Single-Photon Emitter in the Blue-Green Spectral Range with a Nanowire Quantum Dot: Brightness and Integration

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Quantum dots (QDs) embedded in semiconductor nanowire heterostructures have emerged as a highly promising platform for quantum technologies. Their unique geometry enables efficient light extraction, and straightforward integration with photonic circuits. The blue-green spectral band (450–580 nm) is especially advantageous for quantum communication with single-photons, as it supports both airborne and submarine communication channels. Here, we introduce a robust solid-state system capable of emitting triggered single photons within this spectral range, even at room temperature [1]. Our single-photon emitter is based on a CdSe quantum dot (QD) embedded in a ZnSe core-shell nanowire (NW), synthesized via bottom-up molecular beam epitaxy. The NWQD structure, with a typical base diameter of 150 nm and length of 5 µm (Fig. 1a–b), features a conical tip that adiabatically expands the guided mode, effectively reducing the divergence angle of the emitted light. This behavior is confirmed by far-field emission measurements collected along the NWQD axis (Fig. 1d), highlighting the structure's efficient photon channeling. We have carried out a practical brightness measurement at 6 K, exciting the NWQD with pulsed above-bandgap laser light at 76 MHz. Using a bandpass filter and an avalanche photodiode (APD), we obtained a single-photon rate of 2.9 MHz just before the detector, from the neutral exciton recombination, that is a brightness (efficiency) of 0.04 (0.15 if we include charged excitons contribution) photon per pulse, a value better than for currently used SPDC (Spontaneous parametric down-conversion) sources. The conical shape of the NWQD thus enables efficient extraction of emitted photons along the NW axis. It also allows for efficient injection into a ridge waveguide via adiabatic evanescent coupling. We will present our preliminary work on the hybrid integration of a NWQD onto a silicon nitride ridge waveguide.

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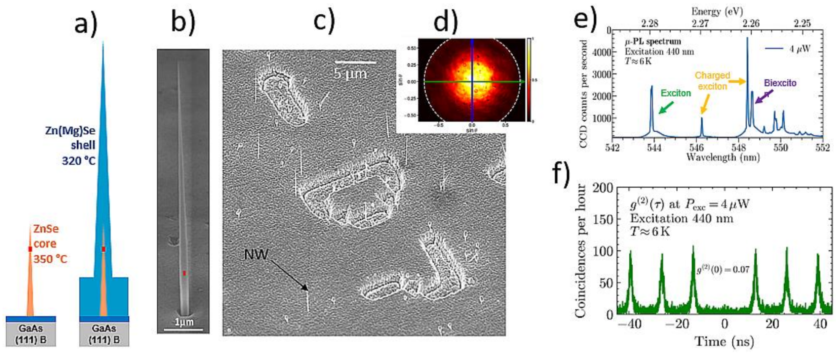

Fig. 1: (a)-(b) Core-shell NWQD structure; (c) sample with few NWs around a marker; (d) far-field emission diagram; (e) Photoluminescence spectrum at 6 K; (f) auto-correlation measurement of the exciton line at 6 K.

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