Broad-band single-photon sources based on carbon nano-emitters boosted by Cavity Quantum Electrodynamics

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Individual semi-conducting nano-structures are ideal candidates for solid-state sources of single-photons for future quantum secured telecommunications and other quantum technology applications. In particular carbon based nano-structures includind single-wall carbon nanotubes, graphene quantum dots or ribbons are especially attractive since their emission wavelength is fully tunable through quantum confinement due to the gapless nature of their parent material – graphene. They are among the very few candidates for telecom band (1,3-1,5µm) single-photon operation, which are sought for long range telecommunication using the fiber network infra-structure. Nevertheless, these nano-emitters suffer from their inhomogeneity essentially because of the inevitable and poorly controlled interaction of the nano-structure with its local environment, resulting in wavelength and linewidth dispersion and possibly spectral diffusion. Hence, coupling of such nano-emitters to resonant photonic devices is challenging, especially for low temperature applications where the resonance conditions are more stringent. Here, we propose an orginal geometry where an open Fabry-Perot micro-cavity is engineered at the apex of an optical fiber, which makes it possible to deterministically match the cavity to the emitter position and wavelength by tuning the lateral and longitudinal position of the fiber. When resonance is met, we observe a strong enhancement of the emission properties through cavity quantum electrodynamics effects, including Purcell effect, resulting in the brightening of the emitter by more than an order of magnitude, a narrowing of its angular emission diagram and funelling of photons into the fiber mode. We further exploit the phonon side-bands to achieve a broad band tunable single-photon source.

References

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Figures

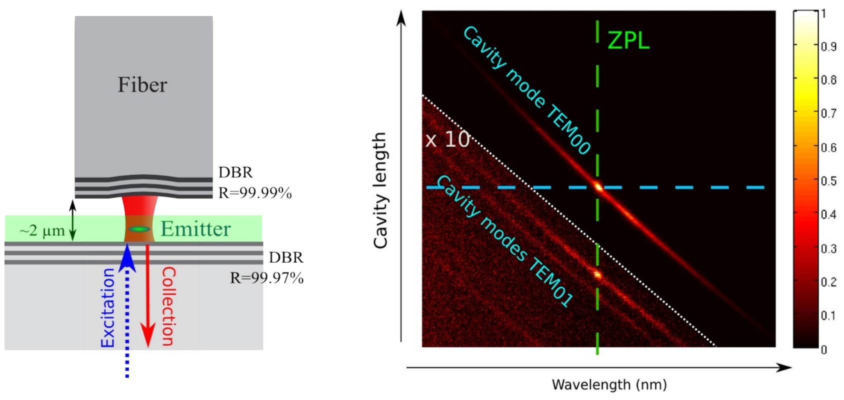

Figure 1: (left) Sketch of an open-geometry Fiber Fabry Perot with high Q to taylor light-matter interaction with individual quantum emitters. (Right) Photolumnescence intensity as a function of cavity/emitter detuning showing a strong boost of emission at resonance.