Epitaxial InAs/InP quantum dots as emitters of single photons and entangled photon pairs for fiber-based quantum communication

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Quantum dots (QDs) are an important resource for quantum communication, because of their capability of generating various non-classical light states. Compared to other physical systems, QDs provide high single-photon purity independent of the source brightness. They offer the possibility for on-chip integration and compatibility with well-established semiconductor technology, including deterministic fabrication of photonic devices. To fully exploit their application potential, emission in the telecom bands is required. InAs/InP material system is one alternative to provide emission in the telecom C-band [1].

Our work concerns InAs/InP QDs grown using ripening assisted molecular beam epitaxy technique [2]. They have been proven to be efficient sources of (triggered) single photons, with multiphoton emission probability below 1% [3] and spectrally broad (~60 nm) extraction efficiency for the QDs placed inside simple cylindrical photonic structures, at the maximum exceeding 13% [4]. Their thermal stability is better than for GaAs-based QDs emitting in this spectral range due to deeper confining potential, and it is mainly limited by escape of holes via the ladder of QD's excited states [5,6]. It enables maintaining single QD emission for temperatures as high as 150 K, which makes this system suitable for simple and cost-effective cooling methods, thus considerably increasing its application potential.

Additionally, these dots feature spin memory effects allowing for preferential initialization of electron spin state [6]. However, identification of trions is not straightforward and requires magnetooptical investigations [7], due to high in-plane symmetry of these dots, manifesting in low exciton fine structure splitting [2]. This, on the other hand, allowed achieving emission of entangled photon pairs (fidelity exceeding 0.55) generated from biexciton-exciton cascade at telecom C-band. It was realized under non-resonant excitation of a QD in a simple mesa structure and it can be improved by selected excitation of target states and placing QDs deterministically in microcavity structures. This enables application of such InAs/InP QDs in implementation of quantum teleportation schemes or quantum repeater architecture.

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