions have been synthesized by high-temperature solid-state reaction technique. Samples obtained by annealing in air for 4 hours at temperatures of 1000, 1100, 1200 or 1300 °C are identified as $LiAl_5O_8$ belonging to the $P4_132$ spinel-type crystal structure with the lattice parameter 'a' changing from 7.925 to 7.908 Å. Ceramics annealed at temperatures of 1000 - 1200 °C show intense red luminescence of Mn^{4+} ions, having a narrow emission band peaking at 662 nm. The charge compensation of Mn^{4+} ions replacing Al^{3+} ions at the octahedral sites of the $LiAl_5O_8$ lattice is achieved due to the excess amount (with respect to stoichiometry) of lithium ions substituting for some Al^{3+} ions near Mn^{4+} ions. On the other hand, annealing at a higher temperature (1300 °C) or long annealing (170 hours) at a lower temperature (1100 °C) leads to almost complete disappearance of Mn^{4+} luminescence at 662 nm, although X-ray diffraction analysis shows that the crystal structure of these ceramics remains the same belonging to space group $P4_132$, but with a lattice parameter a = 7.908 Å, which exactly corresponds to this parameter for the ideal single crystal $LiAl_5O_8$ [1]. One can assume that ceramics obtained at a lower temperature and having a larger lattice parameter are solid solutions in which some of the Al^{3+} ions are replaced by larger Li^+ ions. Such solid solutions are not stable and lose Li^+ ions during annealing, transforming into the stoichiometric compound $LiAl_5O_8$. In the "perfectly" stoichiometric $LiAl_5O_8$, Mn^{4+} ions cannot be stabilized at octahedral sites due to the lack of a charge compensation mechanism, and the red luminescence of Mn^{4+} ions in such samples is absent.

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Doping-site dependence of upconversion emission of Ho^{3+} ion in $CaHfO_3$

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The Upconversion (UC) emission properties of Ho3+ and Yb3+ co-doped CaHfO¬3 ceramics were investigated in terms of the site substitution, i.e., Ho3+ and Yb3+ ions occupying the Ca sites (A-site) and Hf sites (B-site). Upon excitation of 980-nm near-infrared light, the Ho3+ activators in our samples exhibited sizable green emissions with assistance of Yb3+ ions as sensitizers, together with relatively small red emissions. Interestingly, the A-site doped samples showed much stronger UC emission intensities than B-site doped ones. Because the emission intensity of the Ho3+ ions increased with the increasing asymmetry in their local lattice environments, our finding suggested that the A-sites should have lower crystalline symmetry than B-sites in CaHfO3. The intensity of green UC emission was found to decrease with increasing Ho3+ concentration commonly in both A-site and B-site doped samples. We observed the non-monotonic temperature dependence of the UC emission, which might originate from the complexity in the energy transfer and relaxation.

Insight into the luminescent properties of Yb^{3+}/Bi^{3+}- doped $La_2Zr_2O_7$: charge transfer state and sensitization

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In this work, we report on the photoluminescent features of Yb^{3+}/Bi^{3+} incorporated into the pyrochlore-type $La_2Zr_2O_7$ (LZO) host. The materials were synthesized by a facile soft-chemical polymeric complex method including a final calcination step at 1000°C for 1h. X-ray diffraction patterns (Fig. 1 (a)) confirm the presence of the expected crystalline structure for all samples, it is cubic compatible with the Fd-3m symmetry. Furthermore, whole fitting of those patterns, lead to consistent variations in the cell parameter according to the amount and size of the substitutional ions. Addition of Yb and Bi into the LZO produces appreciable changes in the absorption (Fig. 1 (a)) and photoluminescent (Fig. 1 (b)) spectra. In the first, the conspicuous absorption band between 200 nm and 250 nm ascribed to the fundamental LZO electronic transition broadens slightly, and a shoulder attached to that appears, respectively, when Yb and Bi are added. In the latter, an intense excitation band when Yb^{3+} emission is monitored at 976 nm is observed. It is ascribed to a ligand-to-metal charge transfer $O^{2-/-} \rightarrow Yb^{3+/2+}$ state. On the other hand, the presence of an additional excitation band between 275 nm and 375 nm in the Yb/Bi co-doped sample, assigned to the $^1S_0 \rightarrow {}^3P_{0,1}$ Bi^{3+} electronic transitions, demonstrate that the Yb^{3+} luminescence is being sensitized by Bi. Finally, a whole rational picture of all optical experimental observations using a vacuum referred binding energy diagram [1, 2] is presented, where relevant electronic levels of $La_2Zr_2O_7$, Yb and Bi are depicted.

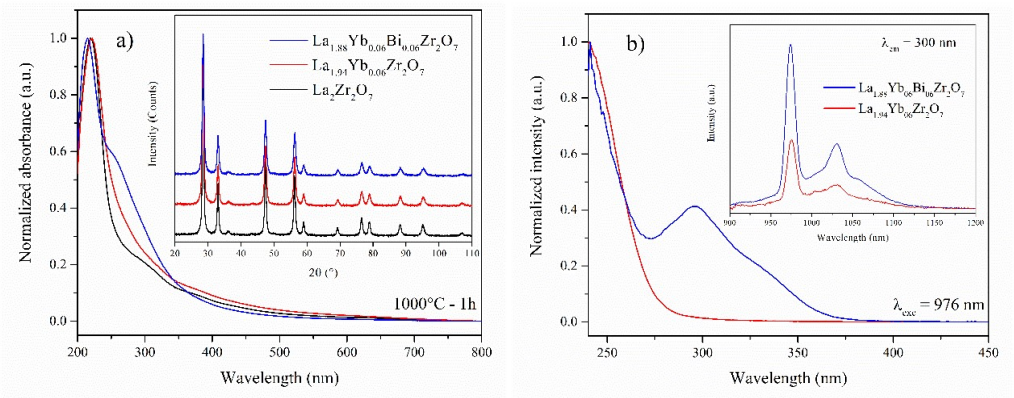


Figure 1. a) Absorption spectra and XRD patterns, b) luminescence spectra for $La_2Zr_2O_7$: Yb^{3+}-Bi^{3+} samples.

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Synthesis, structure, and high efficiency luminescence of $Ba_3Y_4O_9:Gd^{3+}/Eu^{3+}$

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A serie of novel $Ba_3Y_4O_9:Gd^{3+}/Eu^{3+}$ uniform phosphors were prepared via NH_4HCO_3 co-precipitation. The $Ba_3Y_{(4-x-y)}Gd_xEu_yO_9$ phosphor particles exhibited typical red emissions ($^5D_0 \rightarrow {}^7F_2$ transition of Eu^{3+}) at 614 nm upon ultraviolet excitation, and the quenching concentration of Eu^{3+} is found to be ~5 at.%. The lattice expanded as a function of Gd doping ratio, and the conduction band shifted to the lower energy, leading to a redshift of the charge transfer band (CTB) center from 251 nm to 256 nm ($^8S_{7/2} \rightarrow {}^6I_J$ intra f-f transition of Gd^{3+}). The phosphor could maintain triangular rhomboid structure when the doping ratio of Gd is up to ~40 at.%, and the red luminescence was significant enhanced, which is attributed to the effective $Gd^{3+} \rightarrow Eu^{3+}$ energy transfer. Meanwhile, the quantum efficiency of $Ba_3Y_{2.2}Gd_{1.6}Eu_{0.2}O_9$ enhanced up to ~156% than that of $Ba_3Y_4O_9:Eu^{3+}$. Moreover, temperature-dependence photoluminescence indicated that the thermal stability of $Ba_3Y_4O_9:Gd^{3+}/Eu^{3+}$ phosphors could be significant improved due to the introduction of Gd^{3+}. The co-doping uniform phosphor obtained in this work could have hotprospect applications in high-resolution display technologies and novel-functionalities.

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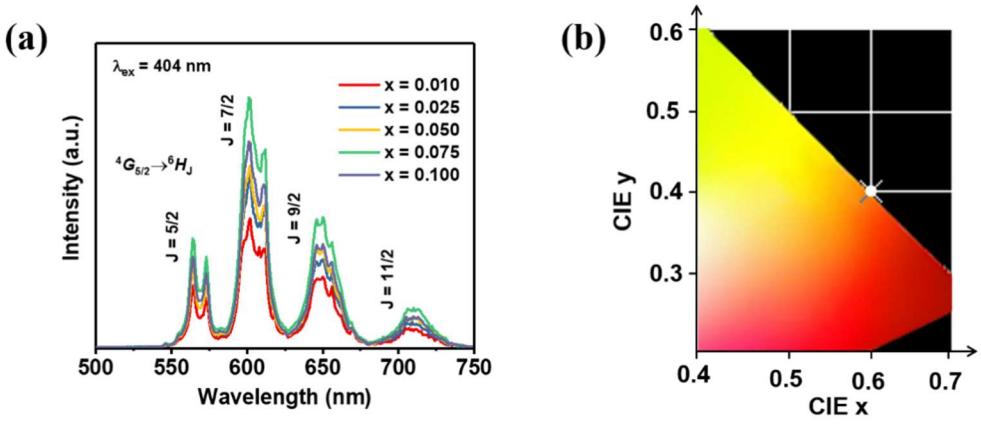
Luminescent properties of a novel red phosphor activated with Sm^{3+}

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Red phosphors play an important role in in WLEDs simulating natural sunlight. A novel red phosphor activated with Sm^{3+} was synthesized via a high temperature solid-state reaction. The crystal structure of the host is structurally characterized with the space group of $P6_3cm$. And all of the characteristic diffraction peaks from the host are clearly retained after Sm^{3+} doping and no unwanted reflections from the impurity phases can be found at the same time. Under the excitation of 404 nm, the phosphors doped with different concentration of Sm^{3+} exhibit orangish red emission. The emission intensity improves monotonically with increasing Sm^{3+} content up to 7.5% and then decreases. The CIE chromaticity coordinates are *(0.6001, 0.3988)* and the quantum efficiency is 13.9% when Sm^{3+} doping concentration is 7.5% under 404 nm excitation. All the results indicate that the novel phosphor activated with Sm^{3+} has potential applications in WLEDs simulating natural sunlight as a red component.



Concentration-dependent emission spectra of Sm^{3+} doped phosphors (a) and CIE chromaticity diagram of the sample with the Sm^{3+} doping concentration of 7.5% (b)

Acknowledgements

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A novel bright yellow emitting phosphor - $Ca_3(BN_2)I_3:Eu^{2+}$

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Among divalent lanthanides, Eu^{2+} is the most frequent investigated ion, due to its relative high stability as well as the variability of the position of the excited 5d levels leading to different emission colors covering the whole UV/VIS range. In general, very intense 5d-4f emission bands due to the parity-allowed nature of these transitions are observed. Eu^{2+} has been well investigated doped in inorganic hosts in bulk [1, 2] as well as nanoscaled form [3]. Alkaline earth di-nitridoborate halides are very rarely used as hosts, although, it can be assumed that the emission and excitation bands are located at low energy, which is interesting for applications in LEDs.

In this work, the photoluminescence of $Ca_3(BN_2)I_3$ doped with Eu^{2+} ions is presented for the first time. The synthesis was performed using Ca_3N_2, BN, CaI_2 and EuI_2 as starting materials in a sealed tantalum container at 700 °C. The emission band maximum is located in the yellow range peaking at around 580 nm (Fig. 1). The respective excitation spectrum shows that excitation at low energies, like e.g. 520 nm, is possible. Therefore, $Ca_3(BN_2)I_3:Eu^{2+}$ is a promising candidate for future energy saving LEDs. The redshifted emission for $Ca_3(BN_2)I_3:Eu^{2+}$ in comparison to for instance, $CaI_2:Eu^{2+}$ [4] can be attributed mainly to the increasing covalency caused by the nitrogen atoms of the complex anion $[BN_2]^{3-}$.

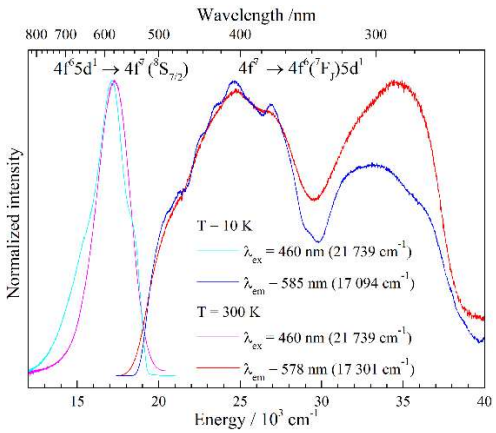


Figure 1: Emission- and excitation spectra of $Ca_3(BN_2)I_3$:0.5 % Eu^{2+} at T = 10 K and T = 300 K.

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Eu^{3+}-doped $BaMO_4$ (M: W or Mo) luminescent materials for lighting applications prepared by coprecipitation method

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This work presents the development and investigation of the structural, spectroscopic, and electronic properties of Eu^{3+}-doped $BaMO_4$ (M: W or Mo) compounds obtained by the coprecipitation method, at room temperature, targeting applications in phosphor-converted Light-Emitting Diode (pc-LEDs) lighting devices [1,2]. A systematic study was performed to determine optimal doping concentrations in order to obtain high-intensity monochromatic-like luminescence with efficient lanthanide quantum yield for red light emission. Structural analysis by X-Ray Powder Diffraction showed a stable characteristic scheelite-type structure for all of the studied compounds, with no phase segregation, as confirmed by Rietveld Refinement, whereas average crystallite size was estimated to be about 30 nm. Morphology and elemental distribution were probed by Scanning Electron Microscopy coupled with Energy dispersive X-ray spectroscopy, where homogeneous europium distribution was identified even at high doping concentrations (up to 10% molar). The optical behavior of the prepared materials was studied by Diffuse Reflectance Spectroscopy and Luminescence Spectroscopy in the UV-Vis range, displaying characteristic red emission, together with the nephelauxetic effect associated with spectral red-shifts attributed to structural distortions around the Eu^{3+} ion and significant (LMCT) contribution. The intensity parameters $\Omega_{2,4}$ and lanthanide quantum yield Q^{Ln}_{Ln} of all Eu-doped materials were also determined. Furthermore, the CIE color diagram was investigated, showing the rate of greenish-blue host matrix contribution ($[WO_4]^{2-}$ or $[MoO_4]^{2-}$) and Eu^{3+} luminescence in different compounds.

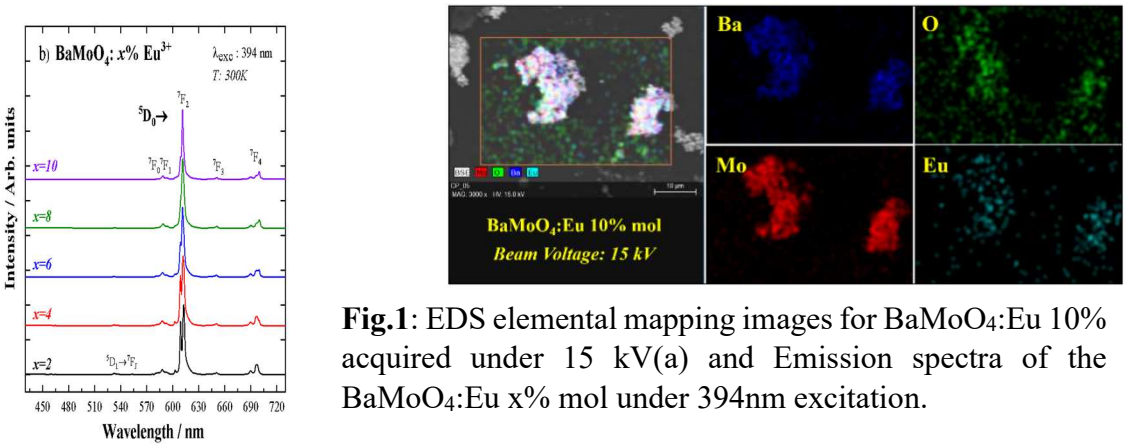


Fig.1: EDS elemental mapping images for $BaMoO_4$:Eu 10% acquired under 15 kV(a) and Emission spectra of the $BaMoO_4$:Eu x% mol under 394nm excitation.

