Controlling excitons in semiconductor quantum dots for nanophotonic applications

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Miniaturization of optical elements and switches can make photonic integrated systems more compact and functional, but the size of optical devices is fundamentally diffraction-limited. Excitons, bound electron-hole pairs confined in nanostructured materials, such as semiconductors quantum dots, can be converted to and from photons, providing a novel approach to manipulate light on the nanoscale. This talk presents our study on exciton flow through quantum dot arrays and electrical switching of individual quantum dot emission. First, we explore exciton diffusion in one-dimensional and two-dimensional quantum dot arrays and how an external electric field influences exciton diffusion dynamics. Second, we show a switch that electrically modulates the photoluminescence of individual nano-emitters. It is achieved by gate-tuning the energy transfer from semiconductor quantum dots to graphene (see Fig. 1). Our results show the potential of exploiting excitons for nanophotonic communication, imaging, and sensing.

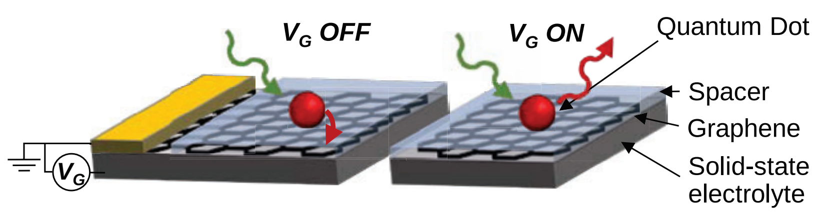

Figure 1: Electrical control of energy transfer from quantum dots to graphene: At $V_G = 0$, the photoluminescence of quantum dots is quenched, as the energy in quantum dots is resonantly transferred to graphene. When a gate voltage is applied sufficiently, the energy transfer is suppressed and the quantum dots emit photons to free space.