Metactronics: Optical Circuits and Information Processing in Nanoworlds

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In recent years, the two fields of metamaterials and plasmonic optics have each seen exciting developments. Owing to some of the fascinating features that are common in both areas, the two fields are merging into a single topic that may be called *metaplasmonics*. In the microwave and optical domains, materials with unconventional constitutive parameter values, such as negative or near-zero, exhibit interesting properties in their interaction with microwave and optical waves. Negative-permittivity plasmonic media, such as noble metals in the infrared and optical frequencies, and epsilon-near-zero (ENZ) materials, such as plasmonic materials near their plasma frequencies, can be exploited as the building elements for engineering of novel metamaterials.

In my research group, we have been exploring fundamental concepts and various potential applications of metamaterials and plasmonic phenomena, for which these unconventional parameter values can play important roles. We have studied various metaplasmonic-based structures, devices, and nanocircuit, and have developed the concept of "metactronics" and meta-nanocircuits, i.e., "circuits with light at nanoscales", in which the arrangement of a tapestry of plasmonic and nonplasmonic nanostructures can provide optical circuits in which the optical electric fields can be tailored in subwavelength regions. Indeed, "lumped" nanocircuit elements can be envisioned at the optical wavelengths. (N. Engheta, A. Salandrino, A. Alu, Phys. Rev. Lett. 95, 095504 (2005); N. Engheta, *Science*, 317, 1698-1702, 2007). In my research group, a variety of ideas for nanocircuit functions, optical antennas for beam shaping and "photonic wireless at the nanoscale", optical nanoscopy, nanospectrometer for molecular spectroscopy, nanotagging and barcodes based on meta-nanocircuits, and metamaterial-based supercoupling and EM energy squeezing through narrow subwavelength channels are being studied.

In this talk, I will give an overview of these studies in my group, present physical remarks behind the findings, and forecast future ideas and potential applications in these areas.