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Metamaterials, Shrinking Circuit Elements, and Nanooptics

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260 Dreese Laboratory

Metamaterials are engineered composite media with unconventional electromagnetic and optical properties. They can be formed by embedding sub-wavelength inclusions as "artificial molecules" in host media in order to exhibit specific desired response functions that are not readily available in nature, but physically realizable. These metamaterials have exciting characteristics in manipulating and processing RF, IR and optical signal information. In my group, we have been investigating various features of these media and have been developing some of the fundamental concepts and theories of wave interaction with a variety of structures and systems involving these material media. From our analyses and simulations, we have found that the devices and components, such as cavity resonators and waveguides, formed by these media may be ultracompact, while supporting resonant and propagating modes even when they have very small, sub-wavelength dimensions. This implies that in such structures RF, IR and optical signals can be controlled and reshaped beyond the diffraction limits, leading to the possibility of miniaturization of optical interconnects and design and control of near-field devices and processors for the next generation of information technology. This may also lead to computational nano-architectures capable of information processing in the near-field optics, which has the potential for significant size reduction in optical computation and information storage. Furthermore, the nanostructures made by pairing these media can be compact resonant components, resulting in enhanced wave signatures and higher directivity. We are also interested in nano-optics of metamaterial structures that effectively act as "nano-circuit-elements". These may provide nano-inductors, nano-capacitors, and nano-resistors as part of "metamaterial nanocircuits" in the optical regimes, and can provide roadmaps to more complex nanocircuits formed by collection of such metamaterial structures. All these characteristics may offer various potential applications in high-resolution near-field imaging and microscopy, enhancement or reduction of wave interaction with nano-particles and nano-apertures, miniaturization of optical devices and components, optical data storage, and optical coupling and interfacing of cells and molecules, to name a few.

In this talk, we present an overview of the concepts, salient features, recent developments, and some of the potential applications of these metamaterials and structures, and will forecast some futures ideas and directions in this area.

Biography Nader Engheta is the H. Nedwill Ramsey Professor of Electrical and Systems Engineering, and Professor of Bioengineering at the University of Pennsylvania. He received the B.S.E.E. degree from the University of Tehran, and the MS in E.E. and the Ph.D. degrees in electrical engineering (with a minor in Physics) from Caltech. His current research activities span a broad range of areas including theory of nanooptics and nanophotonics, metamaterials and plasmonics, bio-inspired sensing and imaging, miniaturized antennas and nanoantennas, physics and reverse-engineering of polarization vision, mathematics of fractional operators and physics of fields and waves phenomena. A Guggenheim Fellow, an IEEE Third Millennium Medalist, a Fellow of IEEE, and a Fellow of the Optical Society of America, he has been the recipient of various awards and distinctions including the UPS Foundation Distinguished Educator term Chair in 1999-2000, the Fulbright Naples Chair award, NSF Presidential Young Investigator (PYI) award, the S. Reid Warren, Jr. Award (two times), the Christian F. and Mary R. Lindback Foundation Award, and the W. M. Keck Foundation's 1995 Engineering Teaching Excellence Award.

Reception to follow in Dreese 220, the ECE Faculty Lounge