SOLAR QUEST

SEMINAR ANNOUNCEMENT

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EXCITONIC PROPERTIES QUANTUM-LIGHT SINGLE PHOTON SOURCES FROM WURTZITE III-N QUANTUM DOTS

DATE: Thursday, May 16, 2013
TIME: 14:00 pm-16:00 pm
PLACE: Seminar Room A-502
CCR Building, 5F

ABSTRACT

Sources of triggered entangled photons emitted from the biexcitonic cascade decay are highly desired for applications in quantum-cryptography and quantum- information processing, and were already realized in InAs/GaAs quantum dot (QD) material systems. Radiative recombination from exciton (X) and biexciton (XX) states, confined in InGaN/GaN wurtzite QD, could potentially provide useful sources of visible quantum-light, targeting applications in the nascent field of quantum information, amongst others. To assess their potential, a theoretical methodology with which to calculate single-particle states was established, based on both an 8-band and 12-band strain-dependent envelope function k.p Hamiltonian, with contributions from the spin-orbit interaction, crystal-field splitting, piezoelectric and spontaneous polarization all included. Excitonic states were found using the configuration interaction method, whilst taking into account the important second-order effect of piezoelectricity in this III-N material system. We compared the results of the 8-band k.p Hamiltonian with the artificially high C6v symmetry to the newly developed 12-band k.p Hamiltonian that predicts the correct atomistic C3v symmetry of the wurtzite QDs. The influence of mirror changes to the periodic boundary conditions were eliminated with a Makov-Payne correction, adapted to hexagonal and trigonal lattices. The optimal QD morphology for use in quantum light sources was determined by varying the diameter/height ratio (D/h), based on the optimization of the target function, which depends on the biexcitonic shift and optical dipole matrix element of the excitonic transition. The model established in this work is validated against experimental results on existing single GaN QD sources. Further to this the model predicts that, with suitable variation of the In concentration within the QD, from 20 to 70%, it is possible to find morphologies that emit throughout the entire visible spectrum, i.e., from ~3 to 1.6 eV. Within this range of In-concentrations conditions can be found for the formation bound biexcitons. The competition between strong confinement in InGaN QDs and the internal electric field, generally reported in wurtzite III-N, was also investigated, as well as its effect on existence of bound biexcitons and a vanishing fine-structure spitting. The latter is a prerequisite for the on-demand generation of the entangled-photon pairs from InGaN-QD's.

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