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Metasurfaces and Epsilon-Near-Zero Modes in Semiconductors

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Abstract: I will discuss the physics of epsilon-near-zero (ENZ) modes in thin conducting layers. These ENZ modes can be used to alter and enhance the coupling between metasurfaces, phonons and intersubband transitions in semiconductor heterostructures.

Planar metamaterial resonators can couple efficiently to a variety of excitations that exist or can be designed in semiconductors and their heterostructures. Examples are phonons[1], intersubband transitions[2] and plasmons [3]. This coupling can be exploited for fundamental studies of light matter interaction or for optoelectronic functionality such as light modulation, tunable spectral filtering or optical nonlinearities. Thin layers of semiconductors where the permittivity crosses zero, support a particular polariton mode called epsilon-near-zero (ENZ) mode. [4, 5] This zero crossing can be obtained near optical phonon resonances in dielectrics or the plasma frequency in doped semiconductors. The coupling of metamaterial resonators to these ENZ modes leads to particularly large Rabi splittings. ENZ layers can be added to metamaterial-based strongly coupled systems to increase this coupling even further. An interesting implication of this increased coupling is that with the right design, nonlinearities from metamaterials strongly coupled to intersubband transitions can be increased even further compared to previously published results. [6, 7]

In this talk I will show several examples of these coupled systems that include metasurfaces, phonons, intersubband transitions and ENZ modes. Finally, I will discuss other interesting applications of ENZ modes such as directional thermal emission.

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