Antenna-based THz nanocavities for plasmon assisted light-matter interaction

Xin Jin[1], Andrea Cerea[2], Gabriele C. Messina[2], Andrea Rovere[1], Riccardo Piccoli[1], Francesco De Donato[2], Francisco Palazon[2], Andrea Perucchi[3], Paola Di Pietro[3], Roberto Morandotti[1], Stefano Lupi[4], Francesco De Angelis[2], Mirko Prato[2], Luca Razzari[1], Andrea Toma[2]

[1]INRS EMT, 1650 Blvd Lionel Boulet, J3X 1S2 Varennes 26 (Québec), Canada.
[2]Istituto Italiano di Tecnologia, via Morego 30, 16163 Genova, Italy
[3]Elettra - Sincrotrone Trieste S.C.p.A, AREA Science Park, S.S. 14 km163.5, Trieste, Italy
[4]CNR-IOM and Dipartimento di Fisica, Università di Roma "La Sapienza", Piazzale A. Moro 2, I-00185, Roma, Italy.

Email: andrea.toma@iit.it

Improving the sensitivity of THz spectroscopy is a longstanding challenge that envisions a great impact on fundamental studies involving the interaction of such long wavelengths with nano-objects at extremely low concentrations. Within this context, THz resonant dipole antennas coupled through nanogaps are effective in confining THz radiation on a deep subwavelength scale [1], with a significant field enhancement in close proximity of antenna-based nanocavities (see Figure). These properties are particularly promising for improving THz radiation-matter interactions within nano-volumes. In particular, we have recently studied the coupling between the phonon resonance of semiconducting nanocrystals and the plasmon resonance of nanoantenna arrays. When the two resonances are matched, the combined system shows a clear interference feature in THz extinction measurements (see Figure). We have successfully employed this effect to perform enhanced THz spectroscopy of a single layer of CdSe quantum dots [2]. The conjugation between quantum emitters and confined optical modes has been further extended towards the strong coupling regime, where intensified THz radiation-matter interaction promotes the formation of novel hybrid states. In this view, light-matter hybridization can dramatically change the physico/chemical properties of the pristine systems, envisioning exciting scenarios in many fields, e.g. in the advanced control of the optical phonon response of functional nanomaterials as well as in the realization of novel platforms for nanoscale quantum technologies.

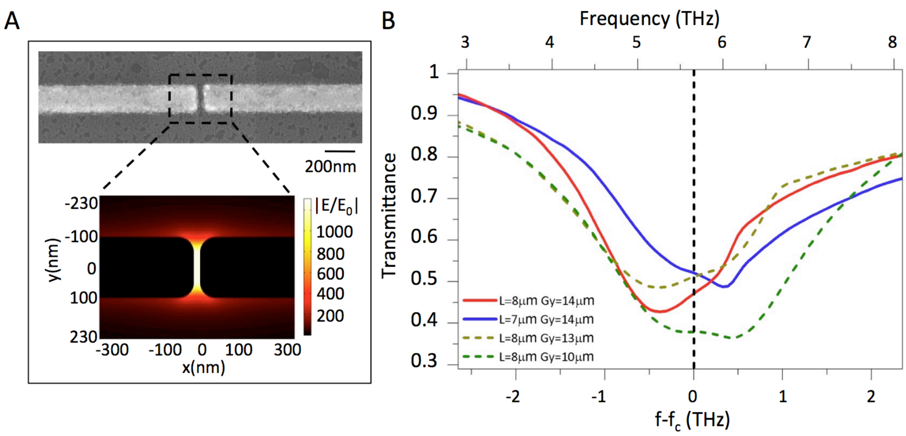

Figure. (a) SEM detail of a nanogap region covered with a QD monolayer. The electric field enhancement under resonant conditions is reported in the bottom panel. (b) Normalized transmission of nanoantenna arrays (for different length L and spacing G_y) covered with CdSe QDs. f_c represents the QD phonon mode frequency.

References

[1] L. Razzari, A. Toma, M. Shalaby, et al. 2011 *Opt. Express* Vol. 19, 26088.
[2] A. Toma, S. Tuccio, M. Prato, et al. 2015 *Nano Lett.* Vol. 15, 386.