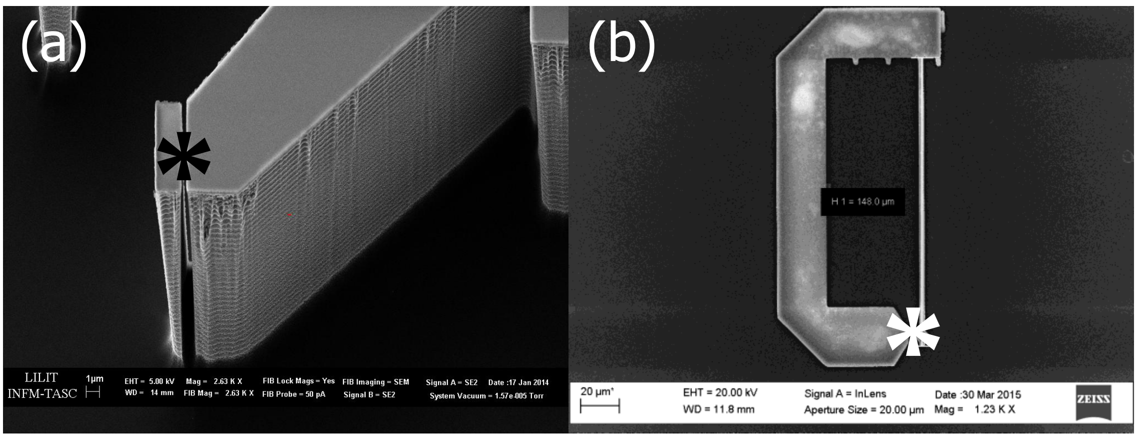
Nanomechanical modulated Raman spectroscopy.

Silvio Greco [1,2], Valeria Toffoli[1], Simone Dal Zilio[1], Alpan Bek[3], Marco Lazzarino[1],* and Denys Naumenko[1,4]

[1]CNR-IOM, TASC Laboratory, AREA Science Park, 34143 Trieste, Italy
[2] 2Ph.D. School of Nanotechnology, University of Trieste, 34100 Trieste, Italy
[3] 3METU Middle East Technical University, Ankara, Turkey
[4]Elettra Synchrotron ScpA 34149 Trieste Italy
**lazzarino@iom.cnr.it*

Hot spots are defined as nanostructures of noble metal able to locally enhance the electromagnetic field of several orders of magnitude and to confine this effect to a region several orders of magnitude smaller than the light wavelength. Hot spots are particularly important for surface enhanced Raman spectroscopy (SERS) applications in which the field enhancement is used to amplify the usually weak Raman scattering signal. Hot spots are mostly generated between two or more plasmonic nanostructures separated by nanometric gaps. Several strategies are used to design and realize hot spots, both in solution, using noble metal nanoparticles, and on surfaces using nanolithography and evaporation.
In this contribution we demonstrated the fabrication of nanomechanical tunable and switchable plasmonic devices for Raman spectroscopy, in which hot spots are modulated when actuated at their resonant frequency. Two different micromechanical devices were fabricated, one oscillating vertically at MHz frequencies (Figure 1a) and one oscillating horizontally at 100kHz (Figure 1b). The areas where tunable hotspots were localized are marked with an asterisk on the figure.
When the signal is collected in CW mode, the micromechanical Raman substrate, when operated at its resonance frequency, can be used to generate local metastable hotspots and allows an on/off switching of the Raman signal [1].
When instead the signal is collected in real time it is possible to observe the time-dependence of the hotspot generation at the eigenfrequency of the nanomechanical oscillator and thus demodulate the Raman signal according to the first and higher harmonics: we demonstrated that the nonlinear modulation of polarization-dependent SERS signal from a synthetic dye can be analyzed with lock-in techniques, thus realizing the first demonstration of frequency modulated Raman spectroscopy, and the spatial localization of SERS hotspots below the diffraction limit.



SEM images of the nanomechanical devices used to generate a tunable hotspot. The Hotspot location is indicated with an asterisk on both pictures.

References

[1] Naumenko D., Toffoli V, Greco S., Dal Zilio S., Bek A., and Lazzarino M. Applied Physics Letters **109**, 131108