Applied Physics & OSA

Optics Seminar

Metamaterials, Shrinking Circuit Elements, and Near-Field Nano-Devices and System

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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. A particular example of these materials is the media in which one or both parameters of permittivity and permeability may have negative real parts in a certain band of frequency. Another class is the low-permittivity, low-permeability or low-index media where one or some of these parameters attain very small, even near zero, relative values. 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 in the optical regimes, and can provide roadmaps to more complex nanocircuits (e.g., optical transistors) formed by collection of such nanostructures. All these characteristics may offer various potential applications in high-resolution near-field imaging and microscopy, RF and optical information processing in ultracompact optical near-field devices, enhancement or reduction of wave interaction with nano-particles and nano-apertures, miniaturization of optical devices and components, optical data storage, molecular-optical circuits, 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 potential applications of these metamaterials and structures, and will forecast some futures ideas and directions in this area.

Biography:

Nader Engheta is a Professor of Electrical and Systems Engineering 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. After spending one year as a postdoctoral research fellow at Caltech and four years as a Senior Research Scientist at Kaman Sciences, he joined the faculty of the University of Pennsylvania, where he is currently a Professor. He is also a member of the Mahoney Institute of Neurological Sciences, and a member of the Bioengineering Graduate Group at the University of Pennsylvania. He was the graduate group chair of electrical engineering from July 1993 to June 1997.

He is a Guggenheim Fellow, a recipient of the IEEE Third Millennium Medal, a Fellow of IEEE, and a Fellow of the Optical Society of America. In addition, 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 in 1998, 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. He was also an IEEE AP-S Distinguished Lecturer in 1997-1999.

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