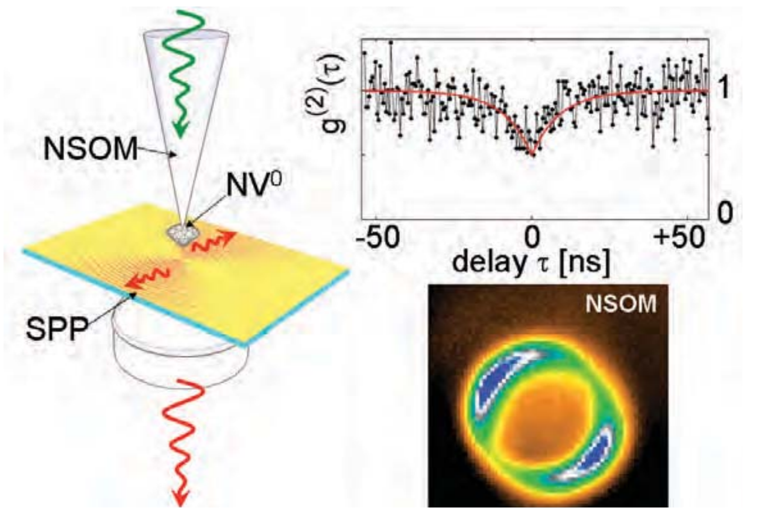
Surface plasmon polariton scanning quantum source

A crucial obstacle to the further miniaturization of electrical devices is the difficulty of making electrical contacts between nano-objects. Indeed, energy transfer and communication between devices at the nanometer scale has become a major issue in developing nano-electronic or nano-optical devices. Recently, photonic and plasmonic methods have been proposed to address these problems. Surface Plasmon Polaritons (SPPs), which are hybrid state electron-photon modes propagating at the interface between a metal like gold and an insulator (e.g., glass or air), are naturally adapted for two-dimensional applications. As surface waves, SPPs are exponentially damped in the directions perpendicular to the interfaces and can be guided in structures that are miniaturized beyond the diffraction limit. These appealing properties make

Relevant to this, we recently developed highly stable, scanning single-photon sources that operate at room-temperature. This was achieved by controlled grafting of a selected nanodiamond (size about 20 nm) hosting a single nitrogen impurity-lattice vacancy (N-V) color-center at the apex of an optical probe (a chemically etched fiber tip). A variant of this method is to graft a larger number (typically 3 to 5) of unselected fluorescent nanodiamonds.

We now report the implementation of these nanodiamond tips for launching Surface Plasmon Polaritons on gold films. A nanodiamond-based tip is excited by 488 nm light (which does not itself excite SPPs efficiently in gold) and brought into the close vicinity (20 nm distance) of a thick, nanostructured Au film imaged by Near-field Scanning Optical Microscopy (NSOM). As illustrated in Figure 1, we have demonstrated that SPPs are efficiently launched by the red near-field light emanating from the fluorescent nanodiamonds situated on the fibre tip. When the number of N-V centres is reduced down to two (hosted by a single 20 nm diamond), single SPPs are launched into a nanostructured film. This opens the way to innovative studies in "deterministic" scanning quantum plasmonics.



Deterministic quantum plasmonics. Left: A single diamond nanocrystal containing two NV color centers is glued at the apex of a bare fibre tip. The fluorescence of the color centers is coupled to Surface Plasmon Polaritons propagating along a gold film. Light is subsequently collected by a microscope for either leakage radiation measurements or Near-field Scanning imaging (NSOM). Right: A typical, intensity-time, second-order correlation function of the photon emission from the two color centers at the tip apex, showing the quantum nature of the emitted light. Bottom: A typical near field optical image of a gold nanostructure acquired using such a quantum plasmonic device.

CONTACTS

Aurélien DREZET
aurelien.drezet@grenoble.cnrs.fr
Tel: +33 456 38 70 62

Serge HUANT
serge.huant@grenoble.cnrs.fr
Tel: +33 438 10 86

FURTHER READING

NEAR-FIELD OPTICAL MICROSCOPY WITH A NANODIAMOND-BASED SINGLE-PHOTON TIP
A. Cuche, A. Drezet, Y. Sonnefraud, O. Faklaris, F. Treussart, J.-F. Roch, S. Huant
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