Resonance Energy Transfer in hybrid configurations for light harvesting and light emitting applications

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Abstract: We engineer resonance energy transfer into hybrid organic/inorganic and colloidal epitaxial semiconductor nanostructures and utilize it as an efficient mechanism to couple these heterogeneous material systems leading to improved efficiencies both in photovoltaic solar and light emitting diode devices.

The brightness, large absorption cross-section and flexibility of colloidal nanocrystal quantum-dots (NQDs) and organic semiconductors render them promising new materials for light harvesting and light emitting applications. However, both classes of material are plagued by low-charge-transfer efficiency that limits the overall power conversion efficiency when compared to silicon-based or epitaxial p-n junction photovoltaics, and epitaxial light emitting diodes. A route to circumvent altogether issues associated to low charge transfer in NQDs and organic semiconductors is to engineer devices that utilize alternative energy transfer schemes to electrical injection and transport while still benefiting from their large oscillator strength.

In nature, funnelling of energy between different chromophores predominantly occurs through a nonradiative dipole–dipole coupling mechanism, commonly referred to as resonance energy transfer. Nonradiative energy transfer does not involve charge transfer or emission and absorption of photons between donor and acceptor and can exceed the radiative energy transfer routinely used in phosphor light emitting devices. Theoretical calculations predict that free quantum well excitons can undergo resonance energy transfer with an order of magnitude higher rate compared to localized, point–like dipole excitons exemplifying the potential of hybrid optoelectronic devices utilising resonance energy transfer as a means to overcome charge transfer related limitations. Here we will present recent advances in the new field of hybrid optoelectronics in architectures where nonradiative energy transfer is used to combine the high carrier mobility of single crystal inorganic semiconductor heterostructures and the versatility offered by colloidal NQDs and organic semiconductors both in light and light emitting applications[1-6]. The relevant physics will be presented at postgraduate level.