[PhD project] (ANR grant-2012)]: Quantum plasmonics with a single photon source integrated on a waveguide platform

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Introduction and context:

Quantum plasmonics, the study of surface plasmons (SPs) and localized plasmons modes (LPs) at the quantum level, is a promising framework for building new technological platforms at the nanoscale. As hybrid photon-electron states, SPs and LPs naturally confine at a metal-dielectric boundary. This draws a promising avenue for quantum information processing or cryptography in one or two dimensions. One of the key issues however, is the control over the coupling of a quantum fluorescent particle emitting photons *one by one* with a plasmonic device or antenna.

In this context, our group has developed recently several methods adapted to the optical analysis of a quantum emitter, i.e., a nitrogen vacancy (NV) colour centre, located in the vicinity of a nanostructure. Relevant achievements include the development of active tips for near field scanning optical microscopy (NSOM) made of a single nanodiamond crystal (~20 nm) hosting a single NV centre. Using the sole fluorescence of this NV centre allows for launching single SPs at a well-chosen position; see Fig. 1. The quantum nature of the source of light, and therefore of the launched plasmons, is ascribed from the measurement of the so-called "second-order time-intensity correlation function" $g^{(2)}(\tau)$ [1]. A single NV being a single photon-plasmon source, the $g^{(2)}(\tau)$ function shows at zero delay (τ=0) a strong anti-correlation dip called photon antibunching. This is a clear signature of the quantum nature of the emission process [1-4].

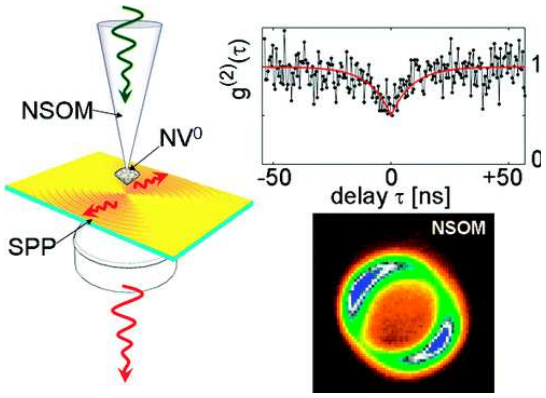

Figure 1: "Deterministic" launching of propagating SPs at freely chosen positions on gold plasmonic receptacles using the sole fluorescence of a single NV centre attached to an optical tip. The autocorrelation function $g^{(2)}(\tau)$ confirms the quantum nature of the source of light and the NSOM image confirms the efficient SP launching. Reprinted from [2].

Project summary :

In this context, one of the main challenges for technological applications is the development of a compact single-photon source taking advantage of the plasmonic coupling with an antenna supporting either LPs or SPs. In this project [Project Sinphonie, ANR Grant P2N 2012], we aim at developing such a device by integrating a quantum emitter (i.e. a single NV) to a plasmonic structure elaborated from conventional integrated optics in order to have single photons available directly in optical fibres.

The three project partners are the *Laboratory for Nanotechnology and Optical Instrumentation (LNIO)* of the University of Technology in Troyes (UTT), *the Néel Institute* in Grenoble and the

Teem Photonics Company in Meylan, near Grenoble. They complement each other in their expertise in quantum optics, waveguide optics, plasmonics, and integrated optics.

PhD Proposal:
For this project, we wish to reinforce our research team by hiring a PhD student for 3 years. His/her research, co-supervised by A. Drezet and S. Huant, will involve the design and mounting of the new NSOM microscope setup and its use for the single-ND manipulation and functional characterization of the integrated device. During his/her PhD, the student will interact tightly with the project Partners in Troyes and Meylan. Therefore, this PhD student will participate in an up-to-date ambitious project built around a well-balanced partnership that includes two academics and a company. His supervisors will encourage him/her to participate in measurement campaigns in Troyes and in national or international conferences/schools to strengthen his/her background. He/she will become familiar with different fields of nanosciences and technologies such as scanning-probe microscopy, quantum optics, plasmonics, integrated wave guiding, etc... This will certainly be very beneficial to his/her future career either in the academic world or in the photonics industry. This student will preferentially have graduated from one of the many Master programs in Optics and Photonics or Engineering in France or elsewhere, such as for example the UTT, Grenoble INP, or Institut d'Optique Graduate School.

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References:

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