Growth and properties of type II ZnTe/CdSe radial nanowire heterostructures

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The most common design of a quantum well involves a band alignment providing a potential minima for holes and electrons in the same part of a sample, so the probability of recombination is maximized. This configuration is often called type I junction, as opposed to type II (fig 1a), where both conduction and valence band of one semiconductor are situated energetically below (or above) the other one. This layout allows for charge separation and is commonly found in p-n diodes.

Thanks to such a band alignment, an "indirect" (in real, not momentum space) exciton is formed after an excitation. The behavior of such an "indirect" exciton exhibits several interesting properties and grants access to some emission energies, which would not be available with ordinary bandgap engineering.

This kind of structure was realized in a radial ZnTe/CdSe nanowire heterostructure capped by (Zn,Mg)Te or (Cd,Zn)Se shell. ZnTe and CdSe are nearly lattice matched, so it is almost strain-free. The nanowires were grown by molecular beam epitaxy (MBE) in vapour-liquid-solid (VLS) mode. They were about 1.5um long and 60-70nm in diameter. CdSe layer is estimated to be less than 10 nm.

a)

b)

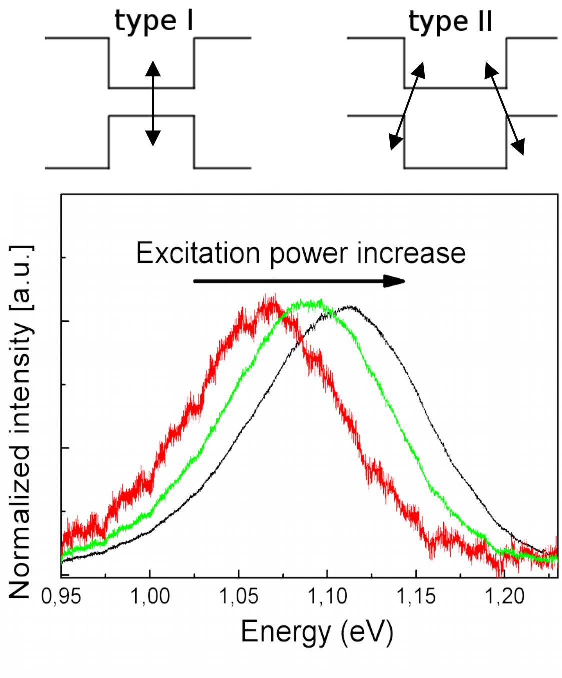

Figure 1 a) type I versus type II band alignment b) Normalized emission from an as-grown nanowire sample as a function of excitation power. Excitation powers were 1; 4; 12.5 mW from left to right, T=10K, λ_{ex}=473nm

The chosen band alignment should result in a near infrared emission, at approximately 1.1eV. This emission has indeed been observed in as-grown nanowires as well as the reference sample containing a quantum well (QW). Emission from nanowire samples and a QW exhibit a strong (tens of meV at 5K) blueshift as a function of excitation power increase (fig 1b). This effect is due to coulomb interaction between same sign charges, which raises the energy of the transition with a charge buildup [1]. Another interesting feature of the indirect transition is a lower probability of recombination because of a charge separation. This results in a longer exciton lifetime and a different decay characteristics [2].

For radial structures where charge is separated, yet another effect has been predicted – an optical Aharonov-Bohm effect, observation of which is the main motivation directing this research. It was initially investigated in columnar quantum dot ensemble [3] and quantum rings [4]. Our plan is to check if it can be observed in nanowires as well.

References:
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