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Semiconductor Hyperbolic Metamaterials for the Mid-Infrared

DONGXIA WEI, University of Delaware, CHRISTIAN HARRIS, Lincoln University, CORY BOMBERGER, JING ZHANG, JOSHUA ZIDE, STEPHANIE LAW, University of Delaware — Hyperbolic metamaterials have shown great promise for controlling light in the visible spectral range. However, moving metamaterials to the infrared is not just a matter of scaling geometries, but also of choosing new materials with appropriate optical properties. We demonstrate infrared hyperbolic metamaterials with optical properties tunable across the mid-infrared created from semiconductor superlattices grown by molecular beam epitaxy. The metamaterials are made of alternating subwavelength layers of metal (doped semiconductor) and dielectric (undoped semiconductor). By tuning the doping density, layer thicknesses, and metal:dielectric thickness ratio, we can control the onset and bandwidth of metamaterial behavior across the infrared. Our materials exhibit low optical losses as well as high sample uniformity and sharp interfaces. Transmission and reflection properties of the samples are studied by Fourier transform infrared spectroscopy and modeled with effective medium theory. We will also show the results from a beam optics experiment which demonstrates that our materials exhibit negative refraction.

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