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Double perovskites a new family of highly symmetric oxide matrices

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So far the most common example in the literature of highly symmetrical matrices where the impurity ions are located in the Oh symmetry site with the center of inversion is the elpasolite matrices. In the 70s of the last century, many works appeared on the spectroscopic properties of such matrices. Elpasolites, however, are halides, often very sensitive to moisture. The obtained double perovskite matrices exhibit very good resistance to external conditions.

In this study A2BB'O6 (where A= Ba, Sr; B=Mg, Zn and B'=W, Mo), double perovskites were obtained and examined by spectroscopic means. In the course of the research, it turned out that the dopants of the Eu^{3+}, Nd^{3+}, Er^{3+} ions occupy the position of Mg^{2+} or Zn^{2+} instead of selecting larger sites of Ba^{2+} or Sr^{2+} ions coordinated by a greater number of oxygen ligands. The Mg or Zn site has perfect Oh symmetry with an inversion center. High symmetry leads to full compliance with the selection rules, therefore electrical dipole transitions are completely forbidden. In the emission spectra, only lines associated with magnetic dipole and vibronic lines associated with electric dipole transitions are observed. However, charge transfer transitions namely $O^{2-} \rightarrow Mg^{2+}$ / Zn^{2+} are allowed. This allows convenient excitation of the dopant ions. The presence of CT emission, as well as the simultaneously observed emission of Ln^{3+} ions, makes double perovskite a very interesting research material not only from the scientific point of view but also for its application aspects.

Acknowledgments: This study was supported by "The National Science Centre" under Grant No. 2017/25/B/ST5/02670, which is gratefully acknowledged.

Temperature behaviour of La_2MgTiO_6 double perovskite doped with Mn^{4+} and Cr^{3+} ions

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Double perovskites with general formula $A_2BB'O_6$ is a large group of materials. Due to their excellent performance such as good chemical stability, high emission intensity, and thermal stability they provide growing interest. These materials crystalize in a different crystallographic structure such as cubic, tetragonal, monoclinic, and orthorhombic depending on the charge and ionic radii.

The orthorhombic La_2MgTiO_6 (LMT) has been recently attracted huge attention because of its flexible crystal structure and thermal stability. Due to the strong absorption of the TiO_6 groups, this host can be excited efficiently by the UV-VIS range. The samples of $La_2MgTiO_6:Mn^{4+}$, $La_2MgTiO_6:Cr^{3+}$, and $La_2MgTiO_6:Mn^{4+}$, Cr^{3+} were prepared by co-precipitation method. The structure of the samples was confirmed by powder X-ray diffraction. The absorption and emission spectra, as well as decay times of the emitting level of dopant, were investigated. In particular, the influence of Mn^{4+} concentration on the luminescence properties has been analyzed. LMT:Mn^{4+} exhibits spin-forbidden $^2E_g \rightarrow {}^4A_{2g}$ transition with the maximum at 709 nm. For co-doped samples, additional peaks assigned to spin-forbidden emission of Cr^{3+} ions centered at 744 nm were detected. The temperature-dependent behavior of emission of single doped and co-coped samples was analyzed in detail.

Acknowledgments: This study was supported by “The National Science Centre” under Grant No. 2017/25/B/ST5/02670, which is gratefully acknowledged.

Investigation of thermochromic properties of $Sr_4Al_{14}O_{25}:Mn^{4+}/Tb^{3+}$ for temperature imaging

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In recent years, the luminescence thermometers are emerging as compelling tools for spatial and temporal temperature changes determination in distinct applications [1,2]. Among luminescence thermometers, the inorganic phosphors co-doped with transition metal and lanthanide ions are especially attractive due to their high photo- and thermochemical stability combined with the easiness in the modification of their spectroscopic and thermometric parameters by the selection of the host material. Here we present, the novel approach of exploitation of the luminescence thermochromism of the $Sr_4Al_{14}O_{25}:Mn^{4+}$, Tb^{3+} nanocrystals to determine temperature [3]. The combination of temperature sensitive Mn^{4+} luminescence with the almost temperature independent emission of Tb^{3+} ions was used to observe the explicit change of the emission color from red to green at elevated temperatures (Fig. 1). Our results demonstrate the variability of chromaticity coordinates can be used to detect the temperature changes. The calculated relative sensitivity for this phosphor reached $S_R(x) = 0.6\%/°C$ at 150 °C.

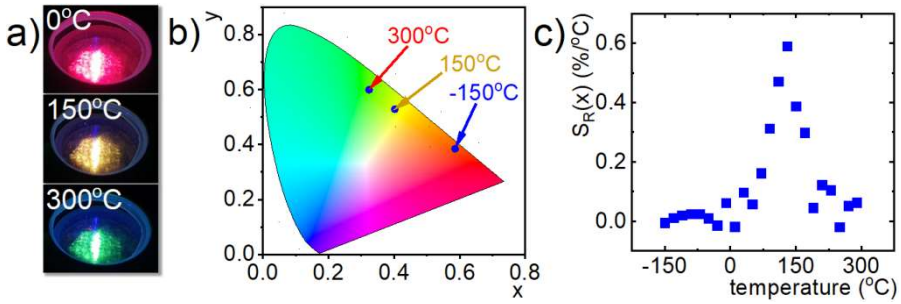


Figure 1. Photographs of the color of the emitted light upon 266 nm excitation - a), the CIE 1931 coordinates of the emitted light - b); and thermal evolution of $S_R(x)$ - c) for $Sr_4Al_{14}O_{25}:Mn^{4+}$, Tb^{3+} powder.

Acknowledgments: This work was supported by the National Science Center Poland (NCN) under project no. DEC- UMO-2018/31/G/ST5/03258 and by the German Research Foundation (DFG) under project 426574030.

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Crystal structures and luminescence properties of new phosphate phosphors

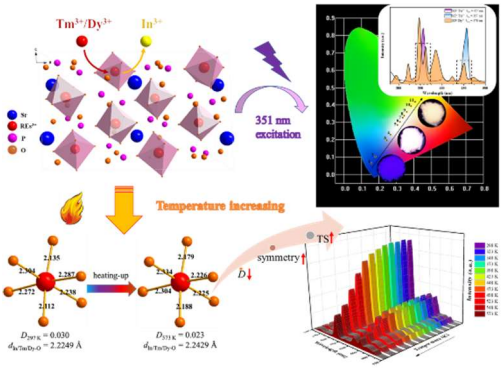
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The photoluminescence behaviors of a rare earth luminescent material are not only dependent on the type, valence, and concentration of rare earth ions, but also related to the crystal field and energy transfer provided by the host compound. Therefore, the key to the development of new rare earth luminescent materials is the exploration of new host compound and matching design of doping ions.

In this work, aiming at designing new phosphors for fluorescent lamps and LED lamps, we investigated the subsolidus phase relations in MO (M=Mg, Sr)-In_2O_3-P_2O_5 ternary system, explored potential ternary compounds and solved their structures. Based on their structural characteristics and physical properties, appropriate rare earth ions were chosen to dope into the host compounds, and the photoluminescence behaviors as well as related mechanisms were analyzed and discussed.



The Daylight-White Emitting and Abnormal Thermal Anti-Quenching Phosphors Based on a Layered Host $SrIn_2(P_2O_7)_2$

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Mn^{4+} luminescence in double-perovskites. The effect of temperature, pressure and chemically induced structural disorder

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Detailed studies on optical properties of Mn^{4+} in a series of double perovskites, $Ba_2LaNbO_6:Mn^{4+}$, $Ba_2La(Zr_{0.5},W_{0.5})O_6:Mn^{4+}$, and $Ba_2La(Nb_{0.8},Zr_{0.1},W_{0.1})O_6:Mn^{4+}$, were performed. Photoluminescent experiments were conducted in the range of 10-500 K under ambient and high (Gpa) pressure in order to determine parameters responsible for both energy and intensity of the $^2E_g \rightarrow {}^4A_{2g}$ zero-phonon emission transition. The Mn^{4+} energy levels were calculated using the exchange charge model (ECM) of crystal-field theory and were compared with the corresponding experimental data. It was found that chemically introduced structural disorder leads to the broadening of the emission features (see fig. 1) as well as to the changes in the covalency of the Mn-O bond and distorts the Mn^{4+} octahedron. Changes observed in spectroscopic data are fully consistent with the results obtained from ECM calculations.

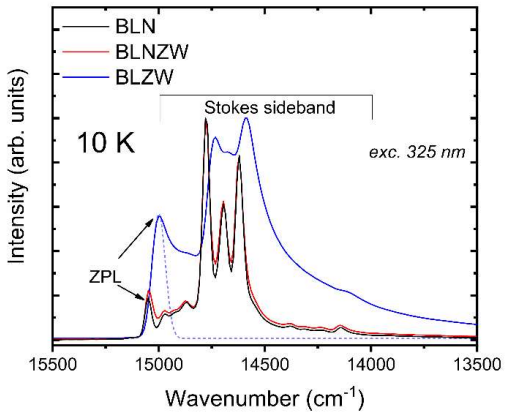


Fig. 1. Low temperature emission spectra of (a) $Ba_2LaNbO_6:Mn^{4+}$ (BLN), (b) $Ba_2La(Nb_{0.8}Zr_{0.1}W_{0.1})O_6:Mn^{4+}$ (BLNZW) and (c) $Ba_2La(Zr_{0.5}W_{0.5})O_6:Mn^{4+}$ (BLZW) in wavenumber scale. The line ca. 15000 cm^{-1} is the zero phonon line (ZPL), while the rest of the lines constitute Stokes phonon sideband. In case of sample (c), the ZPL was reconstructed by Gaussian fit of the edge of the emission spectrum (dashed line), due to overlap between ZPL and phonon structure.

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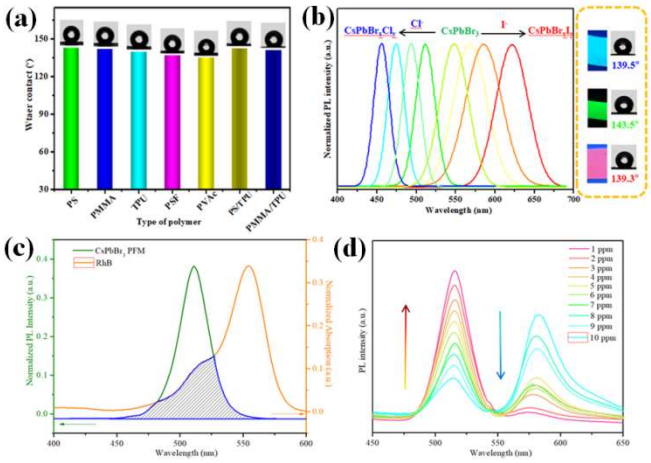
In situ growth of $CsPbX_3$ NCs in PS nanofibers toward ultrahigh stability as multifunctional supersensitive detectors

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All-inorganic ($CsPbX_3$, X = Cl, Br, I) perovskite nanocrystals demonstrate promising optoelectronic properties, however their practical applications have been limited by poor stability. Herein, highly stable $CsPbX_3$@PS nanofibers with uniform morphology and excellent fluorescence performance can be synthesized by electrospinning strategy, and their hydrophobicity could be significantly improved than the initial PNCs. Moreover, the obtained $CsPbBr_3$@PS nanofibers show the accurate detection of R6G and RhB, the FRET efficiency could reach up to 15.11% and 18.03%. More importantly, The obtained $CsPbBr_3$@ PS based-WLED with LE of 40 lm/W and color gamut covering 121.2% of NTSC gamut, exhibits a broad prospect solid lighting fields. This work not only provides a robust method for the preparation of PNCs with high stability but also sheds some light on the applications of $CsPbX_3$ NCs.



(a) Water contact of $CsPbBr_3$@PS nanofibers, (b) Emission peak of $CsPbX_3$@PS (X = Cl, Br, I) nanofibers, (c) Asorpation of RhB and PL spectra of $CsPbBr_3$/PS nanofibers, (d) Fluorescence detection to RhB by $CsPbBr_3$/PS nanofibers

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Enhanced photoluminescence efficiencies of Mn doped perovskite nanocrystals by incorporating neodymium ions

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Mn doped perovskite nanocrystals (NCs) have been paid much attention due to their excellent luminescent properties and potential applications for white light emitting diodes. However, the low emission efficiency and poor stability of doped NCs restricts their development. Recently the metal ions such as alkaline-earth metals, transition metals and bivalent rare earths were widely used to improve the optical properties. Here we report the synthesis and photoluminescence (PL) properties of Mn doped $CsPbX_3$ NCs with addition of neodymium chloride by using steady-state and time-resolved PL spectroscopy, compared with those of the corresponding intrinsic NCs. It is found that the maximum PL quantum yield (QY) of Mn doped $CsPbCl_3$ NCs with various Nd/Pb/Mn molar ratios are enhanced of over 60% by doping Nd ions. The X-ray diffraction results show that Nd ions were successfully introduced into the lattice of NCs. On the other hand, the violet- and blue-emitting $CsPbCl_3$ and $CsPbCl_{3-x}Br_x$ NCs were synthesized with neodymium chloride and neodymium bromide to improve the PLQY to 58% and 80%, respectively. The radiative recombination rates of the NCs are significantly improved with Nd ion doping as shown in the time-resolved PL spectra, indicating that Nd ions doping can passivate the defects and traps in the NCs and reduce the nonradiative recombination process of the NCs. Therefore, the experimental results indicate that Nd ions play an important role in improving the efficiency of exciton and manganese luminescence.

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Highly stable and luminescent silica-coated perovskite quantum dots at nanoscale-particle level via nonpolar solvent synthesis

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Currently, unsatisfactory optical stability and toxicity of all-inorganic lead halide perovskite (CsPbX3, X = Cl, Br, and I) quantum dots (QDs) with excellent photoelectric properties is a major obstacle for their practical application. In this work, the $CsPbBr_3$ QDs were assembled into SiO_2 shell via nonpolar solvent synthesis, and monodisperse $CsPbBr_3@SiO_2$ nanocomposites (NCs) with high photoluminescence quantum yield (PLQY) of ~87% were successfully prepared. Moreover, the introduced hydrophobic and multibranched trioctylphosphine oxide (TOPO) effectively suppressed the hydrolysis rate of tetraethoxysilane (TEOS), resulting in the formation of core@shell NCs at a nanoscale-particle level. Benefiting from the protection of TOPO and SiO_2 shell, the $CsPbBr_3@SiO_2$ NCs exhibit remarkably improved stability against thermal treatment, UV irradiation and water compared to the bare perovskite-QDs. Notably, the anion-exchange reaction among different perovskite-QDs was completely inhibited. To improve stability of iodide-substituted perovskite-QDs and expand emission wavelength, the $CsPbBr_{0.6}I_{2.4}@SiO_2$ NCs with PLQY of 75% were also successfully prepared by similar strategy. White light-emitting-diodes (WLEDs) were designed by combining $CsPbBr_3@SiO_2$ NCs with $CsPbBr_{0.6}I_{2.4}@SiO_2$ NCs onto blue GaN chips. Bright white-light with high color-rendering index of 90 and luminous efficiency of 80 lm W− 1 were achieved from these WLEDs, indicating the synthesized perovskite NCs possess huge potentiality in displays and solid-state lighting.

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The influence of SiO_2 shell on the spectroscopic properties of V-doped YAG nanocrystals

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The luminescence of V^{3+} ions in inorganic host materials, being attributed to the $^3T_2 \rightarrow {}^3T_{1g}$ *d-d* electron transitions, was found to be strongly affected by the changes of the external conditions and the crystalographic environment of the lattice structure. This susceptibility is high of importance for the development of temperature sensors [1], [2]. Furthermore, the spectral position of the emission of V^{3+} ions, located in the NIR regime (λ_{em}=820 nm), makes the V-doped nanoparticles interesting in terms of biological-oriented applications. From this perspective, it is therefore crucial to obtain biocompatible nanocrystals that are stable in an aqueous medium [3].

