Photoinduced Energy and Charge Transfer in InP Quantum Dots-Polymer/Metal Composites for Optoelectronic Devices

Authors : Akanksha Singh, Mahesh Kumar, Shailesh N. Sharma

Abstract : Semiconductor quantum dots (QDs) such as CdSe, CdS, InP, etc. have gained significant interest in the recent years due to its application in various fields such as LEDs, solar cells, lasers, biological markers, etc. The interesting feature of the QDs is their tunable band gap. The size of the QDs can be easily varied by varying the synthesis parameters which change the band gap. One of the limitations with II-VI semiconductor QDs is their biological application. The use of cadmium makes them unsuitable for biological applications. III-V QD such as InP overcomes this problem as they are structurally robust because of the covalent bonds which do not allow the ions to leak. Also, InP QDs has large Bohr radii which increase the window for the quantum confinement effect. The synthesis of InP QDs is difficult and time consuming. Authors have synthesized InP using a novel, quick synthesis method which utilizes trioctylphosphine as a source of phosphorus. In this work, authors have made InP composites with P3HT(Poly(3-hexylthiophene-2,5-diyl))polymer(organic-inorganic hybrid material) and gold nanoparticles(metal-semiconductor composites). InP-P3HT shows FRET phenomenon whereas InP-Au shows charge transfer mechanism. The synthesized InP QDs has an absorption band at 397 nm and PL peak position at 491 nm. The band gap of the InP QDs is 2.46 eV as compared to the bulk band gap of InP i.e. 1.35 eV. The average size of the QDs is around 3-4 nm. In order to protect the InP core, a shell of wide band gap material i.e. ZnS is coated on the top of InP core. InP-P3HT composites were made in order to study the charge transfer/energy transfer phenomenon between them. On adding aliquots of P3HT to InP QDs solution, the P3HT PL increases which can be attributed to the dominance of Förster energy transfer between InP QDs (donor) P3HT polymer (acceptor). There is a significant spectral overlap between the PL spectra of InP QDs and absorbance spectra of P3HT. But in the case of InP-Au nanocomposites, significant charge transfer was seen from InP QDs to Au NPs. When aliquots of Au NPs were added to InP QDs, a decrease in the PL of the InP QDs was observed. This is due to the charge transfer from the InP QDs to the Au NPs. In the case of metal semiconductor composites, the enhancement and quenching of QDs depend on the size of the QD and the distance between the QD and the metal NP. These two composites have different phenomenon between donor and acceptor and hence can be utilized for two different applications. The InP-P3HT composite can be utilized for LED devices due to enhancement in the PL emission (FRET). The InP-Au can be utilized efficiently for photovoltaic application owing to the successful charge transfer between InP-Au NPs.

Keywords : charge transfer, FRET, gold nanoparticles, InP quantum dots
Conference Title : ICNN 2018 : International Conference on Nanoscience and Nanotechnology
Conference Location : London, United Kingdom
Conference Dates : March 15-16, 2018