3D adiabatic compression of plasmon polariton for nanomapping below 10 nm resolution

Francesco De Angelis[1,2], Gobind Das[1,2], P. Candeloro[2], C. Liberale[1,2], F. Mecarini[1], R. Proietti[1], and Enzo Di Fabrizio[1,2]

[1]*Fondazione Istituto Italiano di Tecnologia, Via Morego 30, I16163 Genova, Italy*
[2]*BIONEM lab, University of Magna Graecia, viale Europa, 88100 Germaneto (CZ), Italy*

Here we report on the design, fabrication, and characterization of a novel nano-optical device conceived for label-free detection and chemical mapping of few molecules by means of Raman Scattering combined with AFM [1]. The device consists in a silver cone acting as a plasmonic nanoantenna, placed at the centre of a photonic crystal (PC) cavity (figure 1, device is fabricated on AFM cantilever). The PC cavity produces an efficient coupling between the external optical source and the nanoantenna, in fact, direct coupling of the far field to the nanoantenna in the absence of a PC is inefficient, as we observed both theoretically and experimentally. The nanoantenna placed at the cavity centre supports SPP modes and acts as a nano-scale waveguide, able to propagate and focus the SPP towards the tip where strong enhancement of the e.m. field intensity occurs [2]. Raman scattering and AFM measurements were performed with different substrates and experimental conditions; in particular the Raman spectrum of a silicon nanocrystal stripe on silica substrate is reported in figure 2. When a scan is performed across a stripe of silicon a clear variation of Raman signal (from silicon peak at 520 cm^{-1} to silica peak at 460 cm^{-1}) can be observed. The corresponding AFM topography is reported in figure 3. In our best condition a chemical resolution of 7 nm is reached, also when Raman scattering and AFM topography are performed at the same time.

The present results open up new perspectives on label-free single molecule detection in sub-wavelength regime and in far field configuration. We also aim at achieving unambiguous chemical information of molecular species localised in a region down to 5-10 nm and in label-free conditions.

[1] F. De Angelis et al., Nanoscale chemical mapping using three-dimensional adiabatic compression of surface plasmon polaritons, *Nature Nanotechnology* **5** (2010), doi:10.1038/nnano.2009.348

[2] F. De Angelis et al., Hybrid plasmonic-photonic nanodevice for label-free few molecules detection, *Nano Lett.* Vol. 8 (8) 2008.

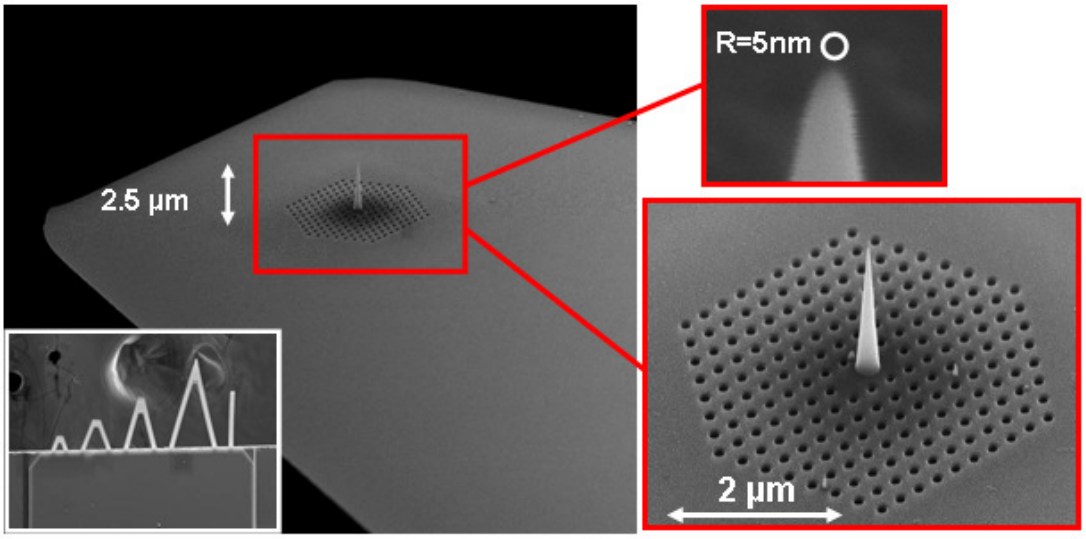

Figure 1: SEM images of the Photonic crystal on silicon nitride AFM cantilever with the silver cone acting as nanoantenna in the centre of the cavity. The radius of curvature of the tip is below 10 nm.

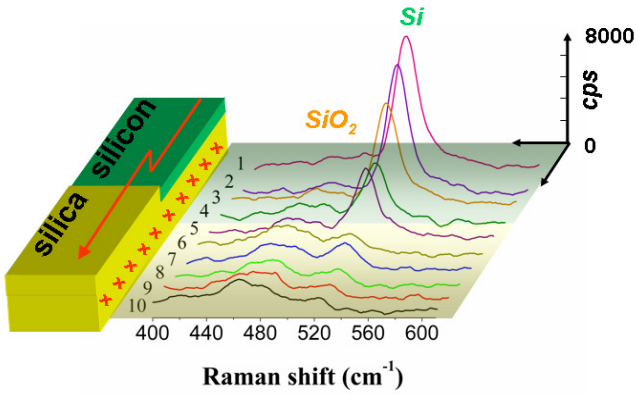

Figure 2. Raman spectrum measured across a stripe of silicon nanocrystal (figure 3). A clear variation of Raman signal can be observed when substrate change from silcon (520 cm^{-1}) to silica (460 cm^{-1}).

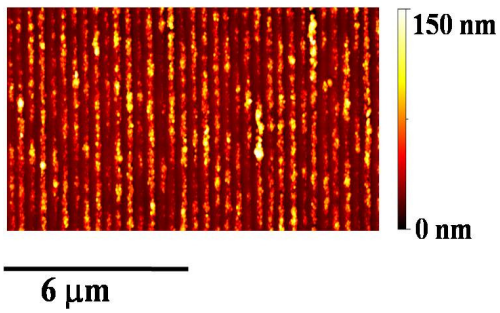

Figure 3. AFM topography of silicon nanocrystal stripe growth on silica substrate. The Raman spectrum performed across a single stripe is reported in figure 2.