CdSe/ZnSe nanowire quantum dots for efficient single-photons sources

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The single-photons source is a key element in the framework of quantum communication where single-photons act as flying qubits for the information exchanges. Such a source can be obtained using semiconductor quantum dots (QDs), as demonstrated in various material system, but their operation is mostly restricted to cryogenic temperatures. CdSe QD inserted in ZnSe nanowire (NW), namely a NW-QD, offers the possibility to emit single-photons up to room temperature [1] opening the prospect for a realistic application in quantum information technologies. However, the emission efficiency strongly decreases at high temperature. To make such a system an efficient single-photons source, we investigate the growth of core-shell type NW heterostructures in order to enhance the emission quantum yield and the coupling of these nano-emitters to photonic structures for an efficient light extraction and collection.

In this contribution, we present our work on the growth and optical studies of vertically oriented CdSe/ZnSe NW-QDs by molecular beam epitaxy. The NW-QDs are grown on a ZnSe(111)B buffer layer with a ZnMgSe passivating shell to increase the (otherwise weak) QD luminescence. The NWs diameter is typically 10 nm and single QDs shows clearly exciton, biexciton and charged exciton transitions.

Single-photons can be extracted more efficiently along the NW axis if the NW-QD is embedded in a photonic wire [2], providing directivity of the photon emission. We show that such a photonic wire can be obtained with a thick conformal dielectric coating of Al_2O_3 using Atomic Layer Deposition (ALD) [3] (fig. 1). Optical studies of single NW-QDs show that a 4-fold increase of the collected photoluminescence intensity is obtained with an oxide shell of 110 nm thick. This improvement is due to an increase of the QD emission rate (as confirmed by decay time measurements) and a redirection of the emitted light [4] as shown by numerical simulations.

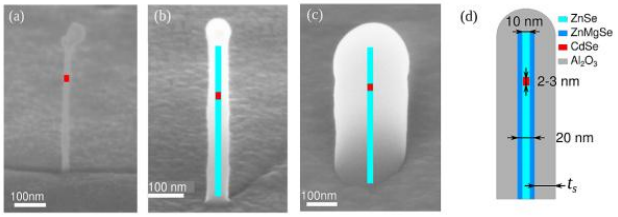

Figure 1 : Nanowire quantum dot in a photonic wire

We will discuss the parameters to be mastered in this NW system in order to obtain a workable single-photon source.

[1] S. Bounouar, M. Elouneg-Jamroz, M. den Hertog, C. Marchutt, E. Bellet-Amalric, R. André, C. Bougerol, Y. Genuist, J.-P. Poizat, S. Tatarenko, and K. Kheng, Nano Lett. **12**, 2977 (2012).
[2] J. Claudon et al., Nat. Photonics **4**, 174 (2010).
[3] M. Jeannin, T, Cremel, T. Häyrynen, N. Gregersen, E. Bellet-Amalric, G. Nogues, and K. Kheng, Phys. Rev. Applied **8**, 054022 (2017)