Dark-field microscopy for resonant excitation of self-assembled quantum dots

Advertising institute: PGI-9 Semiconductor Nanoelectronics

Background:

Self-assembled quantum dots of InAs in GaAs have been successfully used to demonstrate single photon emission and spin-photon entanglement. Most applications have relied on optical generation and manipulation of the excitons in the quantum dots. Typically, optical excitation of the dots is achieved with the laser emitting at the energy higher than the energy of excitons in the quantum dot. Such excitation scheme allows one to filter the excitation light from the measured signal with long pass filter but it introduces undesirable decoherence channel. Optical excitation at the energy of the exciton (resonant excitation) is possible if polarization of light degree of freedom is used to filter the excitation signal from the photoluminescence from the quantum dot.

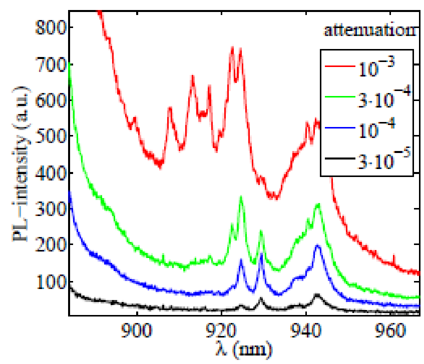

Figure 1: Typical spectra of an InAs quantum dot excited with a laser at 780nm wavelength. The excitation of such high energy causes recombination not only in the quantum dots (between 900 and 960 nm) but also from higher energy stated in thin layer of InAs (so called wetting layer) seen here for wavelengths shorter than 900 nm and especially at lower attenuation of the laser beam. This signal can be removed by excitation with laser emitting at 900 nm or longer wavelength.

Your tasks:

In this project, you will develop dark-field optical microscopy setup for resonant excitation of InAs single quantum dots and use it to characterise properties of the dots. It will require adding polarization controlling optics into an existing micro-photoluminescence setup and developing an algorithm (to be implemented in Python) to align it to minimize amount of laser light reaching photon detectors. At this stage you measure spectra of emission of InAs quantum dots near two dimensional electron gases and their recombination rates.

You will gain experience with optical spectroscopy, with techniques of photoluminescence and photoluminescence excitation, light polarization control and as well as with Python based control of experiments.

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