Engineering of semiconductor quantum dots for light emitting applications

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One of the emerging applications exploring the potentialities of fluorescent nanomaterials is related to light emitting technologies. In particular for the realization of practical light-emitting diodes and large-area displays, semiconductor nanomaterials may overcome many issues of such challenging technologies. A critical aspect of semiconductor nano scaled materials is related to the large Coulomb interaction between electrons and holes, and their strong spatial confinement, with respect to their bulk analogues. When the size is reduced to levels smaller than the exciton Bohr radius, size-dependent absorption and emission properties develop. Upon formation of excitons within quantum dots (QDs) through optical or electrical processes, Coulomb interactions play a key role in subsequently determining their radiative and non-radiative decay rates, fluorescence quantum yields, multi-exciton generation and its decay. Appropriate engineering of QDs, through the colloidal synthesis of core/shell heterostructures, has emerged as the most facile manner to gain control of these Coulomb processes. The strong electronic coupling between the core and shell in core/shell QDs ensures that the electronic structure, composition and thickness of the shell must be considered in parallel with the properties of the core in order to predictably manipulate the electron and hole probability densities to obtain the desired optoelectronic characteristics. This spatial control of carriers affects the direct Coulomb interaction between electrons and holes, but also influences the rate and carrier selectivity of trapping at surface and, possibly, interface defects. The latter is highly dependent on the core/shell structure, for which lattice mismatch between materials must be carefully managed to avoid defect formation stemming from excessive interfacial stress. The above structural and electronic factors define the dynamics of single and multi excitons in QDs, which directly influences aspects such as recombination lifetimes, luminescence efficiency and optical gain properties. Considering the importance of each of these properties for light emitting applications, in this presentation we compare different approaches for the enhancement of light emission quality in terms of high fluorescence efficiency, high color quality, enhanced photostability under prolonged irradiation and easy implementation of solution processable methodologies. All these excellent features make the use of QDs materials a promising way for the realization of optically and electrically pumped light emitting devices.

Speaker Biography

Raffaella Signorini Since October 2015 working as an Associate Professor in Physical Chemistry at the Department of Chemical Sciences of the University of Padova. Her major research interests focus on non-linear optical spectroscopies and nanomaterials. The research activity spans from the NLO characterization of chromophores, including reverse saturable absorption, two-photon absorption and emission, to the realization of compact devices, like optical limiters and integrated lasers, and micro-fabrication

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