

Tutorial

Circuits with Light at the Nanoscale: Meta-nanocircuits and Metactronics

Nader Engheta
University of Pennsylvania
engheta@ee.upenn.edu

Abstract

Imagine optical circuit elements so small that you could fit many of them in a tiny microscale volume (e.g., a cell)! Imagine that such circuits could work with light at the nanoscale instead of electronic currents! What could you do with such optical nanocircuits? Would you be able to use them in wireless gadgets at nanoscales, like a “nanoradio”, that may connect our nanoworlds? Could these tiny optical nanocircuits be coupled with biological entities and thus provide nanoscale sensors? The fields of metamaterials and plasmonic optics may provide road maps for such futuristic nanocircuits and wireless nanosystems and sensors. 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”. We have been developing and investigating some of the fundamental concepts and theories, and key features of such metaplasmonic structures, devices, and circuits. These nano-optical circuit elements and components may be envisioned as a tapestry of properly-arranged nanostructures (e.g., nanoparticles) of sizes much smaller than the wavelengths of light. Indeed, “lumped” nanocircuit elements can be envisioned at the optical wavelengths. This field, for which I have coined the term metactronics, addresses metamaterial-inspired optical nanocircuits and nanosystems (N. Engheta, *Science*, 317, 1698-1702, 2007). In my group, a variety of ideas and paradigms for nanocircuit functions and systems, optical antennas and sensors for beam shaping and photonic wireless at the nanoscale, optical nanoscopy, nanospectrometer for molecular spectroscopy, nanotagging and barcodes based on these optical circuits are being studied. In this talk, I will give an overview of these studies, present insights into these findings, and forecast future ideas and road maps in these areas.

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Biosketch

Nader Engheta is the H. Nedwill Ramsey Professor of Electrical and Systems Engineering, and Professor of Bioengineering, at the University of Pennsylvania. He received his B.S. degree in EE from the University of Tehran, and his M.S and Ph.D. degrees in EE from Caltech. Selected as one of the *Scientific American Magazine* 50 Leaders in Science and Technology in 2006 for developing the concept of optical lumped nanocircuits, he is a Guggenheim Fellow, an IEEE Third Millennium Medalist, IEEE Fellow, American Physical Society Fellow, Optical Society of America Fellow, and the recipient of the 2008 George H. Heilmeier Award for Excellence in Research from UPenn, the Fulbright Naples Chair Award, NSF Presidential Young Investigator award, the UPS Foundation Distinguished Educator term Chair, and several teaching awards including the Christian F. and Mary R. Lindback Foundation Award and S. Reid Warren, Jr. Award. His current research activities span a broad range of areas including metamaterials and plasmonics, nanooptics and nanophotonics, biologically-inspired sensing and imaging, miniaturized antennas and nanoantennas, physics and reverse-engineering of polarization vision in nature, mathematics of fractional operators, and physics of fields and waves phenomena. He has co-edited the book entitled “Metamaterials: Physics and Engineering Explorations” by Wiley-IEEE Press, 2006.

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