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Plasmonic metamaterials with tuneable optical properties

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Negative refraction in metamaterials has recently attracted significant attention due to its possible numerous applications in high-resolution imaging and photolithography with the so-called "perfect lenses," for electromagnetic shielding (invisibility cloak), optical signal manipulation, etc. Among various realizations of negative index materials, plasmonic nanostructures play a prominent role as they allow negative refraction properties to be engineered in the visible and near infrared spectral ranges. The coupling of light to plasmonic modes, that are collective electronic excitations in metallic nanostructures, provides the possibility to confine the electromagnetic field on the sub-wavelength scale and manipulate it with high precision to achieve the desired mode dispersion and, thus, reflection, absorption and transmission properties of the nanostructures. In this talk we will discuss various pathways to control dispersion of the electromagnetic waves in plasmonic metamaterials, including plasmon polaritonic crystals and plasmonic nanorod arrays, and the approaches to active tuneability of their optical properties using optical and electric control signals. Both approaches take advantage of the very high sensitivity of surface plasmon mode dispersion on the refractive index of the dielectric adjacent to metallic nanostructure. Hybridization of plasmonic nanostructures with molecular species exhibiting nonlinear optical response allows the development of metamaterials with high effective nonlinear susceptibility due to the electromagnetic field enhancement related to plasmonic excitations. Signal and control light are then coupled to plasmonic modes that strongly interact via nonlinearity introduced by the hybridization. Concurrently, the use of electro-optically active dielectrics incorporated into plasmonic nanostructures provides the route to control optical signals electronically. Plasmonic metamaterials with tuneable optical properties can be used to control negative refraction and electromagnetic field propagation in various applications in nanophotonics, optoelectronics and optical communications.