Dimensionality Matters:
Dimensionality Effects on Optoelectronic Behavior of Semiconductor Nanocrystals

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Studying the transition of properties of nanostructures as they develop from the zero-dimensional to the one-dimensional regime is significant for unravelling the modifications that occur in the electronic structure of the particle as its length to width aspect ratio is increased. Such understanding can lead to better design and control of the particle properties, with relevance for a wide range of technological applications. The ongoing improvements in the control of shape and morphology of nanoparticles in colloidal synthesis, which allows forming structures of similar composition but of different dimensionalities and shapes, open the way for probing such dimensionality effects. We will present several effects involving the 0D to 1D transition in colloidal nano heterostructures of different morphologies including “sphere in a sphere”, “sphere in a rod” and “rod in a rod”. In addition, a recently discovered new architecture of “nanorod couples” will be introduced.

Both ensemble and single particle based measurements were used to decipher these effects providing complementary viewpoints. The first dimensionality related aspect involves the modification of emission and absorption polarizations, as the dimensionality of the particles and of their cores changes. The second aspect relates to the function of these nanocrystals as donors in energy transfer processes to multiple dye molecules bound on their surfaces and functioning as acceptors (see schematic of the FRET process in the figure below). We will show how the dimensionality of the particles’ core and shell affects the donor’s time dependent survival probability, as well as the behavior of FRET to multiple acceptors on single particle level. The opportunity to tailor the systems dimensionality with multiple acceptors on the surface results in enhanced FRET efficiencies with relevance for optical, sensing and energy funneling applications.

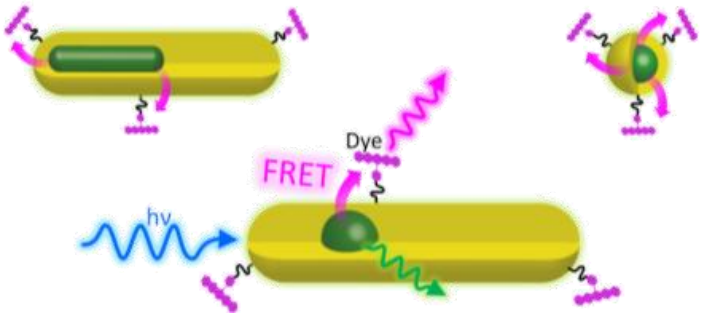

Fig. 1: Schematic representation of energy transfer processes between different core/shell semiconductor nanocrystals and multiple dye acceptors on their surface.