Confinement in thickness controlled polytype quantum dots in GaAs

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Abstract

We have investigated polytype quantum dots of wurtzite GaAs embedded in a zincblende GaAs nanowire host as well as the inverse system, zincblende GaAs dos in a wurtzite GaAs nanowire host. The main characterisation tool was single wire photoluminescence which was combined with transmission electron microscopy on the same wires. This allows a very careful correlation between the optical and structural properties of the quantum dots. We correlated the optical and structural properties of about 50 dots. The quantum dots have a type II band alignment which manifests itself as an emission which shifts in energy with excitation power density. We find a valence band offset of about 115 meV between wurtzite and zincblende GaAs which compares very favourably with theoretical predictions. The bandgaps of the two polytypes is very similar in our experiments. We can fabricate the shortest possible dots (one monolayer) and they still emit light. In fact in zincblende GaAs the dot emission dominates the photoluminescence for all dot lengths including the shortest possible, a twin plane, which binds an exciton with a binding energy of 50 meV. In wurtzite GaAs the situation is slightly different. The shortest possible quantum dot in wurtzite GaAs, a stacking defect, does not give observable photoluminescence in our experiments. However all longer dots do. By changing the dot length we have been able to extract a hole mass in wurtzite GaAs of about 0.45 m_0, using a simple effective mass model. Despite having exactly the same length we observe some differences in the emission energy of the quantum dots. This is correlated with the thickness of the nanowires. We speculate that bandbending and/or charging at the surfaces influence the confinement energies.