PURDUE UNIVERSITY

Birck Nanotechnology Center

Dr. Augustine Urbas earned a B.A. in Physics from the University of Chicago in 1996 and a Ph.D. in Polymer Physics from the Massachusetts Institute of Technology in 2003. As a post doctoral researcher at the Air Force Research Laboratory, Dr. Urbas expanded this work by investigating responsive patterned optical materials, holographic fabrication and HPDLCs with periodic and non-periodic structures. Dr. Urbas then moved on to study the nonlinearities and molecular photophysical properties of high performance chromophores, and developed a comprehensive program to explore applications of metamaterial electromagnetic composites at the Air Force Research Lab, Materials Directorate. Dr. Urbas is currently the Integrated Opto-Electronics Research Lead for the Materials Directorate of AFRL. Research in this area encompasses; structured materials, self-assembled optical composites, nanophotonics, adaptable/ responsive materials, nonlinear materials properties and enhancements, EM properties of composite and structured media, integrated photonics, detector materials and structures, and the design and characterization of structured electromagnetic materials. His expertise includes laser spectroscopy, nano-optics, photonic materials, self-assembly, holography and morphological characterization. Dr. Urbas has over 40 refereed publications.

Dr. Augustine Urbas

Plasmonics and nonlinear metasurfaces for optical applications

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Plasmonic and metamaterial systems are enabling to many relevant technologies. Detecting optical signals in the mid and long wave infrared, and the generation, detection and conversion of single photons for quantum information applications are significant to a range of Air Force technologies and drive the research to increase performance and functionality. We will discuss two metamaterial inspired systems for that have the potential to enable new applications. Both spectral and spatial information is obtained in hyperspectral images. Compressive sensing may allow for the acquisition of more efficient data with higher information content, while preserving functionality. Our research develops a combined method to integrate plasmonic filters and microptical elements onto detector structures which can both improve their performance and provide a means to introduce compressive sensing methods. By coupling a variety of simlulation environments which cover the optical, plasmonic, and electronic domains, we can efficiently comprehensively detector function and performance for a wide range of designs and incorporate compressive sensing into the design loop. We will present the results of several design studies and experimental verification of the modeled device performance. In the second section, we explore how nonlinear properties of metasurfaces can be engineered for quanutm information applications. We show that nonlinear multipole interference allows both a non-reciprocal and unidirectional nonlinear generation from nanoelements or their periodic arrangement, with the direction of nonlinear generation preserved with respect to a fixed laboratory coordinate system when reversing the direction of the fundamental field. Alternatively, it can ensure a directionally selective inhibition of the nonlinear response for certain respective directions of the fundamental beams. We attribute the presented phenomena to the existence of the common (electric or magnetic) pathways inducing the electric and magnetic Mie resonances via a nonlinear interaction, such that switching the phase of one (electric or magnetic) of the vectors of the fundamental field can change simultaneously the phase of all (electric and magnetic) nonlinearly generated multipoles. Furthermore, the interference can occur between various effective hyperpolarizability terms within the electric and magnetic (nonlinearly produced) dipolar modes themselves. Both cases are example where the engineering of materials response through structure to achieve desired optical properties can enable new potential technologies.