Therefore in this work the procedure of the coating of the $Y_3Al_5O_{12}:V^{3+}$ ($YAG:V^{3+}$) nanocrystals with the SiO_2 shell is presented. The silica coating of nanomaterials enables their stabilization in polar solvents and facilitates further biofunctionalization [4]. The silica coating of nanomaterials allows their stabilization in polar solvents and facilitates further biofunctionalization. Moreover, the silica shell has a positive influence on the emission intensity brightness of nanosized phosphors. The influence of the SiO_2 shell deposition on the spectroscopic properties of the $YAG:V^{3+}@SiO_2$ is detailly investigated. It should be emphasized that the presented results can significantly broaden the scope of the applicability of vanadium – doped nanoscaled phosphors.

Acknowledgements

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The synthesis and spectroscopic properties of $NaYF_4$ nanoparticles doped with Cr^{3+}

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One of the most promising temperature measurement techniques that enables non-contact temperature readout with sub-micron/nanometric spatial resolution is luminescence thermometry (LTh). LTh enables temperature readout by analyzing the variation of spectroscopic parameters of nanoparticles as a function of temperature. Among different nanoparticles $NaREF_4$-type materials (RE- rare earths metals) have significant application potential as luminescent nanothermometers, due to their low phonon energy and a well-developed surface biofunctionalization protocols. Therefore, the $NaREF_4$-type nanoparticles doped with lanthanide ions for applications in luminescence thermometry have been studied extensively. On the other hand, data reported in the literature demonstrate that emission of transition metal ions can be used as highly sensitive thermometric probes.[1] Therefore, it can be expected that $NaREF_4$ (RE- rare earths) nanoparticles doped with Cr^{3+} ions will allow to obtain highly sensitive luminescent thermometers. Nevertheless, luminescent thermometers based on Cr^{3+} emission in $NaREF_4$-type nanoparticles have not yet been investigated due to unfavorable local site symmetry for Cr^{3+} ions. In this work we report the synthesis and spectroscopic properties of inorganic colloidal $NaYF_4$ doped with Cr^{3+} ions. The influence of dopant ion concentration, morphology of obtained materials on the spectroscopic properties will be investigated.

Acknowledgement

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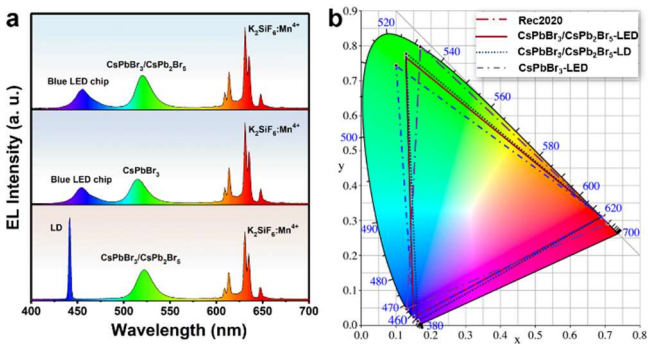
In-situ synthesis of high-efficiency CsPbBr3/CsPb2Br5 composite nanocrystals in aqueous solution

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Here, we present the microemulsion method with the assistance of sodium dodecylbenzenesulfonate and hydrofluoric acid for the in-situ synthesis of brightly luminescent $CsPbBr_3/CsPb_2Br_5$ composite nanocrystals (NCs) in aqueous solution. The obtained $CsPbBr_3/CsPb_2Br_5$ composite NCs exhibit a photoluminescence quantum yield of 77.0% and a full width at half maximum of 16.0 nm. And solid-state back-lighting devices were fabricated by combining $CsPbBr_3/CsPb_2Br_5$ composite NCs and red-emitting $K_2SiF_6:Mn^{4+}$ phosphors with blue light. The as-fabricated device exhibits a wide color gamut of about 95.8% of the Rec.2020. This work provides a green, low-cost, and in-situ water-phase route to synthesize high-quality cesium lead halide NCs for their practical application in solid-state back-lighting devices.



EL spectra of two white LEDs employing $CsPbBr_3/CsPb_2Br_5$ composites NCs and $CsPbBr_3$ NCs, and the LD employing $CsPbBr_3/CsPb_2Br_5$ composites NCs. (b) The chromaticity gamut of two white LEDs, LD, and Rec. 2020.

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Synthesis and luminescence properties of all-inorganic copper-based perovskite materials

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Lead-based halide perovskite materials have the advantages of high luminous efficiency, adjustable band gap, and cheap manufacturing. However, because it contains highly toxic lead atoms, it has poor stability and is extremely sensitive to humidity, temperature, light and oxygen. Therefore, the development of efficient, non-toxic and stable materials has become one of the research focuses in the field of luminescence. Copper-based perovskite materials have high photoluminescence fluorescence quantum yield and excellent stability. We synthesized $Cs_3Cu_2I_5$ and $CsCu_2I_3$ powder materials by adjusting the ratio of CsI and CuI solvent evaporation crystallization, and the emission peaks were located at 450nm and 570nm, respectively. Based on photoluminescence spectroscopy combined with XRD, the effects of different ratios of CsI and CuI on their luminescence properties were studied. The study found that under the excitation of light with a wavelength of 300nm, when the ratio of CsI:CuI increases, the emission peak position gradually shifts to the 450nm wavelength direction and increases. In addition, under the low voltage of 6V, the LED device coated with $Cs_3Cu_2I_5$ material emits bright blue; the LED device coated with $CsCu_2I_3$ material emits bright yellow, indicating the potential application of these two materials in LED lighting. Moreover, the radiation spectrum and photoluminescence spectrum under X-ray radiation are almost the same, indicating that the luminescence mechanism of this material under X-ray radiation is the same as the photoluminescence mechanism, and it has the potential for X-ray detection applications.

Keywords: $CsCu_2I_3$, $Cs_3Cu_2I_5$, Photoluminescence, X-ray detection, LED

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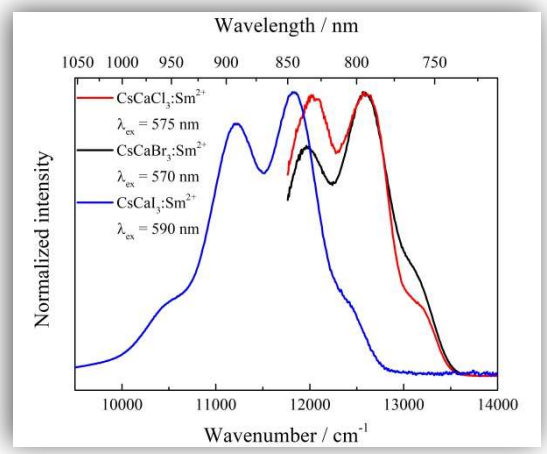
Luminescence of Sm^{2+} doped perovskites $CsMX_3$ (M = Ca, Sr; X = Cl, Br, I) – a comparative study

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In the last years, promising research about the spectroscopy of divalent lanthanides shows interesting properties leading to luminescent materials for several applications. In this context, Eu^{2+} is by far the most investigated divalent lathanide ion. More unstable ions are much less regarded even if they exhibit fascinating characteristics [1–3]. This is espcially true for Sm^{2+} ions. Since the energetic position of the excited $4f^55d^1$ levels depends strongly on the host lattice, this is not the case for the excited $4f^6$ levels. Therefore, broad $4f^55d^1 \rightarrow 4f^6$ as well as sharp $4f^6 \rightarrow 4f^6$ emissions can occur in some systems [4]. The kind of transition is influenced by e.g. temperature and pressure, so that an application as sensor is possible [1]. In this work, the perovskite systems $CsMX_3:Sm^{2+}$ (M = Ca, Sr; X = Cl, Br, I) were investigated for the first time. All of the compounds show broad $4f^55d^1 \rightarrow 4f^6$ transitions, which are obviously located at lower energies than the $4f^6$ levels. Several emission bands could be observed, although only one crystallographically independant alkaline earth site exists. The origin of these bands is discussed. In general, these materials can be regarded as text book examples to investigate luminescence-structure relationships for divalent lanthanides due to the sixfold coordination and O_h symmetry.



Emission spectra of $CsCaX_3$:0.1% Sm^{2+} (X = Cl, Br, I) performed at 10 K.

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High photodegradation performance of ZnO nanoparticles supported on porous Zeolite Na-A: Effects of ZnO loading

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Zeolite Na-A supported ZnO nanocomposites (ZnO/Zeolite Na-A NCs) were synthesized at low temperature (70 ℃) via the sol-gel process and characterized by X-ray diffraction technique (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), UV-visible diffuse reflectance spectroscopy (UV-vis DRS) and Fourier transform infrared (FTIR) spectroscopy for structural, morphological, optical and bonding properties. The textural properties and porosity were obtained by Brunauer-Emmett-Teller (BET) technique. The XRD and microscopy results indicated that the obtained nanopowders were crystalline in nature and no collapse of the structure of zeolite Na-A. In addition, the synthesized ZnO nanoparticles occurred mainly on the surface of the zeolite support. It is clear that the zeolite supported ZnO nanoparticles were more dispersed as compared to the pure ZnO with improved porosity and high surface area. Photocatalytic activity for the ZnO/zeolite Na-A was tremendously increased which was attributed to the combined effects of both ZnO and zeolite aluminosilicate network which included increased surface area (S_{BET}), high adsorption and restrained charge recombination.

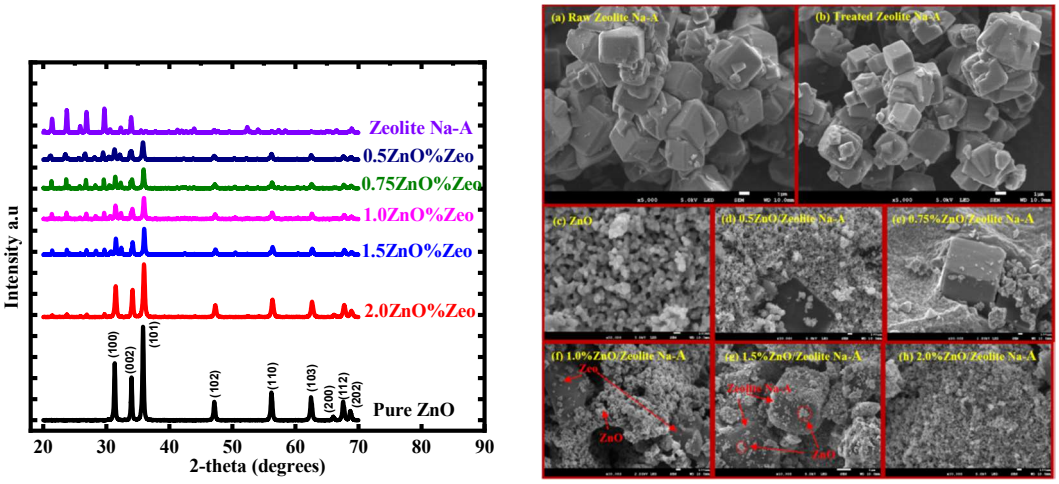


Figure 1: (Left) XRD diffraction patterns for pure Zeolite Na-A and various loaded ZnO/Zeolite Na-A while the corresponding SEM images are shown on the right.

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Computational modeling of LMCT energies in europium compounds

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For some lanthanide ions, specially Eu^{3+}, ligand-to-metal charge-transfer (LMCT) states relevant to their photophysical and luminescent properties. Usually, these LMCT states cause quenching of the luminescence due to non-radiative energy transfer from the excited ligand states and/or from the excited ion states followed by the decay from the LMCT states. To be operative, these LMCT states should have energies near to the excited ligand and/or lanthanide states, which is usually the case of Eu^{3+}-based compounds. Thus, determining the energies of the LMCT states is important, however, this poses experimental as well as computational challenges. Usually, the LMCT bands in the absorption spectrum overlap with the ligand bands and cannot be identified. Computational modeling can then be a useful tool in determining the properties of these states. However, there are no practical computational approaches that provide reasonable results for LMCT states. Here an approach is developed to yield estimates of LMCT state energies by calculating ionization energy and electron affinity of the complex. This method has been tested for aqua-complexes and hydrolyzed ones, $[Eu(H_2O)_{n-x}(OH)_x]^{(3-x)+}$, and cryptates, $[Eu \subset 2.2.1)]^{3+}$ and $[Eu \subset 2.2.2)]^{3+}$,[1,2] at the UB3LYP/MWB28 level of theory. Preliminary calculations predicted values ca. 2.5 eV lower than the experimental ones, which were traced to the errors in the ionization energy calculations of the Eu ions. A series of ECPs (small and large cores) and functionals (including several hybrids, double-hybrids, long-range corrected, and range-separated corrections) were tested. The B2PLYP/MWB28_SEG level produces the best value (24.49 eV) with an error of 1.72%.[3] Other less costly functionals, namely, wB97X and wB97XD yielded results with errors of ca. 2-3%. The calculated energies of the LMCT states improved significantly, with values ca. 1-1.5 eV lower than the experimental. This wB97X method is being tested for other Eu^{3+}-complexes with known experimental LMCT states[1,2] to improve the calibration and validate the computational methodology. In addition, strategies to handle these systems at the MP2 level of theory are being employed to obtain more reliable predictions.

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Study of the amplification of light emission of lanthanide complexes using of copper and copper oxide nanoparticles

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The use of metallic nanoparticles in systems with lanthanides to increase the intensity of emission has been subject of several studies. Theoretical studies have tried to explain what types of mechanisms are happening in the system. It is known that this increase or quenching of luminescence is result of a balance of different factors such as: enhancement of local field, non-radiative energy transfer and non-radiative decays[1]. In this context we developed a theoretical system using rate equations to explain the increase of 300% photoluminescence that was observed by the group at the Hebrew University of Jerusalem, when copper nanoparticles (CuNPs) were added to a system with a chiral pyridine based europium(III) complex[2]. It was observed after checking the experimental data that not only CuNPs were present, but also there was the possibility of copper oxide nanoparticles to be on the material. With the theoretical system made, taking into consideration both types of nanoparticles, it was observed that since the plasmon band of the CuNPs is in resonance with the $^5D_0$, that level was the one most affected by the presence of NPs, because of the energy transfer that happens from the lanthanide to the nanoparticle – but not back to the lanthanide – and also the increase of local field.

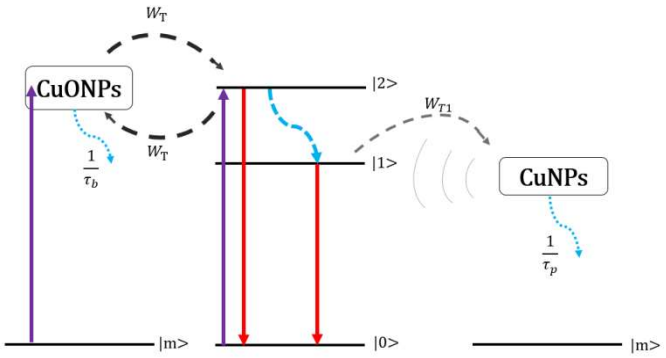


Figure 1. Schematic diagram used for the rate equations.

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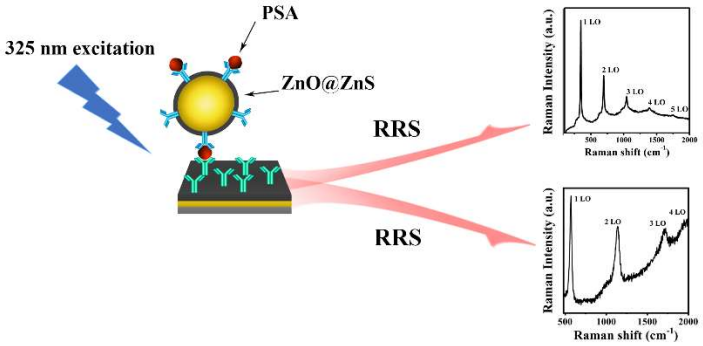
Dual resonance Raman scattering nanoprobe based on ZnO@ZnS nanocomposite for accurate PSA detection

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Accurate detection for biomarkers is one of the most significant long term challenges in clinical diagnosis [1-3]. The current commerical fluorescence method based on the photoluminescence or electroluminescence process has high sensitivity, but the anti-interference capability still has the room to improve. Factors including photobleaching, aggregation quenching and resonance energy transfer hinder the detection accuracy. Resonance Raman scattering (RRS), which is homologous with fluorescence emission process, has excellent anti-interference capability to ensure the accuracy of detection [4,5]. In this work, a dual resonance Raman scattering (RRS) nanoprobe based on the ZnO@ZnS nanocomposite is developed for the detection of prostate specific antigen (PSA). Two groups of independent multiphonon RRS signals can verificated mutually. The heterojunction effect between ZnO and ZnS can reduce the recombination of photogenerated electrons and holes to suppress the fluorescence emission process. It is enable to eliminate the interference from background fluorescence greatly and improve the detection sensitivity. The assay performance including sensivity, detection range, reproducibility, selectivity and specificity were evaluted. The practicability of the nanoprobe was studied by detecting PSA in human serum samples to test the application potential.



