Lasing Spaser Nanoparticle Arrays

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Band structure engineering is critical for controlling the emission wavelengths and efficiency in electronic and photonic materials. Single band-edge states that show trapped slow light have been used as high-quality optical feedback for lasing from photonic bandgap crystals and metal-dielectric waveguides. For example, plasmon nanolasers, or spasers (surface plasmon amplification by stimulated emission of radiation) are devices based on plasmonic cavities and gain media that can compensate loss and achieve amplification of nano-localized electromagnetic fields. Recently, we demonstrated that single band-edge lattice plasmons in periodic metal nanoparticle arrays could contribute to single-mode lasing at room-temperature with directional emission. However, the manipulation of more than a single band-edge mode for nanolasing has not been possible because of limited cavity designs. This talk will describe a new architecture based on plasmonic superlattices—finite-arrays of nanoparticles grouped into microscale arrays—to achieve multi-modal lasing. The underlying mechanism was found to depend on trapped slow light at both zero and non-zero wavevectors. We will discuss how the spectral separation and spatial emission angles of the lasing modes can be tuned by changing patch periodicity. Such characteristics may enable multi-frequency multiplexing and fast-processing of nanoscale coherent light for on-chip photonic integration.

Enabling imaging and spectroscopy of electron beam sensitive hybrid materials

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The very special optoelectronic properties of hybrid inorganic/organic systems (HIOS) are largely determined by the electronic structure and distribution of charges at the inorganic/organic interface. Holographic imaging techniques in transmission electron microscopy (TEM) allow electrostatic potentials, electric fields, and charge distributions to be imaged. State of the art electron energy-loss spectroscopy (EELS) provides a
sub-nanometer-sized probe at a spectral resolution comparable to that of infrared (IR) spectroscopy. In this talk novel approaches to both types of techniques will be presented, which are being developed within project A12.

Their aim is to collect as much information as possible while minimizing the electron beam damage to the beam-sensitive hybrid specimen. One of these approaches will take advantage of the extremely high energy resolution of current EELS instrumentation, while the other one will involve the recently developed technique of inline electron holography.