

Physics Colloquium, University of South Florida

3:00 pm, Friday, Dec 1st, 2017, ISA 2023

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Dielectric Resonator Metasurfaces: Optical Magnetism, Wavefront Control and Optical Nonlinearities

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Metamaterials have been used extensively for wavefront manipulation since their inception more than a decade ago. This has led to a new paradigm in optics with the ability to design optical components with functionality that was unthinkable not long ago. Although magnetic and electric optical resonances of Mie scatterers have been known for more than a century, it is only recently that these particles (dielectric resonators-DR) have been utilized for the realization of low loss metamaterials at optical frequencies. I will describe several examples of passive 2D metamaterials (or metasurfaces) with quite peculiar behavior such as optical magnetic mirrors, Huygens metasurfaces and holograms.

The ability to tailor also the local near fields inside the constituent material of the DRs has implications for other optical behavior such as the nonlinear optical response. When all dielectric metasurfaces are created from materials with inherent high optical nonlinearities, this combination yields some surprising results. In this talk I will also describe new developments in the nonlinear optical response of metasurfaces when these are made from direct bandgap semiconductors. In combination with short pulse excitation using single and multiple pulses, we observe multiple harmonic mixing spanning a wavelength range from the near infrared to the ultraviolet. Additionally, the use of direct bandgap semiconductors as the constituent material for these all-dielectric metasurfaces enables the possibility for a new class of all optical switching devices that can potentially use lower energy than existing counterparts.

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Dr. Igal Brener is a Distinguished Member of Technical Staff at Sandia National Laboratories in Albuquerque, NM. He received a B.Sc. in Electrical Engineering, a B.A. in Physics, and the D.Sc. in Physics from the Technion (Haifa), in 1983, 1983 and 1991, respectively. From 1983 to 1986 he worked for National Semiconductors in microprocessor VLSI design. He was with Bell Laboratories in NJ from 1991 until 2000, with Tellium Inc. from 2000 until 2002, and with Praelux/Amersham Biosciences/GE Healthcare from 2003 until 2004. He joined Sandia National Laboratories, Albuquerque, NM, in 2004 where he is currently science leader for nanophotonics at the Center for Integrated Nanotechnologies and research full professor at the University of New Mexico. He has authored more than 200 refereed publications, and has received 22 patents. Dr. Brener is a fellow of the Optical Society of America, the IEEE and the American Physical Society and was editor for Optics Express and Nature Scientific Reports. During the course of his research career, Dr. Brener has made pioneering contributions to semiconductor physics, Terahertz science and technology, fiber telecommunications and metamaterials. During his stay in industry he also worked in silicon VLSI, optical MEMs, microscopy and biophotonics. His current research activities center around combining semiconductors and other solid state materials with metamaterials to achieve novel behavior and improved functionality. He also maintains numerous collaborations with Academia, industry and other national labs in different areas of nanophotonics.