Schematic of the sandwich immunosensing protocol.

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Effect of the nanoparticles size on thermometric properties of SBR luminescent thermometer in $NaYF_4:Nd^{3+}$

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Luminescence thermometry is a rapidly developing technique that enables to measure and map temperature in a variety of environments such as microelectronic systems, rotating machinery components, high temperature furnaces, but also in harsh environments such as biological systems. Over time, several measurement techniques have been developed, the most common of which is an approach that provides a temperature readout based on the luminescence intensity ratio (LIR). This technique does not always deliver a reliable measurement readout, since often the analyzed emission bands are in close spectral proximity to each other, and moreover, due to the dispersive dependence of the extinction coefficient, the intensity of each band can be falsified to varying degrees by the medium in which they are located. The limitations were overcome by using a single-band ratiometric (SBR) approach in which two types of excitation are used - one matched to the ground state absorption (GSA) and the second one to thermally activated excited state absorption (ESA)[1,2]. Depending on the type of excitation a different luminescence response to temperature changes occurs, making this method highly sensitive to temperature changes. Nevertheless, the phenomenon of absorption from the excited level is a non-trivial process and depends on many factors such as the energy distance between the ground and excited levels, probability of interionic energy transfer, host phonon energy, crystal structure, local ion symmetry, particle size and surface effects.

In this work the analysis of the influence of the nanoparticle size of the thermometric properties of the SBR luminescent thermometer based on β-phase (hexagonal) $NaYF_4:Nd^{3+}$ is shown. The Nd^{3+} ions characterized by a dense ladder of energy levels and a small energy distance between the ground and excited levels ($\Delta E \sim 2000 cm^{-1}$), which can be relatively easily thermally bridged according to the Boltzmann distribution, were chosen as optically active dopants. In order to avoid concentration quenching processes, their 2% molar concentration was chosen as an optimum.

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Four Novel Lanthanide Coordination Compounds Based on Amino Acid Derivative Ligands: Construction, Characterization and Fluorescence Chiral Recognition Performance

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Four novel lanthanide coordination compounds, namely, $[Eu_2(bzgluO)_3(phen)_2]_n \cdot 2nH_2O$ (**1**); $[Tb_2(bzgluO)_3(phen)_2]_n \cdot 2nH_2O$ (**2**); $[Eu_2(tsgluO)_3(H_2O)_4]_n \cdot 4nH_2O$ (**3**); $[Eu_2(tsgluO)_3(phen)_2(H_2O)]_n \cdot 2nH_2O$ (**4**); ($H_2bzgluO$ = *N*-benzoyl-*L*-glutamic acid, $H_2tsgluO$ = (+)-*N*-Tosyl-*L*-glutamic acid, phen = 1,10-phenanthroline) have been successfully synthesized under hydrothermal conditions and structurally characterized by elemental analysis, IR spectroscopy, single-crystal X-ray diffraction analysis and powder X-ray diffraction. Lanthanide coordination compounds **1** and **2** crystallize in the triclinic space group $P2_12_12_1$, they are isostructural and exhibit the 2D layer structure. Compounds **3** and **4** crystallize in the triclinic space group Pī, compound **3** features a 2D layer structure, compounds **4** exhibit the 1D infinite double chain. It is worth noting that the amino acid derivative ligands adopt different coordination modes on the lanthanide coordination polymers to make the crystal structure diverse. Additionally, fluorescent properties study indicates that compounds **1** and **4** show characteristic transitions of Eu^{3+}, and the compound **2** shows characteristic transitions of Tb^{3+}. More significantly, compound **2** can effectively detect the tyrosine enantiomers through the fluorescence spectrometry.

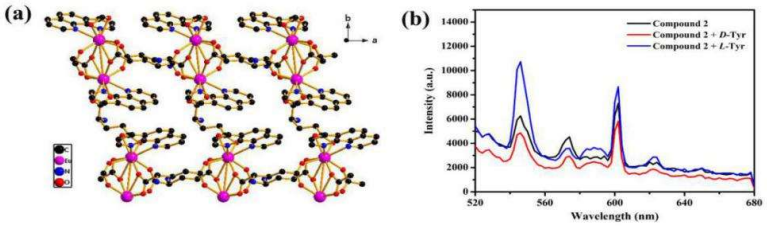


Figure (a) The two-dimensional layer structure of compound **1;** (b)The fluorescence recognition of tyrosine enantiomers of compound **2**.

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Luminescence of Eu(tta)$_3$(*N*-picNO)$_2$ (*N*=2, 3 and 4) doped PMMA films under Synchrotron radiation.

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Since their discovery, trivalent lanthanide β-diketonate complexes often stand out among luminescent coordination compounds [1]. Thus, the incorporation of such complexes into polymeric materials proposes increased photostability, optical quality, and processing conditions [2]. In this work, we prepared and doped the luminescent Eu(tta)$_3$(*N*-picNO)$_2$ (*N*=2, 3 and 4) complexes into Poly(methyl methacrylate) (PMMA) films *via* the solvent casting method, yielding transparent materials under visible light. These amorphous materials (XRD) presented considerable thermal stability up to 300°C (TGA), and their spectroscopic properties with ancillary ligand exchange were investigated by luminescence spectroscopy in the UV-Vis and Vacuum-UV energy range by synchrotron radiation. Mainly, Eu^{3+} transitions ($^5D_0 \rightarrow {}^7F_{0\text{-}4}$) were observed in the emission spectra for all compounds, with intense monochromatic-like red (614 nm) emission (**Fig. 1**), indicating efficient intramolecular energy transfer. Experimental intensity parameters and quantum yields were also determined, where it is seen the influence on the positioning of the methyl group in the luminescence efficiency

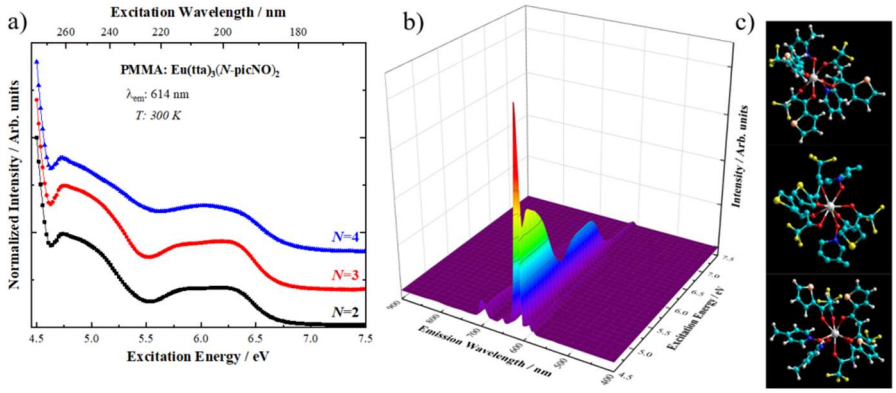


Fig. 1: a) Total absorption of PMMA:Eu(tta)$_3$(*N*-picNO)$_2$ compounds and b) 3D luminescence spectra of PMMA:Eu(tta)$_3$(*2*-picNO)$_2$ under Vacuum Ultraviolet excitation. c) Molecular structures of Eu(tta)$_3$(*N*-picNO)$_2$ complexes, where *N*=2, 3 and 4 from top to bottom, respectivelly.

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ICL 2020

Enhanced glow of ultraviolet phosphor $LuAl_3B_4O_{12}:Bi^{3+},Gd^{3+}$ in ambient light

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Previous research on persistent phosphors has focused primarily on their luminescence properties in ambient dark [1]. It is the requirement for ambient dark that is hindering the further development of persistent phosphors under different ambient conditions [2]. In this work, we develop a novel persistent phosphor $LuAl_3B_4O_{12}:Bi^{3+},Gd^{3+}$. Besides a glow-in-the-dark emission peaking at 312 nm after x-ray charging, the charged phosphor exhibits an interesting ambient stimulated emission (ASE), whose initial intensity increased when the phosphor is exposed to ambient illumination instead of dark condition. The present ASE originates from a novel detrapping mechanism, in which the ambient lighting (*AL*) and ambient temperature (*AT*) can simultaneously release the stored energy in the persistent phosphors and lead to a long-lasting emission, whose intensity at delay of 10 min is evaluated as 2.5 $mW \cdot sr^{-1} \cdot m^{-2}$. Figure 1 shows that, in the decay time of 10–90 minutes, the ASE intensity of $LuAl_3B_4O_{12}:Bi^{3+},Gd^{3+}$ (solid-line curve) is higher than the persistent luminescence intensity of a commercial glow-in-the-dark phosphor $SrAl_2O_4:Eu^{2+},Dy^{3+}$ (dashed-line curve). The research on ASE brings different insight to luminescence research and offers approach to further learn about and utilize ultraviolet persistent phosphors.

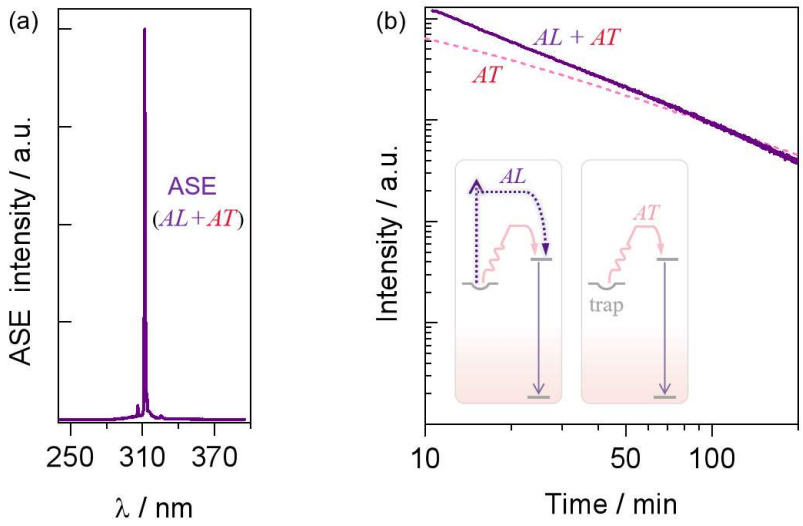


Fig.1 (a) ASE spectrum of $LuAl_3B_4O_{12}:Bi^{3+},Gd^{3+}$. The spectrum is recorded continuous stimulation with *AL* (650 lux) and *AT* (300 K). (b) ASE decay curves of $LuAl_3B_4O_{12}:Bi^{3+},Gd^{3+}$ (solid line) and persistent luminescence decay curve of $SrAl_2O_4:Eu^{2+},Dy^{3+}$ (dashed line).

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Structure and charge transport properties of tris(2-acyl-1,3-indandionate)aluminium(III) complexes

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Aluminum coordination compounds have been widely applied as materials in organic light-emitting diodes (OLEDs), acting as efficient emitters and electron transporters. In this work, molecular structures and electronic properties of tris(2-acyl-1,3-indandionate)aluminum(III) complexes ([Al(aind)$_3$]) were experimentally and theoretically investigated. The crystal structure of the tris(2-benzoyl-1,3-indandionate)aluminum(III) complex was determined by single-crystal X-ray diffraction analysis, showing that the *fac*- isomer of this complex crystallizes in the triclinic crystal system with the space group P_{31c} (fig 1a) and presents three crystallographic independent conformation isomers (fig 1b). The ground state geometries of *fac*-[Al(aind)$_3$] and *mer*-[Al(aind)$_3$] isomers were optimized using the Density Functional Theory (DFT) B3LYP functional, and employing a 6-31G(d) basis set. Theoretical analysis shows that frontier molecular orbitals (HOMO and LUMO) of the [Al(aind)$_3$] isomers are more delocalized on the molecular structure. On the other hand, HOMO-1 and LUMO+1 orbitals are more located in two molecules of the 1,3-indandionate ligand (Fig 1c). Furthermore, the analysis concerning the transport of charges (electrons and holes), performed based on Marcus theory, indicates that *fac* isomers have lower reorganization energies for hole (λ_h) than for electrons (λ_e) transport, suggesting that *fac*-[Al(aind)$_3$] isomers could exceptionally behave as hole transporters.

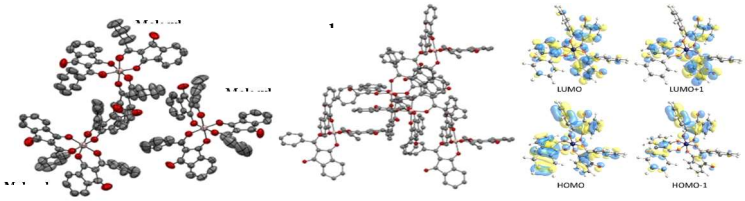


Figure 1. a) Asymmetric unit structure of *fac*-[Al(bind)$_3$] showing the three crystallographic independent complex molecules. b) Selected crystal packing of *fac*-[Al(bind)$_3$] showing the non-usual hydrogen bonds and π–π intermolecular interactions. c) Kohn-Sham molecular orbital HOMO, LUMO, HOMO-1, and LUMO+1 for isomer fac-[Al(bind)$_3$].

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Enhanced red luminescence of Sm^{3+} in structural-modified fluorophlogopite and its potential application

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Mica is a kind of silicate clay mineral with the layered structure. Owing to its unique TOT (tetrahedron-octahedron-tetrahedron) structure and excellent interlayer cation exchange capacity, some light-emitting rare earth ions can be easily incorporated to the interlayer space to generate the specific luminescence. Depending on the prominent structural characteristics of mica and optical properties of rare earth ions, it is of great importance to develop the new inorganic composite with strong luminescence and superior photofunctional performances.

Among the mica species, the fluorophlogopite (Fpl, $KMg_3AlSi_3O_{10}F_2$) in which the interlayer cation is K^+ ion, shows good chemical and thermal ability. In this work, the structure of Fpl was modified by substituting Na^+ for K^+ in the interlayer and adjusting the Si/Al content ratio in the composition, and the rare earth Sm^{3+} ion was doped to the Fpl host. The X-ray diffraction patterns and the photoluminescence of the samples were investigated (Fig. 1). After the structural modification, the luminescence intensity of Sm^{3+} ion was significantly enhanced, and the quenching concentration of Sm^{3+} was obviously changed. The potential application of the structural-modified Fpl in forensic science for latent fingerprint detection was explored.

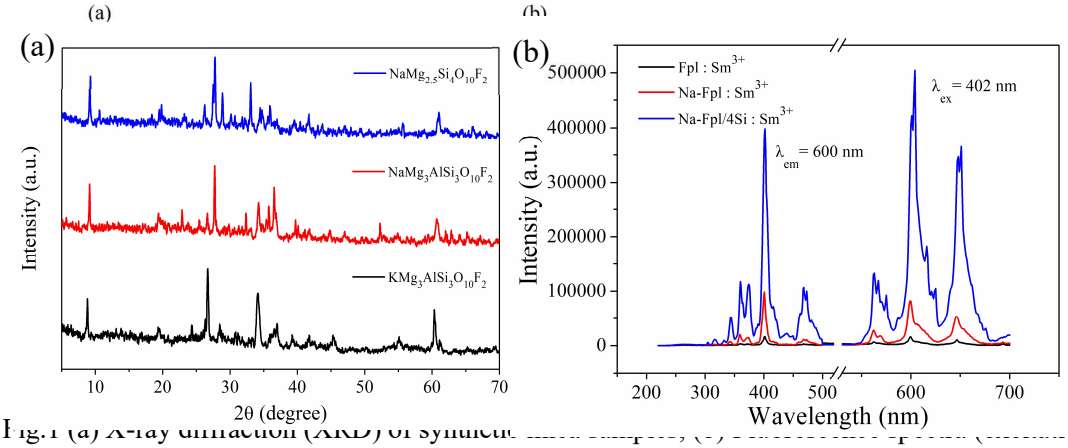


Fig.1 (a) X-ray diffraction (XRD) of synthetic mica samples, (b) photoluminescence spectra (excitation and emission spectra) of synthetic mica samples with optimal Sm^{3+} concentration.

