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Enabling Nanophotonics, Data Storage and Energy Conversion with New Plasmonic Materials

Abstract: Over the past decade, one of the major focal points for the area of nanophotonics has been developing a new class of “plasmonic” structures and “metamaterials” as potential building blocks for advanced optical technologies, including data processing, exchange and storage; a new generation of cheap, enhanced-sensitivity sensors; nanoscale-resolution imaging techniques; new concepts for energy conversion including improved solar cells, as well as novel types of light sources. Designing plasmonic metamaterials with versatile properties that can be tailored to fit almost any practical need promises a range of potential breakthroughs. However, to enable these new technologies based on plasmonics, grand limitations associated with the use of metals as constituent materials must be overcome. In the structures demonstrated so far, too much light is absorbed in the metals (such as silver and gold) commonly used in plasmonic metamaterials. The fabrication and integration of metal nanostructures with existing semiconductor technology is challenging, and the materials need to be more precisely tuned so that they possess the proper optical properties to enable the required functionality. Our recent research aims at developing novel plasmonic materials (other than the metals used so far) that will form the basis for future low-loss, CMOS-compatible devices that could enable full-scale development of the plasmonic and metamaterial technologies. In this work, we replace metals in plasmonic metamaterials by new plasmonic ceramics such as transition metal nitrides, whose properties resemble those of gold. However, unlike gold, these materials have adjustable/tunable optical properties, they are cost-effective, robust, refractory (withstanding very high temperatures) and compatible with standard semiconductor processing. Here, we will demonstrate that titanium nitride’s addition to the short list of plasmonic materials paves the way to a new class of data recording systems and CMOS-compatible, on-chip hybrid nanophotonic devices with unprecedented compactness, speed, and efficiency as well as to novel energy conversion schemes. In this talk, the new material platform as well as novel designs and concepts for nanophotonic devices, data storage and energy conversion will be discussed.

Bio: Vladimir (Vlad) M. Shalaev, Scientific Director for Nanophotonics in Birck Nanotechnology Center and Distinguished Professor of Electrical and Computer Engineering at Purdue University, specializes in nanophotonics, plasmonics, and optical metamaterials. Vlad Shalaev received several awards for his research in the field of nanophotonics and metamaterials, including the Max Born Award of the Optical Society of America for his pioneering contributions to the field of optical metamaterials, the Willis E. Lamb Award for Laser Science and Quantum Optics, Rolf Landauer medal of the ETOPIM (Electrical, Transport and Optical Properties of Inhomogeneous Media) International Association, the UNESCO Medal for the development of nanosciences and nanotechnologies and IEEE Photonics Society William Streifer Scientific Achievement Award, He is a Fellow of the IEEE, APS, SPIE, MRS and OSA. Prof. Shalaev authored three books, twenty-seven invited book chapters and over 400 research publications.