Abstract

The thesis investigates the optical, photo-physical, and electrical properties of CdTe and HgCdTe nano- and micro-structures synthesized by hydrothermal/solvothermal technique. Application oriented studies like fluorescence resonance energy transfer (FRET), bio-sensing, two photon absorption are carried out on colloidal CdTe QDs. Defect related and temperature dependent luminescence studies are carried out in detail on HgCdTe nano and micro-crystals. The electronic device application-oriented studies of nano- Schottky diode and electrical bistability are carried out on colloidal CdTe QDs. This work is presented in seven chapters including summary and directions for future work.

Chapter 1 provides a brief introduction to optical, electrical, and photo-physical properties of semiconductor QDs and hydrothermal/solvothermal technique in preparation of quantum nanostructures. A review of CdTe and HgCdTe nanostructures and its technological applications are discussed.

Chapter 2 provides the experimental techniques used in this work. First, the hydrothermal/ solvothermal synthesis of CdTe, HgCdTe nano- and micro-structures, and secondly, the characterization tools used in this work are briefly presented. Also, we presented hydrothermal/solvothermal synthesis of few other nanostructures such as CdSe, PbTe and Au for future work.

Chapter 3 describes, the interaction of CdTe QDs with biomolecules and the energy transfer phenomena between two different size CdTe QDs in aqueous media with the use of steady-state PL spectroscopy. The structural and optical properties of the QDs were characterized by transmission electron microscopy, photoluminescence and UV-visible spectroscopy and their formation mechanism is discussed. The hydrothermally grown highly luminescent 3-MPA capped CdTe QDs shows good stability in aqueous media even after 45 days under natural ambient and room conditions. The presence of thioalkyl acid groups in 3-MPA helps the QDs to become bio-compatible. The quenching of photoluminescence intensity of CdTe QDs in the presence of l-cysteine and DNA confirms its bio-compatibility nature for bio-sensing. The overlapping in absorption and emission spectra of two different size CdTe QDs is described here as one of the reasons for energy transfer in aqueous media.

Chapter 4 describes the growth and PL properties of NIR emitting Hg1−*x*Cd*x*Te (MCT) nanostructures with different compositions (x = 0.1 - 0.8) synthesized by solvothermal method, which is a facile, cost effective and solution growth approach to the large-scale preparation of MCT at relatively low temperature (180 ◦C) using an air stable and water soluble Te source. The room temperature FTIR transmission and low temperature PL studies for a composition of x = 0.8 gives a band gap of 1.1 eV and a broad emission in NIR region (0.5 - 0.9 eV) respectively. The temperature dependent PL study is understood by the configuration-coordinate model that give insight on the competition between radiative recombination through localized states and non-radiative recombination

process which involves phonon emission. Hence, it is suggested that the observed luminescence bands are related to defect states originating from the compositional disorder in MCT nanostructures.

Chapter 5 describes non-linear absorption studies in 3-mercaptopropioninc acid capped water-soluble CdTe QDs using open z-scan technique in near resonant regime. The origin of optical limiting is predominantly effective two photon absorption mechanism which varies with QD size. The effective two photon absorption coefficient (β) was observed to be 0.55 cm/GW for 2 nm size QDs which is about 10 times higher than the value reported in off-resonant region. Because of their excellent nonlinear optical properties, they are considered to be promising materials for all-optical switching and optical limiting devices.

Chapter 6 describes the current-voltage characteristics of MPA capped CdTe QDs in different device geometries such as planar and sandwiched using Pt, Ag, and ITO as metal electrodes. In particular, nano-Schottky diodes of CdTe QDs with platinum metal electrodes in metal-semiconductor-metal planar configuration fabricated by drop-casting shows an asymmetry and non-linear I-V characteristics between forward and reverse directions, which has been explained in detail in terms of size distributions of QDs. It also describes the observation of electrical bistability in CdTe QD/polymer heterostructures in sandwich device geometry.

Chapter 7 presents the summary and directions for the future work.