Plasmonic response of composite graphene-Au nanopatterned systems

Francesco Bisio[1], Niloofar Haghighian[2], Vaidotas Miseikis[3], Camilla Coletti[3,4], Maurizio Canepa[2]

1 CNR-SPIN, Corso Perrone 24, I-16152 Genova, Italy
2 Dipartimento di Fisica, UniGe, Via Dodecaneso 33, I-16146 Genova, Italy
3Center for Nanotechnology Innovation @NEST, Istituto Italiano di Tecnologia, Piazza San Silvestro 12, I-56127 Pisa, Italy
4 Graphene Labs, Istituto Italiano di Tecnologia, Via Morego 30, I-16163 Genova, Italy
francesco.bisio@spin.cnr.it

We investigated the optical response of a hybrid graphene/plasmonic device consisting of a 2-dimensional array of densely-packed, small (<20 nm) gold nanoparticles (NPs) combined with a large single-layer-graphene foil. The Au NPs were realized by ultra-clean bottom-up fabrication schemes onto nanopatterned CaF_2(110) surfaces, and exhibited a sharp localized surface plasmon resonance (LSP) at a wavelength of 580 nm.

Large foils of mostly-single-layer graphene (SLG) were grown by chemical vapour deposition on Cu foils, then transferred onto the Au nanoparticle arrays in aqueous solution. The Au NPs remain intact, in shape and spatial arrangement, following the graphene deposition. The SLG is directly laid onto the Au NPs, and is suspended above the nanometric gaps between each particle and its next neighbours.

The unique electronic properties of graphene coupled with metallic nanostructures are expected to lead to significant perturbation of the local distribution of electromagnetic field intensity, hence the plasmonic response. Indeed, the system demonstrated a huge redshift of the LSP-resonance, as large as 65 nm, following the SLG transfer. The LSP resonance shift is interpreted as the superimposed effect of the modified near-field electromagnetic environment of the nanoparticles and the graphene-mediated electronic coupling between adjacent nanoparticles.