

New Horizons for Nonlinear Space-Time Optics with Near-Zero-Index Materials

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Abstract: Very few scientific fields have become as pervasive in basic research and everyday life as nonlinear optics which ushered in tremendous achievements in areas like attosecond physics, ultra-broadband optical communication, and high-resolution sensing. The utility of nonlinear optics has therefore been a compelling motivator to increase generally weak light-matter interactions. In this pursuit, novel materials have been explored including materials where in a particular spectral region the real part of the permittivity (ϵ)-epsilon is near zero (ENZ) and materials whose losses in that spectral region are also low leading to a near-zero-index (NZI). ENZs and NZIs increase light-matter interactions via the enhanced fields at the interface between the ‘normal’ and ENZ materials, the “slow-light” effects and relaxed phase matching conditions. One important class of novel ENZ/NZI materials is transparent conducting oxides (TCOs) whose low-losses and high-tunability have made them a leader in ENZ-enhanced nonlinear optics like Kerr-nonlinearities^{1,2} and frequency generation³. More recently, transparent conducting oxides have pioneered ultrafast optically-modulated nonlinear optics opening the door to exotic time-varying media phenomena such as negative refraction^{4,5}, time refraction^{6,7}, time reflection, and photonic time crystals^{8–10}.

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Biographical notes:

Vladimir M. Shalaev, Scientific Director for Nanophotonics at Birck Nanotechnology Center and Distinguished Professor of Electrical and Computer Engineering at Purdue University, specializes in nanophotonics, plasmonics, optical metamaterials and quantum photonics. Prof. Shalaev has received several awards for his research in the field of nanophotonics and metamaterials, including the APS Frank Isakson Prize for Optical Effects in Solids, 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, IEEE Photonics Society William Streifer Scientific Achievement Award, Rolf Landauer medal of the ETOPIIM (Electrical, Transport and Optical Properties of Inhomogeneous Media) International Association, the UNESCO Medal for the development of nanosciences and nanotechnologies, and the OSA and SPIE Goodman Book Writing Award. He is a Fellow of the IEEE, APS, SPIE, MRS and OSA.