Room-temperature single-photon source in the blue-green range based on CdSe/ZnSe nanowire quantum dot

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Semiconductor quantum dots (QDs) are very attractive single-photon emitters due to their solid-state nature and the ability to emit single-photons on demand. In this study, we present a QD-based source capable of emitting single photons up to room temperature. The active element is a CdSe QD inserted within a core-shell nanowire (NW) grown by molecular epitaxy. The GaAs substrate contains etched patterns, enabling multiple characterizations of a single emitter. The QD is typically positioned at the base of the NW, which has a base diameter of 140 nm and a height of 5 µm (system depicted in Fig. a). The NW acts as a photonic waveguide and its conical shape allows an efficient light extraction within a limited numerical aperture. The high collection efficiency of the source can be observed via the Fourier image of the studied QD-NW (Fig. a) presented in Fig. b. This results in a Gaussian mode profile with small divergence angle, as confirmed by finite difference time domain simulations.

Second-order correlation measurements on excitonic lines show anti-bunching at room-temperature with purity $g^{(2)}(0) < 0.3$ (Fig. c) [1]. Complementary measurements conducted at cryogenic temperatures highlighted the role of charged excitons on purity degradation at elevated temperatures. We found that a neutral QD would exhibit a promising brightness, with a potential emission rate of 13 MHz with a 76 MHz excitation rate (i.e. 0.17 photon per pulse).

Importantly, the emission wavelength is lying within the blue-green window (450-550 nm). This is a spectral range of interest for long-range quantum communications through quantum key distribution (QKD), due to low light attenuation in seawater and air. These results pave the way towards implementing practical QD-based sources of on-demand single-photons for free space QKD communications and operating at elevated temperatures.

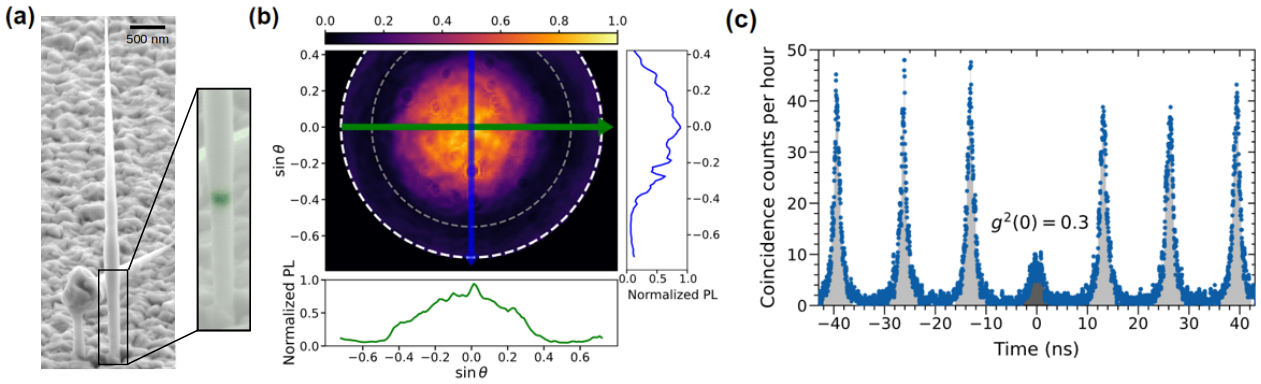

Fig. 1. (a) SEM image of a vertical and tapered ZnSe NW embedding a CdSe QD, with its position determined via a cathodoluminescence measurement. (b) Radiation pattern of the QD-NW emitter displayed in (a) through a microscope aperture of NA=0.72. (c) auto-correlation histogram of the one and same NW at 300K with a $g^{(2)}(0)$ value of 0.3 at room-temperature.

References

[1] F. Granger, et al., Optics Letters **15**, 48 (2023).