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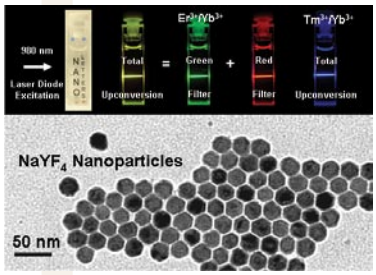
Physical Inorganic Chemistry

Research Interests

Our basic area of research involves the synthesis, characterization and spectroscopy of lanthanide doped nanoparticles. Of particular interest are upconverting nanoparticles that are capable of converting near-infrared into visible light (see figure). These materials have attracted considerable attention due to their potential application as biolabels and in biological assays. Nanoparticles doped with lanthanide ions that emit in the infrared are also attractive to the telecommunication industry.



Physical characterization of the nanoparticles entails powder X-ray diffraction to determine the crystalline phase and crystallite size; low and high resolution transmission electron microscopy (TEM) along with atomic force microscopy (AFM) to examine sample morphology and individual particle size; and reflectance Fourier transformed infra-red spectroscopy to detect the presence of surface species. Dynamics, luminescence efficiency and high resolution spectroscopic measurements on the dispersed nanoparticles enable us to understand the size dependence of the spectroscopic properties. Our lab is equipped to perform high resolution laser excited total luminescence, excitation, fluorescence lifetime measurements, laser induced fluorescence line narrowing, time resolved site selection spectroscopy, and Raman spectroscopy. We are capable of performing these measurements at various temperatures ranging from liquid helium temperature (4K) to 500K. The numerous laser sources available allow for excitation with wavelengths from the NIR to the ultraviolet.

Selected Publications

J. C. Boyer, J. Gagnon, L. A. Cuccia, J. A. Capobianco, Synthesis and Spectroscopic Investigation of $NaGdF_4$: Ce^{3+}, Tb^{3+}/$NaYF_4$ Core-shell Nanocystals, Chem. Mater., (2007), 19, 3358-3360.

J.-C. Boyer, L. A. Cuccia, J. A. Capobianco, Synthesis of Colloidal Upconverting $NaYF_4$: Er^{3+}, Yb^{3+} and Tm^{3+}, Yb^{3+} Monodispersed Nanocrystals, Nano Letters (2007) , 7(3), 847-852.

J.-C. Boyer, F. Vetrone, L. A. Cuccia, J. A. Capobianco, Synthesis of Colloidal Upconverting $NaYF_4$ Nanocrystals Doped with Er^{3+}, Yb^{3+} and Tm^{3+}, Yb^{3+} via Thermal Decomposition of Lanthanide Trifluoroacetate Precursors, Journal of the American Chemical Society, Communications (2006), 128, 7444-7445.

Pandozzi, Fabiano; Vetrone, Fiorenzo; Naccache, Rafik; Boyer, John-Christopher; Capobianco, John A.; Speghini, Adolfo; Bettinelli, Marco. NIR-to-UV/Blue Upconversion in Nanocrystalline $Gd_3Ga_5O_{12}$:Tm^{3+}, Yb^{3+}. J. Phys. Chem. B. (2005), 109, 17400-17405.

Vetrone, Fiorenzo; Boyer, John-Christopher; Capobianco, John A.; Speghini, Adolfo; Bettinelli, Marco. Significance of Yb^{3+} concentration on the upconversion mechanisms in codoped Y_2O_3:Er^{3+}, Yb^{3+} nanocrystals. Journal of Applied Physics (2004), 96 (1), 661-667.

Vetrone, Fiorenzo; Boyer, John-Christopher; Capobianco, John A.; Speghini, Adolfo; Bettinelli, Marco. Luminescence Spectroscopy and Near-Infrared to Visible Upconversion of Nanocrystalline $Gd_3Ga_5O_{12}$: Er^{3+}. Journal of Physical Chemistry B (2003), 107 (39), 10747-10752.

"Our work has had great implications for society and for the economy. There are many applications for fluorescent nanoparticles in scientific, medical and industrial areas. Areas where such labels are used include biotechnology (proteomics, genomics, high throughput drug screening) forensics and security (fingerprint detection, monitoring for drug abuse, tagging of explosives, anti-forgery marking of documents), biosensing (detection of chemical and biological warfare agents, pollution monitoring) medicine (contrast agents for tumor detection, screening of tissue samples) electronic communications, computing, photodynamic therapy and chemotherapy."