Preface

Nanoscale research is a rapidly growing field of science. Recent progress in nanotechnology allows the creation of new materials with properties tunable on the nanometer scale. The various colloidal growth techniques have emerged. The ease with which nanocrystals are formed has made it very popular. Feasibility of obtaining doped nanocrystals, a variety of shaped, and core-shell type of nanocrystals have opened different avenues in field of nanoscience.

In the bulk phase, the band gap can be changed by alloying two semiconductors. In case of nanocrystals, composition can be varied systematically. Changing the composition not only changes the band gap but also controls the confinement potential of NCs, depending on the composition distribution in NCs. The shape of confinement potential is connected to the Auger recombination rate, luminescence efficiency and non-linear optical properties etc.

In the present work electronic structures of compositionally tuned (doped, graded and alloyed) nanocrystals are studied by means of linear optical probes. Manganese –doped ZnSe, ZnSeTe (ZnSeTe:Mn) along with graded core/shell Zn$_{1-x}$Cd$_x$Se nanocrystals were prepared using the high temperature organometallic synthesis route. The chemical route yields highly crystalline, zinc-blende ZnSeTe:Mn quantum dots and Zn$_{1-x}$Cd$_x$Se nanocrystals.

In case of ZnSeTe:Mn NCs, Mn concentration was varied from 0% through 10% and Te concentration was varied from 0 – 4% to obtain ZnSe:Te. In bulk Te incorporation in ZnSe leads to Te isoelectronic level formation. Previous reports indicate that these isoelectronic centers were observable in PL only at low temperature. In the present investigation, the isoelectronic centers are observed at room temperature because of quantum confinement. The effect of these energy levels on Mn emission is studied by optical method. It is found that the incorporation of isoelectronic center in Mn doped ZnSe quantum dots alters the relaxation pathways in such a way that, energy transfer to Mn ion is impaired. Further investigations revealed that the energy transfer from exciton to the isoelectronic center is more dominant than energy transfer from exciton to Mn ion.
In case of graded Zn$_{1-x}$Cd$_x$Se nanocrystals, due to difference in reactivity of Zn and Cd precursors with TOP Se a graded core shell structure with CdSe rich core and ZnSe rich shell is formed. The formation of graded structure is proved by checking the composition at different growth time. Spatial distribution of composition in the nanocrystals can be varied by changing the amount of Cd in precursor solution. Annealing at elevated temperature for longer time provide the thermal energy to attain an uniform alloy structure. The formation of alloy structure is deduced from x-ray photoelectron spectroscopy. Optical studies indicate that the Stokes shift of these NCs goes on decreasing as alloy formation progresses. The electron energy level analysis suggests that the reduction in Stokes shift is caused by spreading of exciton wave function by change in confinement potential due to alloy formation. The energy levels in alloyed nanocrystals come close to each other whereas the band gap increases. In short, only the forbidden gap is controlled by the composition of nanocrystals whereas the higher excited state strongly depend on the confinement of exciton.

The size and shape of the microscopic confinement potential affects the Auger recombination rate. Direct experimental proof of the prediction is not available in the literature. Moreover previous studies on such graded structure attributed blinking suppression to reduced Auger mechanism. However, effect of changed confinement potential shape on blinking is not studied in detail. The microscopic shape of the confinement potential in Zn$_{1-x}$Cd$_x$Se nanocrystals is altered by changing the concentration of Cd and alloying. Single nanocrystal emission from Zn$_{1-x}$Cd$_x$Se nanocrystal was studied. Blinking analysis revealed that, nanocrystals with soft confinement variation lead to suppressed blinking. Whereas alloyed NCs in which the confinement potential is flat, showed substantial blinking. This work clearly indicated that the optical properties of NCs not only can be controlled by confinement but also can be controlled by shape of confinement potential.