Bright and tunable single-photon emission with a carbon nanotube embedded in a fiber micro-cavity.

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Single-photon sources (showing a vanishing probability to emit more than one photon at a time) are a key building block for secured quantum telecommunications or for future quantum optical information processing. In order to bring high speed operation, this source is required to be on-demand and to have high brightness and large anti-bunching purity. In addition, further integration in long range telecommunication networks requires near infrared operation. Room temperature operation together with electrical injection would also be highly valuable for large scale integration.

Carbon nanotubes have strong assets in this perspective since they were shown to have excellent single-photon emission properties (both at low-temperature and room temperature for chemically grafted nanotubes) and high polarization purity. In addition, their emission wavelength can be chosen over a wide range by selecting appropriate chiral species. Electrically induced luminescence has been reported by several teams [1]. Nevertheless, their reported luminescence quantum efficiency is consistently small and their spectral properties may be deteriorated by interactions with phonons or local environment fluctuations.

Here, we show that these latter limitations can be drastically improved by coupling a nanotube to a small volume, high-finesse micro cavity, through the so-called Purcell effect [1].

In order to tackle the so-called spatial and spectral mode matching issues (that become especially critical in high Q applications), we used a tunable cavity designed at the apex of an optical fiber for further integration in telecom networks. We show that the emission rate of the nanotube can be enhanced by a factor 60 leading to an effective luminescence quantum yield of about 40% and a coupling factor close to 100% [2].

In addition, the original tuning capability of our cavity, allows us to exploit the spectral broadening of the nanotube excitonic line and to achieve a widely tunable single-photon source, possibly valuable for multiplexing applications in telecom or for indistinguishability engineering from remote nano-sources for quantum computing. We show how an original asymmetric energy exchange between a phonon broadenend 1D emitter and a cavity can serve as a new handle to bypass the intrinsic spectral efficiency limit of a symmetrically broadened emitter [4].

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