Metatronics: Merging Electronics, Photonics and Magnetics into One Paradigm

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Abstract

In my group we have introduced and been developing the concept of "metatronics", i.e. metamaterial-inspired optical nanocircuitry, in which the three fields of "electronics", "photonics" and "magnetics" can be brought together seamlessly under one umbrella. In such a paradigm, the concept of metamaterials and plasmonics optics can be utilized to bridge the gaps among these fields and to transplant concepts from one field into another. In such a unified paradigm of optical metatronics, the nanostructures with specific values of permittivity and permeability may act as the lumped circuit elements such as optical nanocapacitors, nanoinductors and nanoresistors. Nonlinearity in metatronics can also provide us with novel optical nonlinear lumped elements. Optical nanoantennas can be the links between the "macroworld" with such "nanoworld" of optical metatronics. We have investigated the concept of metatronics through extensive analytical and numerical studies, computer simulations, and recently in a set of experiments at the IR wavelengths. In our experimental efforts, we have shown that nanorods made of low-stressed Si_3N_4 with properly designed cross sectional dimensions indeed function as lumped circuit elements at the IR wavelengths between 8 to 14 microns. We have been exploring how metamaterials can also be exploited to control the flow of photons, analogous to what semiconductors do for electrons, providing the possibility of one-way flow of photons, photon diodes, and photon capacitors. We are now extending the concept of metatronics to other platforms such as graphene, which is one-atom-thick layers of carbon atoms, with unusual conductivity functions. We study the graphene as a new paradigm for metatronic circuitry and also as a one-atom-thick metamaterials, and one-atom-thick circuit elements and optical devices. I will give an overview of our most recent results in these fields and forecast future directions and possibilities.