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Dominant contribution of photosensitizer monomers to upconversion nanoparticles-based photodynamic therapy

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Upconversion nanosensitizers have been widely considered to have important applications in the treatment of major diseases such as tumors and the utilization of solar energy.[1,2] Majority of the efforts so far has been focused on improving the efficiency of energy transfer (ET) between upconversion nanoparticles (UCNPs) and the anchored sensitizers with premise that high ET efficiency shall lead to high acceptor efficacy. This premise is, however, proved by our current work to be invalid for commonly used load. Interaction between adjacent sensitizing molecules was found to be critical which undermines the amount of excited monomer sensitizers and thus fades the efficacy. $NaYF_4$: Yb^{3+}, Er^{3+} UCNPs and rose bengal (RB) photosensitizer molecules were used as the model energy donors and acceptors, respectively. Contrary to monotonous increase of the ET efficiency from UCNPs to RB species with increasing RB loading, acceptor efficacy characterized by the reactive oxygen species, as well as the RB fluorescence, exhibits bizarre dependence on the RB loading. The underlying mechanism was well studied by the steady-state and time-resolved spectroscopy of a series of samples. RB aggregates are believed to be responsible for the severe deviation between the ET efficiency and acceptor efficacy. The conclusion was validated by in vitro test where the photodynamic therapy with the most monomer RB in UCNPs-RB nanosensitizers killed much more cells than that with the highest RB loading. This understanding sheds light on construction of new ET based nanosystems for broad applications, such as medicine, solar energy utilization and optical storage.

This work was supported by the National Natural Science Foundation of China (51972052 and 11604043), Scientific and Technological Developing Scheme of Jilin Province (20190201243JC), Science and Technology Research Project of Education Department of Jilin Province (JJKH20211275KJ), and the Fundamental Research Funds for the Central Universities (2412019FZ033).

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Lanthanide doped vis-to-UV upconversion phosphors for bio-application

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Lanthanide doped phosphors are attractive class of materials especially the specific fluorescence properties from the 4*f*-4*f* transitions that allow fine-tuning. By incoporation of optimal amount of dopants and selection of host matrix, the fluorescence wavelength and lifetime can be manipulated and therefore be able to use for applications such as bioimaging and sensing.[1] More that this, the multiple spectroscopic active levels can also allow multiphotons up-conversion from lower absorption energy to higher emission energy. Precise dosage of dopants and matching with specific excitation source, the desired absorption energy and emission energy can be controlled via this upconversion process.[2] UV emission is particularly interesting due to its potential to deactivate bacterias and viruses. Being able to convert visible light to UV light in situ is preferential as better biocompatibility and more sustainability can be achieved. Tm^{3+}, Gd^{3+}, Nd^{3+} and Pr^{3+} are found to be capable emittors for UV upconversion.[4] Herein, we discuss the potential of introducing Pr^{3+} and Gd^{3+} as dopants into selected host matrix (i.e. $LiYF_4$) and investigate their potential for UV upconversion emssions.

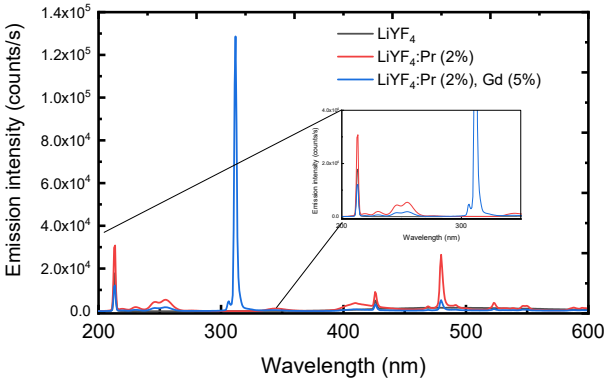


Figure 1: Emission bands of $LiYF_4$:Pr under 213 nm excitation

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Large area directional mechanical peeling and twisting angle stacking of TMDs

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In recent years, two-dimensional materials have opened a new era of moiré physics and low-dimensional quantum device research [1]. Many novels, strong correlation, and topological phenomena have emerged. The stacking and twist of the layers aroused the upsurge of controlling many-body quantum systems.

Transition metal chalcogenides (TMDs), 2H-MX_2 (M=Mo, W; X=S, Se), have more stacking combinations, stronger light-matter interaction, and valley-spin locking. With the advent of the moiré 3.0 era, the specific combination and twisting of multiple layers will enable people to achieve specific control of the quantum Hamiltonian of the research system, and then achieve the regulation of many-body quantum behavior [1, 2]. However, dissimilar graphene, the size of a mono-layer 2H-MX_2 obtained by mechanical exfoliation of high crystalline is usually less than 100 μm with extremely low yield, which greatly limits the advancement of multi-layer stacking and twist angle related research. At present, the use of metals with strong Van der Waals adhesion (for example, gold (Au), etc.) to assist the peeling has obtained single-layer TMDs on the order of millimeters or even centimeters, and the yield is close to 100% [3]. This kind of approach provides strong support for the research of TMDs-based van der Waals heterojunction and twist angle. Furthermore, considering that stacking and twist angle have strict requirements on the relative orientation between layers, it is very important to control the cleavage of crystal orientation based on large-area mechanical peeling.

In this work, we use molecular beam epitaxy to make Au grow laterally at the atomic steps of the zigzag edge on the TMDs surface, and achieve the directional mechanical peeling along the edge of the armchair, for further stacking and twisting with feature edge alignment.

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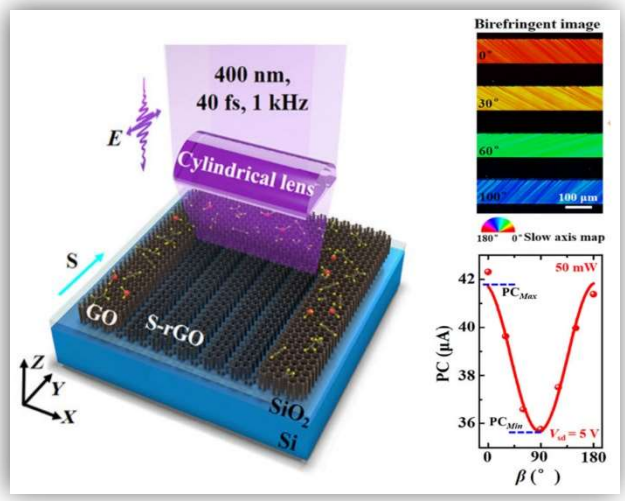
Anisotropic photoelectric response of graphene oxide film high-speed structurized via femtosecond laser

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Graphene analogs, such as graphene oxide (GO) and its reduced forms (rGO), are fascinating carbon materials due to the complementary properties endowed by the sp3-sp2 interconversion. Some of these properties can be further optimized and improved through the proper design and processing of the micro/nanostructures on their surfaces. Here, a new femtosecond laser micro/nanofabrication technology was introduced to realize regular and high-speed fabrication of subwavelength periodic grating structures on the surface of GO thin films. Thanks to the modulation of the dielectric constant and surface morphology of materials, the prepared samples exhibited excellent anisotropic photoresponse and birefringence properties at visible range. This work provides a new idea for the preparation and application of structured GO film materials, indicating the substitutability and potential for industrialization of integrated graphene devices.



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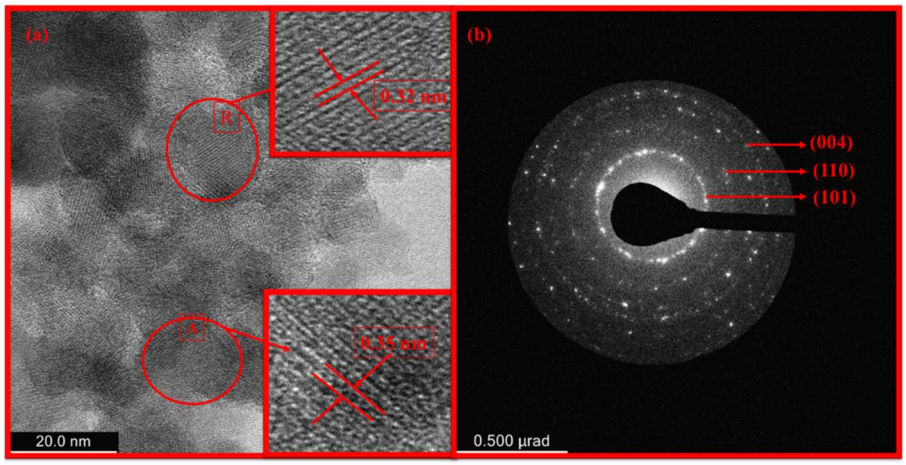
Modification of anatase-rutile mixed-phase properties using Sn^{4+} doping for photocatalytic brilliant green degradation.

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Incorporating a dopant into the microstructures of TiO_2 will improve its properties. Including ions of Sn^{4+} into the lattice of TiO_2 nanoparticles allow transformation of phases from anatase to rutile at low thermal treatment. The structure, bandgap, morphology, and photocatalytic activity were all studied. The findings showed that ions containing the sulfate group Sn^{4+} substituted that of Ti^{4+} in the TiO_2 lattice and dispersed uniformly in the matrix [1]. The substitution caused the lattice structure to deform at low temperatures, causing the transformation of the phases. The increase in the mol % of Sn in TiO_2 lattice favored the rutile phase content. The narrowing of the bandgap caused by Sn doping increases photocatalytic operation in the visible light region significantly [2]. Consequently, near-contact phase junctions in between anatase and rutile phase have been established, taking into consideration the charge separations. The sample obtained at 3.5 mol % of Sn exhibited the highest photoactivity during the oxidation of the brilliant green dye. The study provides a simple route to synthesize a mixture of phases for photoactivity and also advances the understanding of their enhanced properties.



(a) HRTEM image of 3.5 Sn-TiO_2 nanoparticles dispersed in ethanol. Insets are magnified HRTEM images showing the lattice fringes of rutile (R) and anatase (A) TiO_2 crystals, (b) SAED patterns of 3.5 Sn-TiO_2 nanoparticles.

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Adaptation and application of the intramolecular energy transfer to complexes containing transition metals and lanthanides

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There is a growing interest in alternatives to lanthanide ions (Ln^{3+}) luminescence sensitizing chromophores for in vivo usage, mainly in the optical biological windows. Transition metals (M) are good candidates as chromophores as they have high absorption rates and emission bands covering a wide range of visible to near-infrared spectrum. However, despite the importance of theoretical models for the design of M-Ln^{3+} complexes, few works have been devoted efforts to elucidating the energy transfer process (ET) between the M and Ln^{3+} ions. In this context, this work aims to adapt and apply the intramolecular energy transfer theory developed by Malta and collaborators[1] to M-Ln^{3+} complexes. As an example, the new model can estimate the ET rates between Cr^{3+} and Ln^{3+} ions. Our theoretical results for energy transfer rates (W ~ 840-1300 s^{-1}) are in good agreement with the experimental available data[2] (W_{exp} ~ 750-1200 s^{-1}), considering an absorption bandwidth around 750 cm^{-1} for the Cr^{3+} ion (figure 1). At the present stage, the proposed model can be useful to predict and explain photophysical properties driven by the energy transfer between the transition metal and the Ln^{3+} ion.

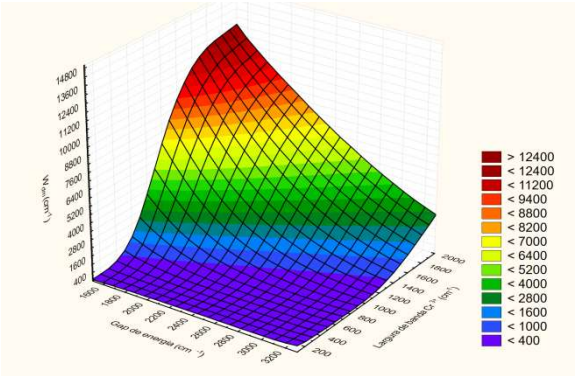


Figure 1. ET rate as a function of Cr^{3+} bandwidth and energy gap.

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GaS: A superior optoelectric material

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Gallium sulfide, a popular two - dimensional material, has good photoelectric properties. Because of its indirect band gap, its application in luminescence is limited. However, its excellent conductivity makes it widely used in photodetection. Based on this, two kinds of photoelectric detectors with excellent performance will be introduced.

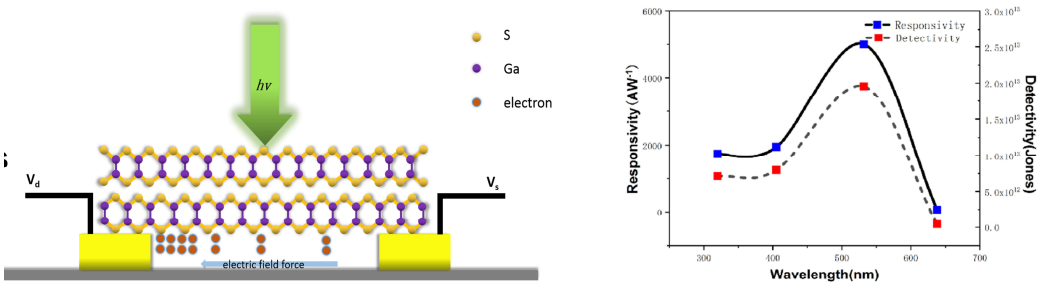


Figure 1. Bridge-like interface-free few-layer GaS detector with ultrahigh photoresponse performance

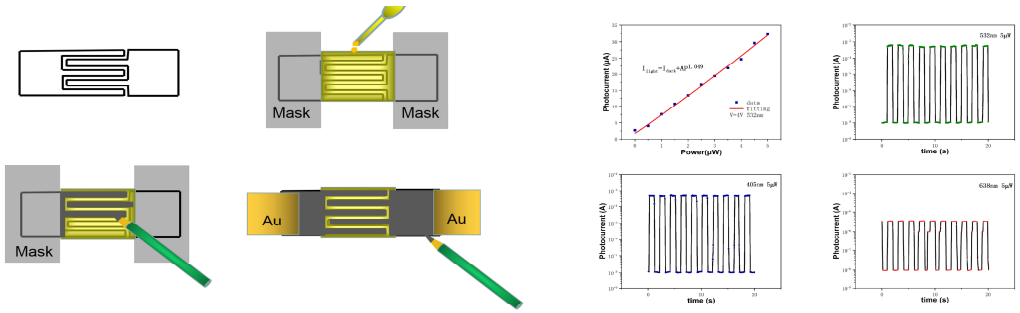


Figure 2. GaS: A photodetector on the paper

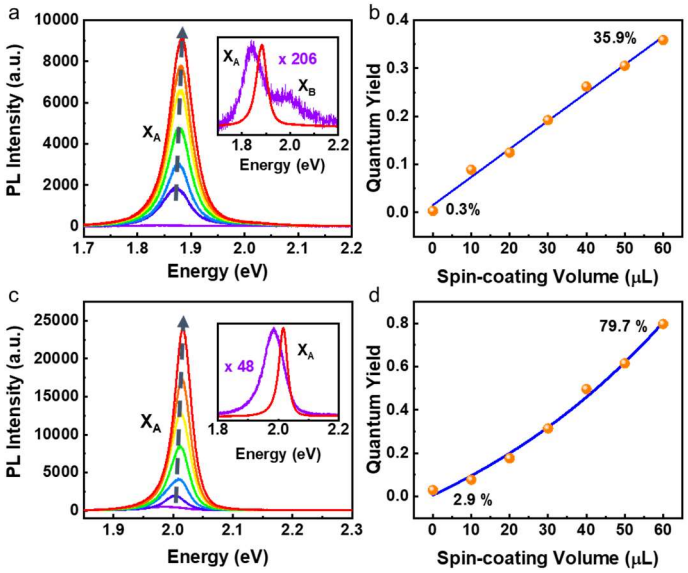
High photoluminescence quantum yield achieved in monolayer MoS_2 and WS_2 via trifluoromethanesulfonic-acid assisted sulfur vacancy repairation and p-type doping

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Chemical treatment of transition-metal dichalcogenides (TMDs) by organic superacid bis(trifluoromethane) sulfonamide TFSI, has been proved as an effective route to reduce the density of sulfur vacancies and improve photoluminescence quantum yield (PL QY) of monolayer TMDs (1L-TMDs). However, such kind of functional organic superacid is only limited to the TFSI so far, and the underlying mechanism of PL enhancement remains elusive. Here, we explored a novel organic superacid trifluoromethanesulfonic (TFMS), which can significantly increase the PL QYs of 1L-MoS_2 and 1L-WS_2 to 35.9% and 79.7% respectively, the highest PL QY values ever reported for CVD-grown 1L-TMDs. Through in-depth study and analysis with scanning transmission electron microscopy and density functional theory calculation, PL enhancement mechanism is attributed to a synergistic effect of TFMS-induced p-type doping and sulfur vacancy repairation. Especially, the respective function of $[CF_3SO_3]^-$ and H^+ of TFMS played in superacid-induced PL enhancement is clearly identified for the first time. Our results not only enrich the functional superacid family that could remarkably improve the luminescence performance of TMDs, but also clearly reveal the PL enhancement mechanism of superacid-treated TMDs.



