Plasmonic Nanoantennas for Nanoscale Interactions with Quantum Dot Emitters

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Silicon nanocrystals (Si-ncs) and other quantum dot embedded dielectrics have long been considered potential candidates for the development of integrated sources for optical interconnects. Si-ncs are often considered particularly attractive, due to their compatibility with CMOS fabrication techniques, enabling their use for Si-photonics. Much work has been done in studying the formation and luminescent properties of such systems, but methods of interacting with Si-ncs post-formation and controlling, or even modifying, their emission properties have been less explored – particularly on microelectronic size scales, which are typically subwavelength and below the diffraction limit of light.

Surface plasmons, the collective oscillations of surface electrons in metallic nanostructures, are excited at optical frequencies and allow for the localization of electromagnetic energy on electronic length scales. Moreover, plasmonic elements can act as the optical analogue to conventional radio antennas – such that nanoantennas can be used to manipulate not just the emission properties of a quantum dot in their near vicinity, but also providing control over the emission profile and directionality.

In this talk, we will discuss the application of plasmonics to the control of light emission on the nanoscale - considering the physics, characterization, and use of plasmonic nanoantennas for the modification of the emission properties of luminescent materials, such as semiconducting quantum dots, in their vicinity. This modification can occur in a two-fold manner, enhancing the excitation of emitters through the localization of exciting EM radiation, and through the modification of the decay rates of the emitters themselves. As an example, Figure 1 shows the emission from a Si-nc sample, fabricated through ion implantation, both on and off an Au nano-disk structure, illustrating the enhancement in the region of the disk.

As mentioned, such structures allow not just for the enhancement of light emission, but also for control of the emission profile and directionality, and the application of such directionality for integration with plasmonic and photonic waveguides will also be considered along with some early stage work currently being conducted in this area.

Finally, we will consider general aspects of the deep subwavelength confinement attainable in plasmonic systems, focusing in particular on interfacing with low dimensional functional materials such as graphene.

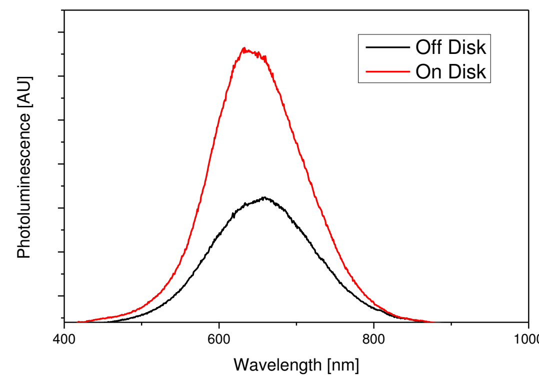

Figure 1: Localized enhancement in the region of a single Au disk structure. The PL is enhanced by a factor of ~2 in the region of the Au disk.