Physics Colloquium

Michigan Technological University

Thursday, March 1, 2012 at 4:00 pm
Room 139 Fisher

Nanophotonics and Subwavelength Electromagnetics Based on Novel Media

Zhaolin Lu
Rochester Institute of Technology
Rochester, New York

Abstract: In this talk, we will discuss surface plasmons, metamaterials, graphene, photonic crystals, and their applications in nanophotonics and electromagnetics.

Plasmonic (or surface plasmon-based) circuits merge electronic and photonic signals at the nanoscale and provide the opportunity to combine the superior technical advantages of photonics and electronics on the same chip. In particularly, the advantages can be well exhibited in plasmonic slot waveguides, where the mode size is essentially determined by the dimensions of the insulator slot. We experimentally demonstrate a compact platform to convert near-infrared signals between nanoplasmonic and nanophotonic domains. The integrated plasmonic devices developed on a silicon-on-insulator (SOI) substrate could build up a solid platform for plasmonic gauges of ultrafast communications and optical sensing.

Furthermore, recent research on graphene has revealed its remarkable electro-optic properties, which promise to satisfy the needs of future electro-optic modulators. However, its ultra-small thickness, compared with operating light wavelength, downplays its role in an optoelectronic device. The key to achieve efficient electro-optic modulation based on graphene is to enhance its interaction with light. To this end, some novel waveguides and platforms will be employed to enhance the interaction. We present our exploration of graphene electro-optic modulators based on graphene sandwiched in dielectric or plasmonic waveguides. Up to 3-dB modulation depth can be achieved within 800nm long silicon waveguides, or 120nm long plasmonic waveguides based on 3D numerical simulations. They have the advantages of nanoscale footprints, small insertion loss, low power consumption, and potentially ultrahigh speed, as well as being CMOS-compatible.

In addition, advances in metamaterials and photonic crystals promise unprecedented flexibility in obtaining materials with very complex specifications, including independent control of the permittivity and permeability with desired (positive, zero, or negative) values, anisotropy, and distribution. Generally speaking, the permittivity (or permeability) of a metamaterial can be designed to be an almost arbitrary, space-dependent tensor, which can achieve material performances beyond the limitations of conventional, naturally-occurring composites. Their applications in imaging systems may result in "negative refraction," which potentially beats the diffraction limit imposed upon conventional imaging systems.

Biography: Zhaolin Lu is an Assistant Professor of Microsystems Engineering at Rochester Institute of Technology. He received his M.S. in Optics from Chinese Academy of Sciences, his M.S. in Physics from Michigan Technological University in 2002, and his PhD in Electrical Engineering from University of Delaware in 2006. During his work at Rochester Institute of Technology, he has established a Nanoplasmonics and Metamaterials group focused on the exploration of the properties and applications of advanced optical and electromagnetic materials. These materials include photonic crystals, metamaterials, and graphene. For years, his work is at the frontier of nanophotonics and has been widely highlighted by public media. He has published over 70 journal and conference papers and is an editor of several optics journals. He is the inventor of 5 patents and the recipient of Texas Instruments/Douglass Harvey Faculty Development Award. His work is currently supported by National Science Foundation, Defense Advanced Research Projects Agency, and American Chemical Society.

MichiganTech