Fiber-based bidirectional photon detection from a single quantum dot

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Semiconductor quantum dots (QDs) are attractive nanoscale structures for solid-state nonclassical light sources and are expected to play key roles in a quantum information network[1]. Above all, single QDs fabricated by epitaxial growth can serve as stable and bright photon emitters. From a scientific and engineering viewpoint, the long-term stability is one of the most important properties for a fiber-based nanoscale photon emitter. However, the precise positioning, solid maintenance of geometry, and highly accurate nanofabrication are required for the efficient coupling between the nanoscale emitters and optical fibers. This study reports a fiber-based bidirectional solid-state single-photon emitter based on epitaxially grown InAs QDs using single-mode-fibers (SMFs). The placing the solid-state single-photon sources and the SMFs in direct contact is useful from a practical perspective because it offers robust stability and does not require an opto-mechanical alignment. Moreover, this simple structure facilitates the low-cost fabrication of photon emitters and the sufficient stability of the output photon number from a scientific viewpoint.

To extract the emitted photons in both directions, we used flake forms of the epitaxial InAs QD on GaAs layers. The detailed growth conditions and overall optical characteristics are presented in Ref. [1]. The flakes having diameter and thickness of 1--20 μm were obtained by simply scratching the surface with an ordinary diamond cutter. These flakes were directly attached to the edge face of an FC/PC SMF patch cable (Corning, SMF-28) by electrostatic forces. To mechanically fix the flakes and effectively extract the generated photons into two SMFs, the edge face of another SMF patch cable was directly connected to the opposite side of the flakes using an conventional FC/PC-FC/PC joint. The FC/PC-FC/PC joint part with its embedded flakes was set in a liquid ^{4}He reservoir at 4.2 K. To spatially separate the emissions that traveled in the SMF in the direction opposite to that of the excitation laser, a wavelength division multiplexing module was used.

For the autocorrelation measurements, the output of each SMF is filtered with a 0.5-nm-wide band-pass filter to select the emissions originating from a InAs QD. The emission was then sent to an SSPD. The single count rate of the X line at each SSPD was ~5 kHz with an excitation power of 1.4 W/cm^2. A histogram of the normalized coincidence counts with time bins of 244 ps and an integration time of 8.5 h is shown in Fig. 1. The data exhibits the well-known antibunching dip at a zero time delay and is fit with the second-order correlation function. At zero delay, the function gives $g^{(2)}(0)$=0.35, suggesting that the single InAs QD emits nonclassical light.

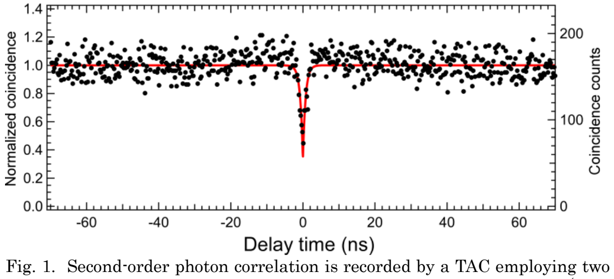

Fig. 1. Second-order photon correlation is recorded by a TAC employing two SSPDs. Normalized histograms of the autocorrelation measurement (solid circles) at an excitation power of 1.4 W/cm^2. Excitation wavelength is 830 nm and the time bins are 244 ps. The integration time and count rates are 8.5 h and ~10 kHz, respectively. The solid (red) line is fit, indicating a dip in the correlation function of $g^{(2)}(0)$=0.35.

[1] H. Sasakura, S. Kayamori, S. Adachi, and S. Muto, J. Appl. Phys. **102**, 013515 (2007).
[2] H. Sasakura, X. Liu, S. Odashima, H. Kumano, S. Muto, and I. Suemune, arXiv:1210.3123v2.