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Quantum Optics with Photonic Nanowires and Photonic Trumpets: Basics and Applications

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Abstract— Optimizing the coupling between a localized quantum emitter and a single-mode optical channel represents a powerful route to realise bright sources of non-classical light states. Reversibly, the efficient absorption of a photon impinging on the emitter is key to realise a spin-photon interface, the node of future quantum networks.

Besides optical microcavities [1], photonic wires have recently demonstrated in this context an appealing potential [2,3]. For instance, single photon sources (SPS) based on a single quantum dot in a vertical photonic wire with integrated bottom mirror and tapered tip have enabled for the first time to achieve simultaneously a very high efficiency (0.72 photon per pulse) and a very pure single photon emission ($g^{(2)}(0) < 0.01$). Furthermore, photonic wires with an elongated cross-section provide polarization control of the spontaneous emission of embedded emitters [4].

However, the performance of photonic wire SPS with tapered tips is sensitive to minute geometrical details and optimum behaviour is only obtained for ultra-sharp tips. Photonic trumpets [5], which exploit the opposite tapering strategy, overcome this important limitation. Moreover, they feature a Gaussian far-field emission, a strong asset for most applications. We report on the first implementation of this strategy and demonstrate an ultra-bright SPS (first-lens external efficiency: 0.75 ± 0.1) [5]. More generally, photonic trumpets appear as a very promising template to explore and exploit in a solid-state system the unique optical properties of "one-dimensional atoms".

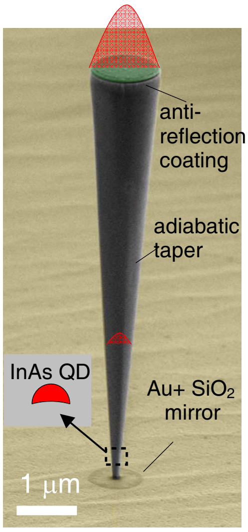

Figure 1: Colorized scanning electron micrograph of a GaAs photonic trumpet (from [5]).

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