Characterization of semiconductor nanostructures using optical spectroscopy is an imporant step towards improvement and developement of the nanophotonic or optoelectronic devices. Low-dimmensional structures reveal its quantum nature in terms of electronic states quite similar to atomic energy levels for electrons which with participation of photon absorption or emission can change the orbital. Especially interesting are 3-dimmensional nanostructures called quantum dots (or dashes) that can be fabricated using self-assembled epitaxial growth and when an embedded crystal structure differs in lattice constant the island constructiun on a surface is preferable.

In this project we will concern the InAs nanostructures of elongated geometry, that unambiguously reveals a single photon character of emission what has been experimentally verified. The resultan emission spectral range can be designed by controlling growth conditions and it is feasible to cover the second (1300 nm) and third (1550 nm) telecommunication windows used for long-haul data transmission. The optical spectroscopy will be performed for both. The elongated shape of quantum dashes induces the existence of polarization anisotropy of emission of exciton which is the first optically active excitation, namely theconfined electron-hole pair. The recombination process of electron-hole pair consists of two optical transitions distinctive in terms of their polarization and energy when the symmetry of the nanostructure is reduced. As a result, in spectroscopy measurement we observe two emission lines separately and with linear polarization mutually perpedicular. Taking into account additional effect related to the asymmetry of confinement potential of nanostructure, the intensity of those transitions is different, which means the enhanced spontaneous emission rate for one exciton. It corresponds to the emission polarized along the elongated direction of quantum dash. However, this effect is limited to about 25 % of the relative intensity ratio.

The main goal of the project is to control the process of spontaneous emission by a copuling of quantum emitter with electromagnetic field of its environement by external factor which is the post-growth modification geometry. The anisotropy of in-plane electric field for nanostructures should lead to enhancement of one linearly polarized transition and in extreme case the suppresion of another simultaneously giving rise to a perfectly linearly polarized single photon source. We will make use of a theoretical model which together with collected experimental data will let us to design the structure for maximum disproportion and simultaneously we will explore what are the limitations for quantum dashes.

First experiments will be performed by high-resolution microphotoluminescence spectroscopy on many predefined excitons with defined linearly polarized detection. A series of nanostructures emitting from 1300 nm to 1550 nm spectral range is available. For single quantum dash measurements it is required to limit the number of emitters by etching the sample surface retaining optically active regions below 1 micrometer edge size. This reduced the number of emitters to tens of quantum emitters and taking acount their subtle structural differences in size, shape or composition, each exciton wavelength is different and can be precisely analysed by spectrometer. Preliminary results have shown that a rectangular dielectric structure of 500 nm x 250 nm in size, aligned with respect to the elongation direction lifts the intrinsic disproportion of 25% to about 50%. Further investigation of polarization anisotropy is planned for other aspect ratios and different orientations of dielectric sample, starting from the perpendicularly oriented rectangle and square geometry. Such data will demonstrate to what extent the polarization anisotropy can be controlled by geometry and how efficient the enhancement of emission could be. The magnitude of this phenomenon should be mainly related to the basis size, thus the rectangular sample along quantum dashes will be examined in a function of its edge size which is limited by detection resolution when the spectral density of emission lines for large sample will be high. It is supposed to identify the nanostructure position dependence due to non-uniform electromagnetic field distribution in the plane. This can be quantitatively described by the standard deviation of the mean for large number of measured emiters using the same gemoetry of dielectric medium.

All experimental results will be confronted with estimated polarization anisotropy using numerical simulations of electromagnetic field distribution for a given plane wave propagating normal to the layer containing quantum emitters. First, the results of field distribution will be analysed in terms of optical degree of anisotropy for linearly polarized waves in cuboidal dielectric structure situated in a vacuum box parametrized by wavelength and sample base geometry. The experimentally available sample of rectangular geometry (2:1) and square will be simulated in function of size. The map of electric field vector will allow to calculate the optical degree of anisotropy in function of position and wavelength. According to computational data we will propose a higher asymmetry dielectric strucutre and different than rectangle geometry for optimalization of the spontaneous emission process. In order to strict comparison with experiment, we will employ a Fermi's Golde Rule formula using the theoretical model for emitter which will confirm the applicability of our model to initiate a novel concept of liearly polarized single photon source at telecommunication relevant wavelength.