Experimental Evaluation of the Indistinguishability of Single Photons at 1.55 µm Generated by InAs(P)/InP Quantum Dots

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Epitaxial quantum dots (QDs) have great potential as non-classical light sources in quantum technologies [1,2]. For advanced quantum cryptographic key exchange algorithms, single indistinguishable photons, generated on demand, are needed [3]. An appealing technology platform in this context are QDs emitting at 1.55 µm, showing prospects for long-haul low-loss optical transmission in a standard silica fiber [4,5].

In this contribution we investigate quantum optical properties of single photons emitted by InAs(P)/InP QDs heterogeneously integrated with silicon. The QDs are grown by metalorganic vapor-phase epitaxy in the Stranski-Krastanow mode and exhibit low areal density (3.1×10^{8} cm^{2}) and emission at ~1.55 µm [6]. A metallic mirror beneath the QDs increases photon extraction efficiency to about 10% [7]. It enables imaging of the QD emission, letting localize a specific QD with ~50 nm accuracy, allowing for engineering of QD photonic environment.

In our study, we confirm single-photon emission from the QDs via measurements of the second-order autocorrelation function $g^{(2)}(\tau)$, revealing $g^{(2)}(0) = (3.2 \pm 0.6) \times 10^{-3}$ under quasi-resonant pulsed excitation. To investigate the degree of indistinguishability of emitted photons and gain insight into underlying dephasing mechanisms, Hong-Ou-Mandel-type two-photon interference (TPI) experiments are conducted as a function of the temporal delay δt between consecutively emitted photons. The TPI visibility, quantifying the degree of indistinguishability, was comparatively analyzed using both, integration of the raw experimental data and applying a fitting model, revealing the raw (i.e. 'as measured') and the post-selected TPI visibility. For $\delta t = 4$ ns, we determine the visibility by evaluating the coincidences around $\tau = 0$ for co- and cross-polarized photons and compare the result with the method based on evaluating the areas of adjacent coincidence maxima in a characteristic five-peak pattern [8]. We obtain raw (post-selected) TPI visibilities of up to 20% (99%) and comparatively discuss the experimental uncertainties.

In summary, our work provides important insights and shows progress in generating telecom C-band single indistinguishable photons for applications in quantum information technologies.

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