Single photon sources for room temperature operation based on CdSe/ZnSSe/MgS quantum dots

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Solid state single photon sources play a central role in quantum information technology. The challenges for a versatile, compact source are twofold: On the one hand, an electrically driven device is highly desirable; on the other hand, operation under ambient conditions up to room temperature is required. This joint goal has been achieved only partially during the recent years: In colloidal quantum dots and in color centers in diamond, high-quality optically driven single photon sources up to room temperature have been implemented, but a straightforward electrical operation remains a difficult task. In contrast, epitaxially grown semiconductor quantum dots based on GaInAs, GaN or GaP, provide excellent electrically driven single photon sources, but have failed to exhibit single photon emission at room temperature.

In this contribution, we show that single photon sources consisting of single, epitaxially grown CdSe/ZnSSe/MgS quantum dots can meet *both* requirements. Wide-bandgap II-VI single quantum dots generally provide a higher carrier confinement than III-V-based structures, and by additional MgS barriers virtually no loss of quantum efficiency can be detected between T = 4 K and T = 300 K [1].

In order to prove room temperature operation, single quantum dots were excited optically using a micro-photo-luminescence setup and lithographically defined metal nanoapertures. Photon correlation measurements were performed using a Hanbury-Brown-Twiss (HBT) setup. Under continuous wave excitation (λ = 457.9 nm), we observe antibunching behavior up to T = 300 K (Fig.1). Second-order correlation measurements exhibit a surprisingly low value of $g^{(2)}(\tau) = 0.16 \pm 0.15$ for zero time delay [2].

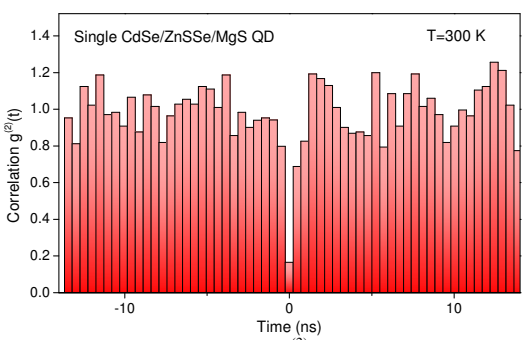

Fig. 1: Autocorrelation function $g^{(2)}(t)$ of CdSe/ZnSSe/MgS SQD emission at 300 K.

For electrically driven devices, these CdSe/ZnSSe/MgS quantum dots were embedded into p-i-n diode structures. Patterned Pd/Au contact layers serve as local current injectors to electrically address only a limited number of quantum dots. Single dot electroluminescence (EL) is collected at a DC voltage of 5.6 V by a Micro-EL setup. For the first time, low temperature photon correlation measurements reveal single photon emission from an electrically driven II-VI-based device. Obviously, the CdSe/ZnSSe/MgS quantum dot devices are ideally suited for future single photon sources that can be electrically driven and operated up to room temperature.

[1] R. Arians el al., Appl. Phys. Lett. 90, 101114 (2007)
[2] O. Fedorych et al., Appl. Phys. Lett. 100, 061114 (2012)