PL spectra and corresponding estimated PL QY of 1L-MoS_2 (a, b) and 1L-WS_2 (c, d) before and after TFMS-treatment.

Slow cooling of high-energy C exciton limited by intervalley-transfer in monolayer MoS_2

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High-energy C exciton in two-dimensional transition metal dichalcogenides with strong photon absorption can be utilized prospectively in light-harvesting and opto-electric devices. Here, a detailed study on C exciton dynamics in monolayer MoS2 is presented by femtosecond transient absorption (TA) spectroscopy. In the experiment, the C exciton with unique parallel band structure exhibits a slow process within tens of picoseconds (~10-50 ps) as well as a fast process within several picoseconds (~1-6 ps) instead of previous reported ultrafast cooling (<500 fs) process. From TA spectroscopy, the experimental results confirmed that the relatively slow cooling of C exciton is mainly limited by the rates of intervalley transfer rather than Pauli blocking effect from band-edge excitons. The timescale of intervalley transfer is longer than that of intraband relaxation of C exciton, therefore, leading to the slow cooling of C exciton. Moreover, intervalley transfer time are estimated with two processes of 5.1 ± 0.6 ps and 69.5 ± 8 ps when the pump fluence is ~127 μJ/cm2. This work provides further understanding for the ultrafast dynamics of C exciton in monolayer MoS2 and opens new opportunities for opto-electric related applications.

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Ultraviolet photoluminescence from $Ti_3C_2T_x$ MXene quantum dots by controlling the oxidation degree

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MXene quantum dots (MQDs) have attracted considerable attention due to their multifarious outstanding properties including natural hydrophilicity, abundant active sites, ready functionalization and good biocompatibility [1]. However, the existing MQDs generally display a limited emission in the region from blue to yellow light [2]. There is a lack of reports on the ultraviolet emissive MQDs, which greatly restricts their practical applications in full-color displays, LEDs, optoelectronic devices and so on. Herein, we developed a new strategy to controllably preparation of ultraviolet-emissive $Ti_3C_2T_x$ MQDs by an aqueous-phase synthesis method using $Ti_3C_2T_x$ MXene as the precursor. Oxidation degree was proved to play an important role in regulating the photoluminescent properties of MQDs. The ultraviolet emission peak was great increased with the decrease of oxidation degree. The main emission of the MQDs can be adjusted to 305 nm from 420 nm. An oxidation degree-related photoluminescent mechanism for $Ti_3C_2T_x$ MQDs was proposed. The results facilitate to deepen fundamental theoretic understanding and broaden the application fields of MQDs.

This work was supported by the National Natural Science Foundation of China (51972052 and 11604043), Scientific and Technological Developing Scheme of Jilin Province (20190201243JC), Science and Technology Research Project of Education Department of Jilin Province (JJKH20211275KJ), and the Fundamental Research Funds for the Central Universities (2412019FZ033).

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$M(AlCl_4)_2:Eu^{2+}$ (M = Ca, Sr, Ba) – A promising new class of Eu^{2+} containing phosphors

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In recent years, the extensive research on divalent lanthanide ion doped compounds has led to luminescent materials for e.g., LED applications. The main focus of these investigations has been on Eu^{2+} because of its broad $4f^65d^1 \rightarrow 4f^7$ transition which can be tuned throughout the visible spectrum by doping into different host lattices [1-3]. In this work, the luminescence properties of Eu^{2+} doped into $M(AlCl_4)_2$ (M = Ca, Sr, Ba) have been studied for the first time [4]. The respective emission spectra are characterized by broad $4f^65d^1 \rightarrow 4f^7$ transitions located in the blue range (388-400 nm, Fig. 1). Temperature dependent emission measurements were conducted to further gather information on the nature of the emission bands. Furthermore, Huang-Rhys factors and coupled phonon energies were determined. The comparison with other chloride hosts leads to some information about the luminescence-property relationship of Eu^{2+} ions. In detail it is interesting to compare host lattices of complex ions like $[AlCl_4]^-$ with those of non-complex Cl^- hosts. The former should cause a shift to lower energies due to higher covalency, whereas a contrary effect is observed in the presented compounds. Therefore, the influence of the $[AlCl_4]^-$ complex anion on the Eu^{2+} luminescence was investigated in more detail.

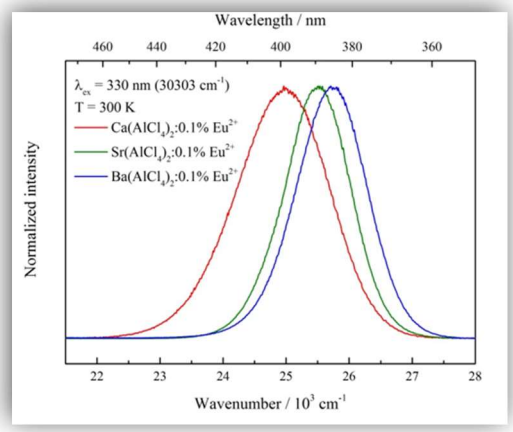


Fig. 1: Emission spectra of $M(AlCl_4)_2:Eu^{2+}$ under UV excitation (330 nm) recorded at 10 K.

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Up-converted persistent energy transfer in $Gd_3Ga_5O_{12}:Pr^{3+},Tb^{3+}$

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In research and applications of persistent phosphors, up-conversion charging (UCC) is a promising candidate for charging phosphors using low-energy excitation light sources [1]. In a typical UCC process, low-energy incident photons (e.g., visible or infrared light) can promote the system from ground state to high-energy delocalized state via an upconversion excitation channel, followed by the fill of the traps. When the stored excitation energy is gradually released, persistent luminescence signal can be generated. Persistent energy transfer (PET) is another interesting phenomenon commonly appearing in various persistent phosphors [2], in which the long persistence of the donor is converted into the long persistence of the acceptor. In recent years, the investigations on persistent energy transfer have provided insight to develop new persistent phosphors. In this presentation, we investigate $Gd_3Ga_5O_{12}:Pr^{3+},Tb^{3+}$ phosphor by combining the unique features of UCC and PET. Such a combination enables us generate persistent luminescence from Tb^{3+} after up-conversion excitation on Pr^{3+}. As a proof of concept (Fig. 1), under illumination with a 450 nm laser, Pr^{3+} ion may absorb two-step excitation to fill electron traps and then persistently transfers the stored energy to Tb^{3+} through Gd^{3+} mediated energy transfer. Sunsequently, long-lasting emission from Tb^{3+} can be realized.

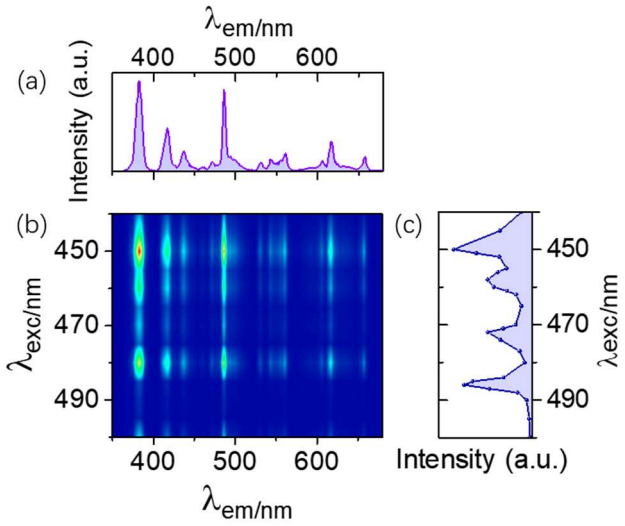


Fig. 1. (a) UCC emission spectra of $Gd_3Ga_5O_{12}:Pr^{3+},Tb^{3+}$ after 450 nm illumination. (b) Contour plot of UCC emission and excitation spectra. (c) UCC excitation spectrum by monitoring at 380 nm.

References

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ICL 2020

Exploiting bandgap engineering to finely control dual-mode $Lu_2(Ge,Si)O_5:Pr^{3+}$ luminescent thermometers

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In this study we examined a series of novel temperature sensors which work in a broad range of temperatures (17 – 650 K) – $Lu_2(Si,Ge)O_5$:0.05%Pr with varying Si:Ge ratio to adjust their forbidden bandgap energy for tuning their thermometric performance [1]. The addition of Ge to replace Si was expected to decrease the host bandgap. Consequently, we expected that the 5d→4f luminescence of Pr^{3+} would be more susceptible for temperature quenching. Indeed, in Lu_2SiO_5:Pr it lasted up to 475 K while in Lu_2GeO_5:Pr it was not observed at all, even at 17 K (see Figure 1a-b). In the (Si,Ge) mixed compositions the 5d→4f luminescence was quenched at temperatures increasing with the increase of the Si:Ge ratio. This, in turn, allowed to control the range of temperatures within which the 5d→4f/4f→4f emission intensity ratio could be utilized for thermometry. Furthermore, the kinetics of the 5d→4f luminescence was also found controllable by bandgap engineering and could be effectively used for luminescence thermometry. Thus, the $Lu_2(Ge_x,Si_{1-x})O_5$:Pr phosphors were designed as dual-mode luminescence thermometers exploiting the inter- and intra-configurational luminescence intensity ratio as well as the 5d→4f emission decay time. The presentation will show more aspects of bandgap engineering important for tuning the luminescence thermometers.

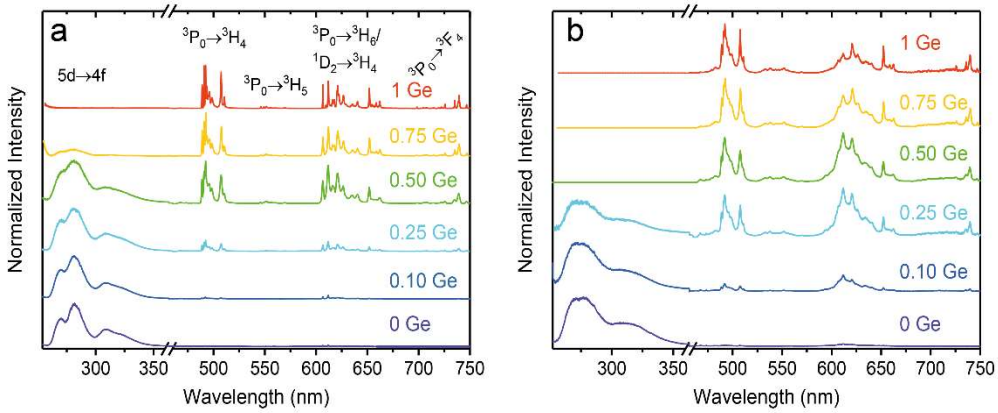


Figure 1. Luminescence spectra of $Lu_2(Ge_x,Si_{1-x})O_5$:0.05%Pr recorded at (a) 17 K, (b) 300 K.

References

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Engineered anisotropic fluids of rare-earth nanomaterials

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The self-assembly of inorganic nanoparticles into well-ordered structures in the absence of solvents is generally hindered by van der Waals forces, leading to random aggregates between them. To address the problem, we functionalized rigid rare-earth (RE) nanoparticles with a layer of flexible polymers by electrostatic complexation, to realize ordered and solvent-free liquid crystal (LC) state of RE nanoparticles. The RE nanomaterials including nanospheres, nanorods, nanodiscs, microprisms, and nanowires all show a typical nematic LC phase with one-dimensional orientational order, while their microstructures strongly depend on the particles shape and size. Interestingly, the solvent-free thermotropic LCs possess an extremely wide temperature range from 40 °C to 200 °C. The intrinsic ordering and fluidity endow anisotropic luminescence properties in the system of shearing-aligned RE LCs, offering potential applications in anisotropic optical micro-devices.

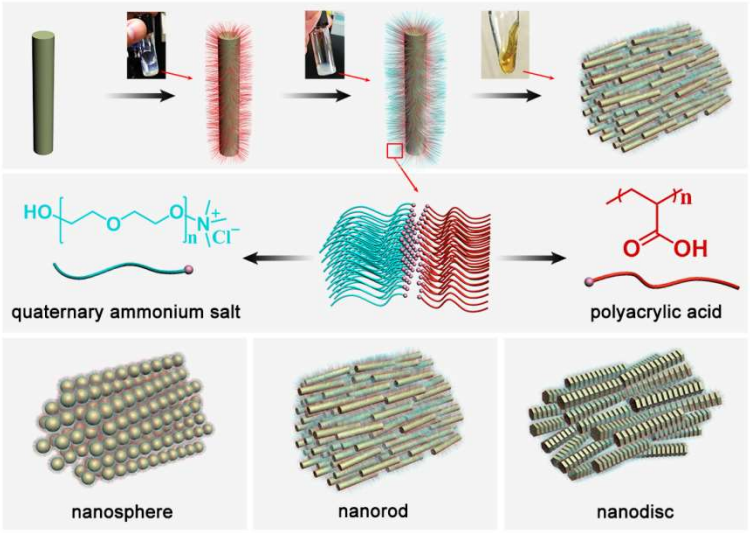


Figure 1 Self-assembly of rare-earth nanoparticles into solvent-free liquid crystal (LC) phases

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Two optical methods of temperature sensing behaviour of upconversion: Yb^{3+}/Ho^{3+} co-doped $KY(MoO_4)_2$ phosphor

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Two optical methods of temperature sensing behavior of Yb^{3+}/Ho^{3+}-codoped $KY(MoO_4)_2$ phosphor were investigated in the temperature ranging 298 - 573K. The phosphor shows strong red emission and sub-strong green emission under excitation at 980nm. The sensitivity was obtained by thermally coupled fluorescence intensity ratio (FIR) and non-thermally coupled fluorescence intensity ratio, respectively.

The thermally coupled levels are $^5F_5(1)$ and $^5F_5(2)$ which are split off from $^5F_5$. The maximum sensor sensitivity is approximately 0.0014 K^{-1} (298K). The non-thermally coupled fluorescence intensity ratio (I_{Green}/I_{Red}) method has a limited temperature range and is more suitable for the temperature range below 478 K. The sensitivity is 0.00048K^{-1}in the temperature ranging 298-378 K. The sensitivity is 0.00048 K^{-1} in the temperature ranging 298-378K. The sensitivity decreases to 0.00028K^{-1} in the temperature ranging 388-458K.

