

Optical Properties of II-VI and IV Semiconductor Nanoclusters for Use as Phosphors

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The optical properties of both II-VI (direct gap) and type IV (indirect gap) nanosize semiconductors are significantly affected not only by size, but by the nature of the chemical interface of the cluster with the embedding medium. This profoundly affects the light conversion efficiency and even alters the shape and energy peak (i.e. the color) of the photoluminescence (PL). As the goal of our work is to embed nanoclusters into either organic or inorganic matrices for use as LED-excited phosphor thin films, understanding and controlling this interface is very important to preserving the high Q.E. found under dilute solution conditions.

Our room temperature synthesis of semiconductor nanoclusters including both indirect (e.g. Ge, Si, MoS₂) and direct band-gap materials (e.g. CdS, CdSe, HgSe, PbS) uses inexpensive, ionic precursors, and uses simple coordinating solvents as the reaction medium. This allows us to add passivating agents, ions, metal or semiconductor "films" to identical, highly dispersed bare clusters post-synthesis. We find that both the absorbance excitonic features and the photoluminescence (PL) energy and excitation profile (PLE) depend on the nature of the surface as well as the average size. In CdS, for example, the presence of electron traps decreases the exciton absorbance peak amplitude but vastly increases the PL. Hole traps have the opposite effect. Depending on the nature of the solvent, the PL yield may either increase (non-coordinating) or decrease (coordinating) with sample age.

Liquid chromatographic (LC) separation of the nanoclusters from other chemicals and different sized clusters is used to investigate the intrinsic optical properties of the purified clusters and identify which clusters are contributing most strongly to the PL. It has also allowed us to identify certain "magic" cluster sizes with extraordinary structural stability.

Finally, recent measurements of very strong NIR and IR emission from PbS and PbSe and measurements of phosphor efficiencies of both films and solutions held at the center of an integrating sphere are also discussed. Acknowledgment This work was supported by the Division of Materials Science and Engineering, Office of Science, US Department of Energy under contract DE-AC04-AL8500. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed-Martin Company, for the US Department of Energy.