Pawan Rastogi
Mentor: Jennifer Hollingsworth, Ph.D.
Los Alamos National Laboratory, Material Physics & Applications Division (MPA)
Center for Integrated Nanotechnologies (CINT)
Columbia University

Sensitizing and Protecting Lanthanide Ion Emission Using Optically Active Nanocrystals

Lanthanide ions (Ln^{3+}) are characterized by their ultra-narrow band emissions of visible to near-infrared light with long luminescence lifetimes. This makes them ideal candidates for applications in lasing, up-conversion, and bioimaging. However, Ln^{3+} ions have specific and narrow absorption bands characterized by small cross sections, and their luminescence is vibrationally quenched in common solvents, thus making such applications difficult. To date, two optically active matrices have been explored as nanoscale hosts for Ln^{3+} ions, YVO_4 and In_2O_3. Specifically, Eu, Tb, Nd, Ho, Yb/Er, Ce/Er were doped into an YVO_4 matrix at varying concentrations (0 – 10%) following a modified *aqueous synthesis route*. Doped YVO_4 nanoparticles were capped with citrate ligands to afford water-soluble and thermally stable particles averaging 22 nm in size. Eu^{3+} luminescence was observed by way of energy transfer (ET) from the YVO_4 host matrix after excitation of the YVO_4, thus confirming sensitization of the Eu^{3+} ions toward absorption. Particles possessed high quantum yields (up to 16%) and were stable at temperatures above 200 ^oC. Additionally, a novel annealing technique using a microwave reactor was implemented to synthesize this class of nanoparticles, reducing reaction time by 70%. Second, a *non-aqueous synthesis route* developed in our laboratory was used to prepare In_2O_3:Eu nanocrystal quantum dots (NQDs) with clear red emission. Photoluminescence excitation spectroscopy was used to demonstrate sensitization of the Eu^{3+} emission by way of the semiconductor In_2O_3 matrix, and time-resolved spectroscopy of the doped NQDs compared with various control samples confirmed the "protective" nature of the NQD matrix. Doping In_2O_3 NQDs with other Ln^{3+} ions has also been attempted, as well as Ln^{3+} incorporation into In_2O_3 nanowires (higher absorption cross sections). Efforts are ongoing to further enhance sensitization (optimizing ET) and protection of Ln^{3+} emission, while expanding the accessible spectral window by increasing the number of successful nanocrystal-lanthanide combinations.