Engineering nonlinearities in plasmonic nanorod metamaterials

Anatoly V Zayats

Nano-optics and Near-field Spectroscopy Group
Department of Physics, King’s College London
London WC2R 2LS, United Kingdom
Fax: + 44-207848-2477; email: a.zayats@kcl.ac.uk

Abstract
Plasmonic metamaterials based on aligned nanorods provide an opportunity to engineer nonlinear optical response by controlling the interaction between plasmonic modes of individual nanorods as well as with active material embedded in the array. In this talk we will overview nonlinear optical properties of such bare and hybrid gold nanorod arrays in weak and strong coupling regimes as well as taking into account the effect of nonlocal electromagnetic interactions in the array.

Plasmonic metamaterials allow realisation of a large number of photonic and nanophotonic applications, including negative index engineering, superlensing, optical cloaking and passive and active integrated photonic circuitry. The rarely studied class of such metamaterials is based on plasmonic nanorod arrays [1—7]. They consist of metal nanorods (20—60 nm diameter, 40—80 nm spacing between rods, 50—500 nm length) attached to the substrate with their axes aligned perpendicularly to it. The nanorods can be free standing or immersed in dielectric, e.g., polymer matrix. They are inexpensive to fabricate over large areas [1,2,6].

Optical properties of such metamaterials are determined by strong interaction between plasmonic resonances of the individual nanorods and are due to collective plasmonic response of the nanorod ensemble. The resonant frequency of such collective plasmonic excitations and spatial variation of the associated electromagnetic field distribution can be designed by modifying the nanorod array parameters: size of the nanorods, their separation, permittivity of the metal and embedding dielectric matrix. Not only linear but also nonlinear optical properties of the nanorods can be designed by adjusting geometrical parameters to invoke nonlocal effects to enhance nonlinearity [1,3] or by hybritising the metamaterials with nonlinear molecular species and engineering weak [5,6] or strong coupling regime [7] between molecular and plasmonic excitations.

In this talk we will overview the studies of nonlinearities in plasmonic nanorod metamaterials in various regimes and discuss applications in nanophotonic devices. Ultrafast nonlinear optical response of such metamaterials allows all-optical modulation of the optical properties with sub-picosecond time response at low intensities of control light and can be useful for designing the all-optical components of integrated nanophotonic circuits.

References


