

NANOPHOTONICS AND MICRO/NANO OPTICS
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PARIS**Photonic wires and trumpets:
an attractive novel platform for quantum optoelectronic devices**

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Over the last 20 years, major efforts have been devoted to the tailoring of the optical properties of semiconductor emitters using optical microcavities and photonic crystals. We have recently introduced photonic wires as a novel platform for quantum optics. I will review recent studies which demonstrate an excellent control over the spontaneous emission of InAs quantum dots (QDs) embedded in vertical single-mode GaAs photonic wires and first applications in the field of quantum optoelectronic devices.

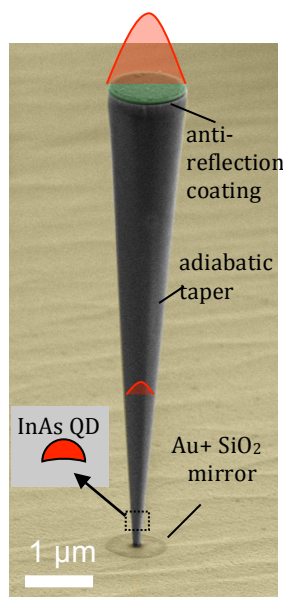


Figure 1: Colorized scanning electron micrograph of a GaAs photonic trumpet

On the basic side, we have demonstrated a strong inhibition ($\times 1/16$ [1]) of QD SpE in thin wires ($d < \lambda/2n$) and a nearly perfect coupling of the SpE to the guided mode ($\beta > 0.95$ for $d \sim \lambda/n$) in circular photonic wires [2]. The polarization of QD SpE can also be tailored by playing with the shape of the cross section of the photonic wire. For elliptical cross sections, a strong ($>90\%$) linear polarization oriented along the long axis of the ellipse is observed [3].

In view of practical applications, a proper engineering of the radiation pattern of the photonic wire is required. We have therefore developed novel hybrid (metal+dielectric) mirrors displaying a high modal reflectivity, as well as integrated tip-shaped or trumpet-like adiabatic tapers, in order to reduce the divergence of the emitted beam. The recently developed photonic trumpet (see fig.1) exhibits superior performances in this context, since it ensures a perfectly Gaussian and low NA far-field emission [4].

As a first application of SpE control in photonic wires, we have developed single mode QD single-photon sources (SPS). Unlike microcavity-based devices, such SPS display an excellent purity ($g^{(2)}(0) < 0.01$) under non-resonant excitation, over the whole range of excitation powers. Furthermore, efficiencies exceeding 0.7 photon per pulse (within $NA=0.75$) have been obtained for tip-shaped [5] as well as trumpet-like [4] SPS. Beyond these first results, photonic wires are also very attractive for developing high efficiency sources of entangled photon pairs or wavelength tuneable SPS, thanks to the broadband SpE control they provide.

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”. Possible long term applications in the field of quantum information processing will be

discussed, including the optimal quantum cloning of single photons, using the amplification by stimulated emission provided by a single 1D atom [6].

Finally, photonic trumpets containing a single QD constitute a hybrid optomechanical system, whose remarkably large coupling between the two-level system and the mechanical degree of freedom, mediated by the strain, opens promising novel perspectives [7].

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