NANOCRYSTAL QUANTUM DOTS: FROM FUNDAMENTAL PHOTOPHYSICS TO LIGHT-EMITTING DIODES AND MULTICOLOR LASERS

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Using modern colloidal chemistry, semiconductor nanocrystals (NCs), known also as NC quantum dots, can be fabricated with nearly atomic precision with a wide range of sizes and shapes. They exhibit high photoluminescence quantum yields, narrow size-controlled emission lines, and can easily be manipulated into complex two-dimensional (2D) and 3D assemblies. All these properties of NCs make them attractive building blocks for applications in various optical technologies including light-emitting devices, broadband optical amplifiers, and tunable lasers. Here we discuss light emitting properties of semiconductor NCs in the regimes of both optical and electrical pumping for the cases when either single- or multiple excitons are created in a NC. We show that by using shape-controlled NCs or multi-shell NC heterostructures, we can almost independently control carrier confinement energies (i.e., emission wavelength) and their recombination dynamics. This capability is particularly important for achieving the optical amplification regime. We use different types of "engineered" II-VI and IV-VI nanocrystals to demonstrate amplified spontaneous emission with colors tunable from the near infrared to the blue. We also develop and study novel types of hybrid epitaxial/colloidal nanostructures, which allow efficient electrical pumping of NC emitters via either exciton transfer or direct charge injection from epitaxial layers of wide gap semiconductors.