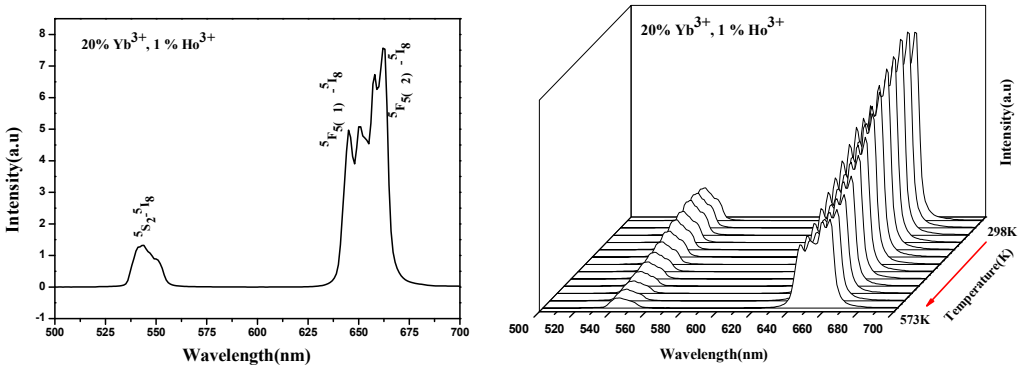


Figure 1. Temperature evolution of the Ho^{3+} upconversion spectra excited by 980 nm laser for $KY(MoO_4)_2$ phosphor

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Highly fluorescent PDI/SiO_2 nanospheres for in situ and real-time latent fingerprint development

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The development of an effective latent fingerprint-detection technology is of great significance in the field of forensic science because the fingerprint is one of the most powerful evidences for individual identification. However, the time-consuming, cost-wasting and the complex synthesis of the materials used in the fingerprint detection restricted the development of latent fingerprint [1, 2]. Herein, PDI/SiO_2 nanospheres were prepared by a simple and high-efficient emulsion-droplet-based growth method. The highly fluorescence and satisfactory stability of the nanospheres were proved. The latent fingerprint was in situ and real-time developed by a colorimetry-fluorescence dual-mode method on a variety of non-porous and porous substrates, including glass side, aluminum foil, steel ruler, white ceramic, common black paper, black plastic bottle cap and leather. The fluorescence images greatly make up for the poor detection contrast caused by the similar color between the nanospheres and substrates. Thanks to the strong adhesive affinity between PDI/SiO_2 nanospheres and the substrates, the aged latent fingerprints preserved for long periods of time were also visualized clearly. This highly fluorescent nanospheres is expected to be a suitable candidate for the latent fingerprint detection in the actual crime scene.

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Probing and controlling photothermal heat generation in thermoplasmonic heating system

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Plasmonic metal nanostructures can be used as efficient photothermal heat sources due to the enhancement of light absorption through surface plasmon resonance. Here, an optical heating system composed of silver nanoislands (Ag NIs) is designed to enable the controllable temperature at the nanometer scale generated by different laser power illumination. Furthermore, Er^{3+} doped single microrods embedded into optical heaters can act as optical thermometers to probe the local temperature. It was found that can realize the tuning color of upconversion luminescent microrods via to manage the local temperature in the optical heating system.

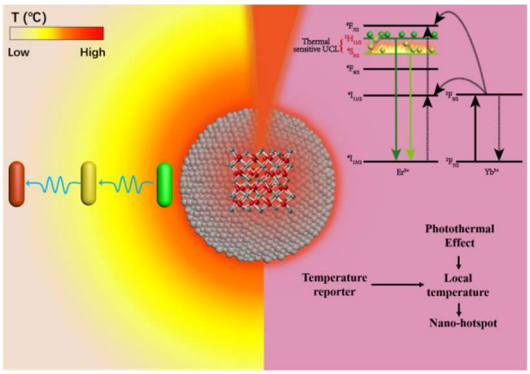


Fig.1 The schematic of the upconversion microrods for accurate monitoring of local temperature in the optical heating system. The local temperature changes are measured through changes in thermally coupled emission lines of the spectrum $^2H_{11/2} \rightarrow {}^4I_{11/2}$, $^4S_{11/2} \rightarrow {}^4I_{15/2}$. Through the management of the temperature in the optical heaing system can realize the tuning color of upconversion luminescent microrods.

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Au- decorated $REVO_4$ particles as potential nanoplatforms to study plasmonic catalysis

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Metal nanoparticles (NPs) have been extensively explored due to the applications arising from plasmon resonance effects,[1] with new emerging applications in plasmonic catalysis.[2] However, accurate description of the mechanisms in reactions catalyzed by irradiated NPs is still limited due the difficult determination local thermal contribution to reaction rates. In this sense, rare earth vanadates ($REVO_4$) show versatile luminescent and redox properties enabling spatially localized optical thermometry and catalysis.[3] We hereby propose a $REVO_4$-based nanoplatform decorated with AuNPs ($REVO_4$-AuNPs) to evaluate thermal fluctuations around metal NPs during plasmonic photocatalysis assays. Tetragonal $I4_1/amd$ $(Y,Er)VO_4$ particles (d~164 nm) were synthesized via hydrothermal precipitation, and AuNPs (d~20 nm) with maximum absorption around 525 nm were synthesized by reduction with citric acid.[4] $(Y,Er)VO_4$ and AuNPs were combined by a wetness impregnation method, so excitation at λ_{exc}=488 nm enables activating both the AuNP plasmons and the $(Y,Er)VO_4$ downshift luminescence. Temperature-dependent luminescence spectra of $(Y,Er)VO_4$-AuNP systems afforded relative thermal sensitivities of 0.9-1.2% K^{-1} at moderate temperatures (283-333K) owing to the thermally coupled $^4S_{3/2}$ and $^4H_{11/2}$ Er^{3+} levels.

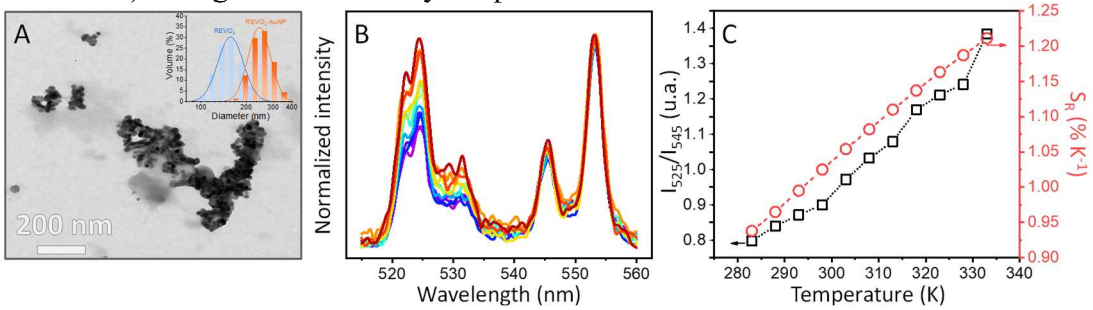


Figure 1. (A) TEM of AuNPs deposited over $(Y,Er)VO_4$, and DLS volume distributions before (blue) and after (orange) impregnation. (B) Temperature-dependent luminescence spectra (283-333 K) of $(Y,Er)VO_4$-AuNP under λ_{exc}=488 nm. (C) Integrated intensity ratio of Er^{3+} emissions [($^4H_{11/2}\rightarrow{}^4I_{15/2}$)/($^4S_{3/2}\rightarrow{}^4I_{15/2}$), left-black squares)] and relative thermal sensitivity (0.9 – 1.2 K^{-1}) (right-red circles) of the nanoplatforms.

The results demonstrate the effective impregnation of RE vanadates with AuNPs to afford thermometric response and catalysis combined. Further studies of model reactions will be conducted to evaluate these systems as tools for investigating local thermal effects in plasmonic catalysis.

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Reprogrammable and reconfigurable photonic molecular logic gates based on Ln^{3+} ions

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The evolution of the internet of things, the digitalization to networking is increasing the demand for computing power as a technological challenge. Therefore, the current ongoing belongs to nanostructured materials where a proper structure is obtained by means of bottom-up nanotechnology. In early 90's, the pioneering works of Prasanna da Silva *et al.* inspired a first general and practical approach to information processing and computing based on molecules able to perform logic operations. Since then, the research field grows studying systems based on organic molecules and exploiting chemical inputs.

Despite it is nowadays recognized that Ln^{3+} ions can improve the state-of-the-art of Molecular logical devices, only a few works have been reported so far. In mostly of the reported works, the Ln^{3+} ions respond to chemical inputs and the Molecular logical devices operate exclusively in wet conditions. Nevertheless, physical inputs have several advantages as homogeneity between input and output, reconfiguration, integration, remote control, dry conditions that allow the system to perform cycles of the same logic operations.

Herein, we present an organic-inorganic hybrid holding Eu^{3+} and Tb^{3+} ions as an illustrative example to demonstrate the potential of these ions to implement diverse logic operations, exploiting the unique photophysical properties of the trivalent lanthanide ions. The molecular system operates at room temperature through stimulation by excitation at distinct energies and enables the simultaneous occurrence of three logic operations (2 INHIBIT and 1 AND) only changing the readout selected.

Furthermore, exploiting the emission from the host material and the Ln^{3+} emitting centers, we present the possibility of designing reconfigurable logic gates, through the steady-state emission or reprogrammable logical gates using the distinct temporal dynamics of the Ln^{3+} ions and the hybrid host.

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Formalization of adaptive management methods by training based on cognitive models

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The digitalization of the adaptive learning environment (system) implies a high level of formalization the processes subjects interaction both with each other and with the external environment (the actual model of the control object), and with a control superstructure that ensures this system the effective. At the same time, in the materials of numerous studies of such authors as Barabanova S.V., Kaybiyinen A.A., Kraisman N.V. IN AND. Zvereva V.I., Yu.A. Konarzhevsky, M.M. Potashnik, I.B. Sennovsky, P.I. Tretyakov, T.I. Shamova (Russia), Hanno Horch (IGIP, Germany), Hans Hoyer (International Federation of Engineering Education Societies, IFEES), Stephanie Farrell (ASEE, USA), David Guralnik (USA), Rovani Sigamoni (UNESCO) and others, adaptive models of the educational processes are presented in verbal (meaningful) categories, which complicates the development of automated learning systems.

A promising type of models for describing educational processes are cognitive models [1,2], which allow us to formalize poorly formalized (not clear) information of a verbal, expert, and statistical nature about an object on the one hand, and form control actions based on causal factors identified by researchers investigative relationships between the characteristics of subjects and learning objectives on the other hand.

The cognitive model (CM) is usually presented in the form of a directed graph with "weights" on arcs in the form of operators whose structure is quite extensive. These can be operators that reflect static relationships: a functional type with parameters specified in the relations scale, in interval and rank scales, statistical characteristics, fuzzy relations, formalized membership functions. It is very important that CMs can also successfully simulate the dynamic processes of the state changing for the educational environment, which is important at adaptive learning systems. The operators in this case can be systems of difference equations, dynamic neural networks.

When forming the controlling parts of the educational environment, CMs are promising, based on logical decision-making methods and artificial intelligence methods. These methods include finite-state models, fuzzy state-of-the-art models, artificial neural networks, etc.

The development of these types of models allows you to develop standard designs of automated adaptive learning systems. At the same time, such systems allow at the design stage to evaluate the predicted effectiveness of adaptive learning systems by building simulators and conducting machine experiments on them.

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Upconverting phosphor-based ultraviolet light source

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When it mentions phosphor-converted (pc) light source, people would think of white and near-infrared light sources. In contrast, attention on the pc light sources at the other end of the spectrum—the shorter-wavelength ultraviolet region is absent. Taking into account the potential applications of ultraviolet light, the investigation of pc design as an alternative ultraviolet light source will be interesting [1]. Here we introduce a concept of ultraviolet pc light source, in which the ultraviolet emission can be achieved upon blue light excitation. As a proof of concept, we demonstrate the pc design using an ultraviolet-B phosphor $Lu_2Pr_{0.01}Gd_{0.99}Al_2Ga_3O_{12}$, and an ultraviolet-C phosphor $Y_{0.99}Pr_{0.01}BO_3$. Upon illumination with blue laser, up-conversion emissions at 313 and 260 nm appear form the two phosphors, respectively [2]. Subsequently, we prepare a series of composite films using the present phosphors , and build transmissive remote phosphor-converted light sources. According to the emission and excitation features of the pc light source, we present an ultraviolet functional demonstration, as shown in Figure 1. This study brings the pc light source to the ultraviolet region, which may offer a unique opportunity for some applications of optical tagging or indicator in bright environments.

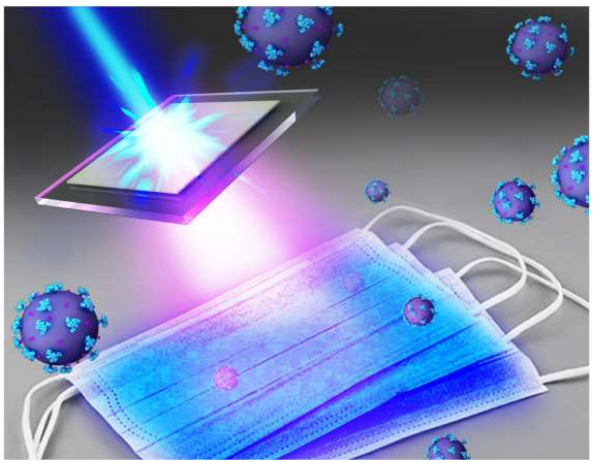


Figure 1. Demonstration of virucidal activity with the transmissive remote pc light source, in which ultraviolet emission can be achieved upon blue light excitation.

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Upconversion inducing persistent luminescence in $NaGdF_4:Yb^{3+},Er^{3+}$/ ZGSO:Cr^{3+} nanoparticles

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In the last few years, few studies using upconversion to charge persistent luminescence were reported in the literature [1]. Within this scheme, we synthesized $Zn_{1.33}Ga_{1.34}Sn_{0.33}O_4$:0.5%$Cr^{3+}$ (ZGSO), a recently known persistent luminescent material [2] at the nanoscale for the first time through hydrothermal method and $NaGdF_4:Yb^{3+},Er^{3+}$ nanoparticles by precipitation. Both nanoparticles were mixed together by dry impregnation. TEM images of the $NaGdF_4$-decorated particles at two scales are shown in Fig. 1a and 1b. Fig. 1c shows the overlap between $NaGdF_4$:Yb, Er $^2H_{11/2},^4S_{3/2} \rightarrow {}^4I_{15/2}$ upconverted emission in the green range and ZGSO $^4A_2 \rightarrow {}^4T_2$ excitation transition. This results to a deep red $^2E \rightarrow {}^4A_2$ emission at about 700 nm which presents persistent luminescence widely used for in-vivo imaging since first presentation in our research group in 2014 [3]. When exciting the decorated ZGSO/$NaGdF_4$ doped nanoparticles with a 980 nm laser with various powers, it is possible to obtain persistent luminescence, with the initial intensity and duration related to the used power (Fig. 1d). This finding allows to predict a possible use of new *in vivo* rechargeable persistent luminescent material for bioimaging in the first biological window (650-1000 nm).

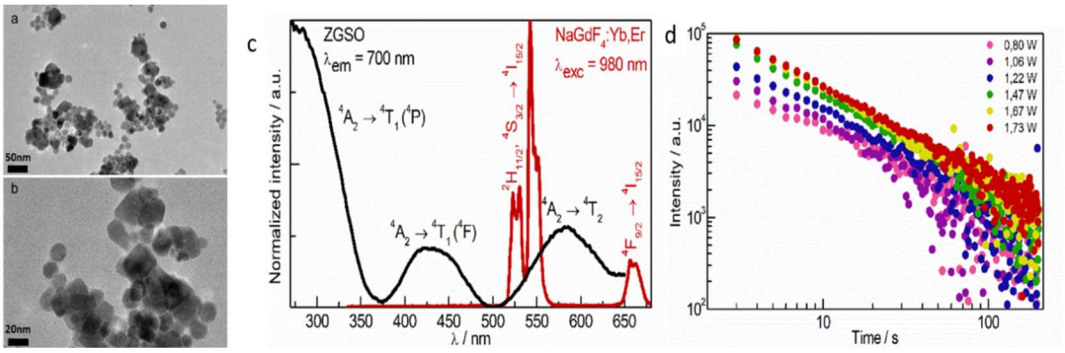


Fig. 1 (a) and (b) TEM pictures of $NaGdF_4:Yb^{3+},Er^{3+}$-decorated ZGSO:Cr^{3+} by dry impregnation. (c) Black line: excitation spectra of ZGSO (λ_{em} = 700 nm) and upconversion spectrum of $NaGdF_4:Yb^{3+},Er^{3+}$ (λ_{ex} = 980 nm). (d) Persistent luminescence of $NaGdF_4$-decorated ZGSO in the deep red range (in the first BW-1 at about 700 nm) with different excitation powers (λ_{ex} = 980 nm).

