Nanotechnology Highlight

Effect of Particle Size and Surroundings on the Luminescence of Eu^{3+}:Y_2O_3 Nanoparticles (9871864)

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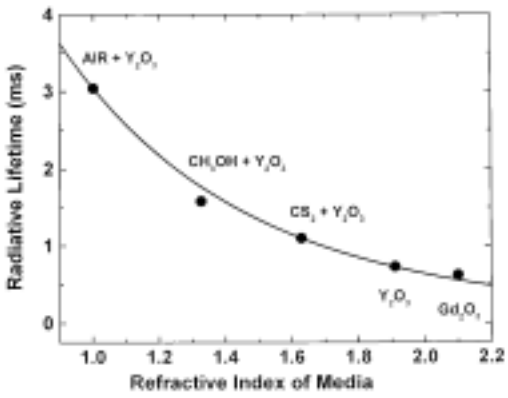
Preparing materials in nanoscale forms can produce materials with enhanced structural, electronic, and optical properties. Recent results on nanoparticles of a red phosphor, Eu^{3+}-containing Y_2O_3, show that the light emission depends on the particle size and on the medium surrounding the nanoparticles. This behavior is quite different compared to conventional phosphor particles and demonstrates the potential to tailor phosphor persistence for lighting or display devices. For example, an energy-efficient phosphor material that is unsuitable for computer or television screens due to a short persistence time might be tailored for these applications by preparing it at the nanoscale and embedding in a matrix.

Preparation and Annealing - In our collaboration between chemists at Virginia Tech and physicists at the University of Georgia, we observe a factor of four increase in the light emission lifetime of Eu^{3+}:Y_2O_3 nanoparticles with diameters less than approximately 15 nm. The Eu^{3+}:Y_2O_3 nanoparticles are prepared by gas-phase condensation using a cw-CO_2 laser to heat a ceramic target. They form with controlled diameters of 25 to 4 nm, depending on the vaporization conditions. Annealing at 800°C for one hour produces single-phase material and increases the brightness of the phosphor. The particle diameter increases on annealing but can be kept less than 10 nm.

Excited-State Lifetimes - The excited-state lifetime of Eu^{3+} in Y_2O_3 increases fourfold from 0.8 ms in micrometer-sized material to 3 ms in nanoparticles. This emission lifetime can be varied over this range by changing the medium between the nanoparticles via compaction or by dispersing the particles in media of different refractive indices. The figure shows the radiative lifetime of Eu^{3+} as a function of the refractive index of the medium surrounding the phosphor nanoparticles. The three leftmost data points are for 7-nm Eu^{3+}:Y_2O_3 particles surrounded by different media and the two rightmost data points are for Eu^{3+} in bulk Y_2O_3 and Gd_2O_3. The line in the figure is a fit to a model that relates the radiative lifetime to the refractive index of the surroundings.



Relevance - The lifetime dependence of these nanomaterials provides a probe for fundamental studies of light emission from luminescent materials and for studies of the surface chemistry of metal oxide particles. For display technologies, the lifetime dependence demonstrates the potential to optimize the persistence of phosphor materials for specific applications. This lifetime dependence might also serve as a new mechanism for chemical sensors, and future experiments will try to develop and characterize Eu^{3+}:Y_2O_3 nanoparticles on fiber-optic supports.

Relevant publication:

R. S. Meltzer, S. P. Feofilov, B. M. Tissue, and H. B. Yuan "Dependence of fluorescence lifetimes of Y_2O_3:Eu^{3+} nanoparticles on surrounding medium," *Phys. Rev. B* **1999**, *60*, R14012-R14015.