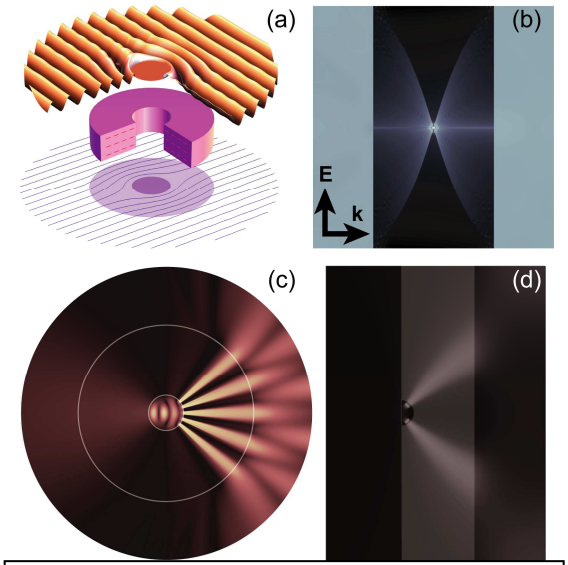
Transformation Optics with Metamaterials: A New Paradigm for the Science of Light

Vladimir M. Shalaev
School of Electrical and Computer Engineering and Birck Nanotechnology Center
Purdue University



Transformation optics devices: a): cloak, b): light concentrator, c): impedance-matched hyperlens, and d): planar hyperlens

One of the most unique properties of light is that it can package information into a signal of zero mass and propagate it at the ultimate speed. It is, however, a daunting challenge to bring photonic devices to the nanometer scale because of the fundamental diffraction limit. Metamaterials can focus light down to the nanoscale and thus enable a family of new nanophotonic devices. Metamaterials, i.e. artificial materials with rationally designed geometry, composition, and arrangement of nanostructured building blocks called meta-"atoms," are expected to open a gateway to unprecedented electromagnetic properties and functionalities that are unattainable with naturally occurring materials. We review this exciting and emerging field and discuss the recent, significant progress in developing metamaterials for the optical part of the electromagnetic spectrum. Specifically, we report on our recent world's smallest nanolaser, describe the phenomena of artificial magnetism across the whole visible and negative refractive indices in the optical range and discuss the promising approaches and central challenges in realizing optical cloaking. A new, powerful paradigm of engineering space for light with transformation optics will be also discussed.