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Effect of graphene addition on the thermal and persistent luminescence properties of the $Gd_{2.994}Ce_{0.006}Ga_3Al_2O_{12}$ and $Gd_{2.964}Ce_{0.006}Dy_{0.03}Ga_3Al_2O_{12}$ ceramics

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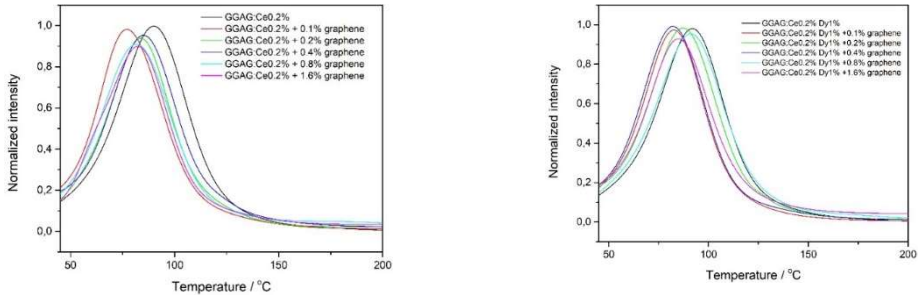
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The persistent luminescence is a phenomenon in which material is emitting light for long time after ceasing the irradiation. The long-time luminescence fading is the effect of releasing the electrons from the deeper traps with the help of thermal energy [1]. The energy needed for releasing the traps is important factor that have great influence on the intensity and time of persistent luminescence. Therefore many attempts are made to prepare materials with the appropriate energy gap end electronic structure, where defects/traps are located near conduction band (CB) where energy of room temperature is sufficient to transfer the electron from the trap to CB [2]. We focus on find out whether the addition of graphene flakes will have impact on the thermal conductivity of the ceramics and in consequence on the persistent luminescence properties. It was checked whether the changed thermal conductivity has an impact on the release of electrons from shallow and deep energy traps. Better thermal conductivity should reduce the amount of energy needed to release charges from energy traps and thus improve the properties of persistent luminescence. To verify this assumption, ceramics showing persistent luminescence and composites containing an admixture of graphene flakes were prepared and characterized. For all materials, their structure, morphology, thermal conductivity, thermoluminescence and spectroscopic properties were examined. Based on the obtained results, the mechanism of persistent luminescence was constructed, taking into account the impact of the graphene flakes addition and its relationship with the thermal conductivity of composites.



Thermoluminescence (TL) glow curves registered for $Gd_{2.994}Ce_{0.006}Ga_3Al_2O_{12}$ and $Gd_{2.964}Ce_{0.006}Dy_{0.03}Ga_3Al_2O_{12}$ ceramics with different graphene content.

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Synthesis and luminescent properties of three new and bright Eu - tta compounds modified on α-carbon for use as biological markers

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Three smarts luminescent Eu^{3+} complexes (Eu1 = Eu(tta-ester)$_3$phen 1, Eu2 = Eu(tta-NH_2)$_3$phen 2, Eu3 = Eu(tta-COOH)$_3$phen, were synthesized by using phenanthroline as the neutral ligand and Cα modified 2-thenoyltrifluoroacetonate and as the anionic ligand. All the Eu(III) complexes were structurally characterized by spectroscopic methods. Photoluminescence (PL) emission spectra of Eu complexes showed red color emission in the solid state. These materials were analyzed by X-ray diffraction, scanning electron microscopy and by energy dispersive, ultraviolet–visible spectroscopy, luminescence and vacuum ultraviolet–ultraviolet spectroscopies.The spectra show several sharp emission bands ranging from 450 to 750 nm due to the 4f–4f transition from the excited state $^5D_0$ to the low-lying multiple level ^7F_J (J = 0, 1, 2, 3 and 4) of the Eu^{3+} ion. The five main sharp emission peaks were observed at wavelengths of c.a. 579, 591, 613, 653 and 702 nm, which are attributed to the f–f electronic transitions of the Eu(III) ion ($^5D_0 \rightarrow {}^7F_0$, $^5D_0 \rightarrow {}^7F_1$, $^5D_0 \rightarrow {}^7F_2$, $^5D_0 \rightarrow {}^7F_3$ and $^5D_0 \rightarrow {}^7F_4$, respectively). These complexes were evaluated also in terms of high energy.VUV-UV emission spectra present the $^5D_0 \rightarrow {}^7F_2$ the transition dominating the spectrum under excitation at higher energies (Fig.1).

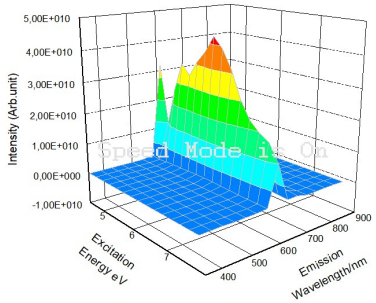


Fig 1. 3D emission spectra recorded under VUV-UV excitation for complex Eu(tta-ester)$_3$. measured at room temperature. c VUV-UV

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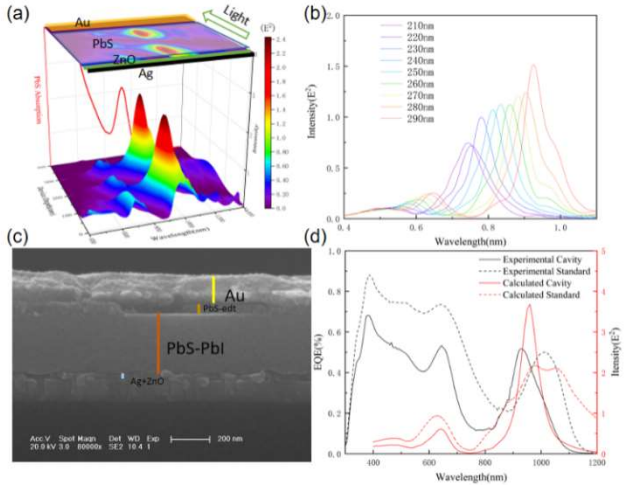
Near-infrared photoelectric efficiency study of PbS solar cells enhanced by bimetallic electrode resonance

Hongbo Zhu, Yinglin Wang*, Xintong Zhang*and Yichun Liu

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Efficient infrared photovoltaic devices are important for emerging sensing applications and solar energy utilization, however, the content of ITO conductive glass used in conventional solar cells is scarce and has strong infrared absorption, and PbS quantum dots have challenges such as low infrared absorption coefficient and insufficient infrared light utilization. Here we propose the use of metal thin film construction Fabry Perot cavity to achieve the effect of enhanced photoelectric response efficiency in the infrared band. Compared with the conventional ITO electrode, its infrared photoelectric performance is significantly improved due to its high electrical conductivity and high infrared band light field energy utilization. We obtained the results in good agreement with experiments using FDTD modeling analysis.

Fig. 1. (a) Simulation of the optical modulation distribution of the resonant cavity with bimetallic electrodes. (b) Simulation results of continuous manipulation of optical field energy distribution by absorbing layer thickness. (c) Electron microscope structure of resonant cavity device. (d) Comparison of experimental and simulated EQE of resonant cavity devices and conventional devices.



(1) Jia, Y.; Wang, H.; Wang, Y.; Shibayama, N.; Kubo, T.; Liu, Y.; Zhang, X.; Segawa, H., High-Performance Electron-Transport-Layer-Free Quantum Junction Solar Cells with Improved Efficiency Exceeding 10%. Acs Energy Lett 2021, 6, 493-500.

In-situ, quantitative and gradient of perovskite composition regulation and trap state-mediated carrier dynamics

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The optical properties of perovskite depends on their composition. Anion exchange can quantitatively regulate the composition of perovskite in situ to achieve the adjustment of its optical properties. However, there is rare related research to put forward at present. Herein, we have developed a facile gas/solid phase anion exchange strategy to achieve in-situ quantitative and gradient of the perovskite composition regulation and optical properties. More importantly, we have proposed an empirical formula for quantitative component regulation. In addition, the optical properties of perovskite are also affected by structural defects. At present, there have been several research reports on the origin of defects and the spatial distribution of trap states in perovskite. However, the carrier dynamics mediated by trap states in the surface and bulk regions of perovskite have not been deeply studied and explored. Thus, we use ultrafast spectroscopy technology to quantitatively measure trap density, and also study the perovskite carrier dynamics. Moreover, we also tried to control pervoskite defects to achieve regulating their carrier dynamics.

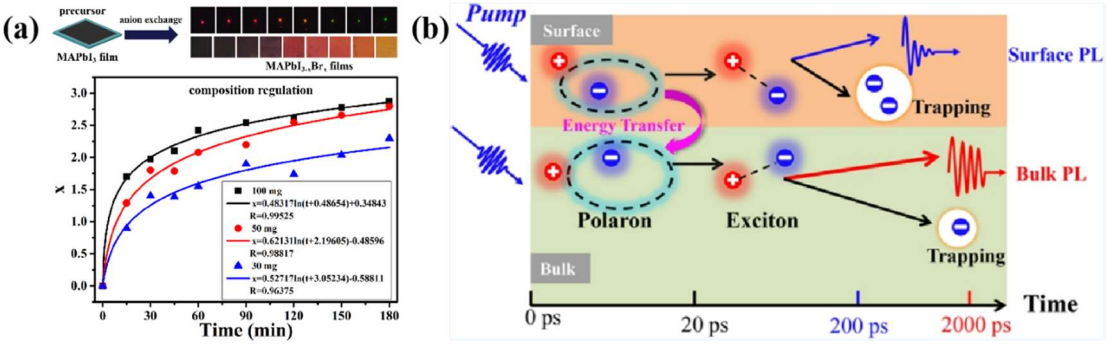


Figure (a) Quantitative of perovskite composition regulation. (b) Trap-state-mediated carrier dynamics.

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Photoacoustic/magnetic resonance imaging-guided photothermal theranostic nanoagent for glioma

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Glioma is the most common and aggressive malignant tumor of the central nervous system. Phototheranostic nanoagents is becoming high efficient tools to treatment glioma. However, it is still challenging to develop appropriate one-for-all phototheranostic nanoagents to overcome the limitations faced by the current all-in-one theranostic agents. Herein, $MnFe_2O_4$ nanoparticle clusters was firstly explored to simultaneously exhibit photoacoustic imaging, magnetic resonance imaging and photothermal performance. And thus, they were used as one-for-all phototheranostic nanoagents to perform a satisfactory imaging and therapeutic effect for glioma. This work proposes a feasible strategy to design and promote high-efficiency phototheranostic nanoagents for practical application.

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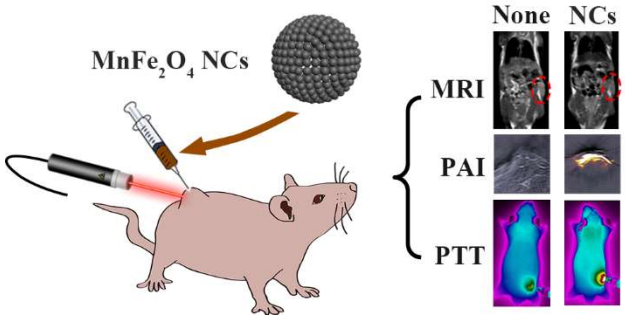


Figure 1 Photoacoustic/magnetic imaging-guided photothermal therapy of glioma.

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High-performance electron-transport-layer-free quantum junction solar cells with improved efficiency exceeding 10%

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Colloidal quantum dot solar cells (CQDSCs) are good candidates for low-cost power generators. Nevertheless, the generally used metal oxide electron transport layer (MOETL) induced various problems, blocking the performance enhancement of CQDSCs, such as band alignment mismatch, high-energy photon loss, and photoinduced interfacial degradation. In this work, we constructed high-efficiency and air-stable MOETL-free quantum junction solar cells (QJSCs) and a record power conversion efficiency of 10.5% was successfully achieved. Increased photogenerated current density was obtained in MOETLfree QJSCs because of the ultraviolet and near-infrared photoresponse enhancement. These unencapsulated MOETL-free QJSCs show long-term air-storage and light-soaking stibility.

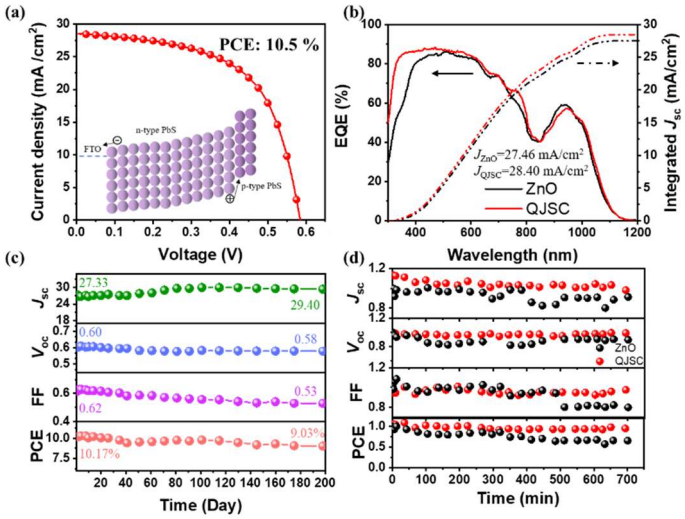


Figure 1. (a) J-V characteristics of QJSC. (b) EQE curves of ZnO and QJSC devices. (c) Evolution of photovoltaic parameters of unencapsulated ZnO and QJSC devices with air-storage time. (d) Normalized PCEs of ZnO and QJSC devices as a function of light-soaking time.

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Up-conversion charging $MgGeO_3:Mn^{2+}$ persistent phosphor upon illumination with white flashlight

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Persistent phosphor $MgGeO_3:Mn^{2+}$ ($MGO:Mn^{2+}$) has attracted attention due to its present and potential applications. To charge this persistent phosphors, high-energy ultraviolet (UV) illumination is typically necessary. Considering that UV excitation is unsuitable for some applications, we developed an up-conversion charging (UCC) $MGO:Mn^{2+}$ upon illumination with white light. Under intense white light excitation, the effective part of the white light excitation can consecutively promote electron to a high energy state via intermediate energy states (Figure 1). Electrons promoted to the high energy state may be captured by traps, followed by persistent luminescence. While the traps of storage phosphor are being filled under non-linear excitation, the trapped electrons may be simultaneously liberated by the UC excitation wavelength itself, as well as other possible wavelengths of white light. We reveal the competition between trap filling and light emptying under white light irradiation. The white light induced UCC dynamics offers a new way to study persistent luminescence and utilize persistent phosphors.

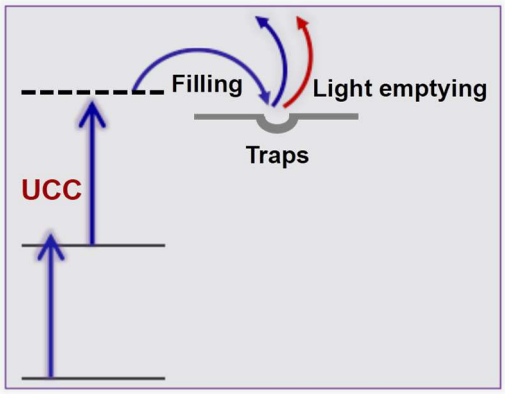


Figure 1. A schematic representation of UCC mechanism in $MgGeO_3:Mn^{2+}$ upon illumination with white flashlight.

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