Paper AOP100-184

Collective modes of self-assembled supercluster metamaterials: towards label-free sensing

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Plasmonics offers exceptional control of light on nanoscale dimensions through strongly enhanced light-matter interactions. And yet, the use of plasmonic structures in sensing schemes has been limited by the extremely small modal volumes, ohmic losses and the cost of their fabrication.

Recently, self-assembled superclusters of chemically-synthesised metallic nanoparticles have been proposed as means of overcoming some of these limitations [1,2]. In this work, the existence of collective modes in such supercluster metamaterials is successfully verified. This is achieved by using 3-dimensional Raman tomography to map the collective modes of the superclusters and by comparing them to electric and magnetic field enhancement maps, obtained from finite-difference time-domain calculations. Good agreement is obtained for different supercluster sizes and excitation wavelengths.

The high density of hot-spots inside the superclusters and their porosity, combined with the internalisation and tunability of their collective modes, hold great promise for their use in label-free sensing. To demonstrate the potential of this material system for sensing applications, proof-of-principle experiments were performed involving the use of a single supercluster to follow the de- protonation of a reporter label attached to the constituent nanoparticles' surfaces.

[1] V.A. Turek et al. ACS Photonics,3, 35 (2015)
[2] A. Lauri et al. ACS Photonics, 4, 2070 (2017)

Paper AOP100-185

Light-matter interaction: plasmon-exciton hybridization in strong coupling regime

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A brief review on studies of plasmon-exciton interactions in various nanostructures of different shapes and sizes is presented. In particular, the interactions between localized plasmons in various plasmonic nanocavities and excitons in organic semiconductors will be considered. In these hybrid structures, the anticrossing behavior of hybridized modes can be tracked using a number of spectroscopic techniques, such as absorption and photoluminescence. The recent advances in the study of plasmon-exciton interaction using magnetic circular dichroism spectroscopy will also be discussed. In these experiments, it has recently been shown that nonmagnetic organic molecules exhibit magneto-optical response due to binding to plasmonic nanoparticles.