

MAR05-2004-000196

Abstract for an Invited Paper
for the MAR05 Meeting of
the American Physical Society

**Negative Refraction, Left-Handed Materials and Heterostructures in Guided Wave Electronics Using
Metamaterials and Nanostructures**
CLIFFORD KROWNE, Naval Research Laboratory

A number of remarkable discoveries which are connected to each other have been made in the general subject area of negative refraction in guided wave structures. This triad of discoveries is (1) the unusual electromagnetic field distributions and dispersion diagrams of guided waves [1] in monolithically compatible structures containing left-handed intrinsic materials, which show electric field lines and magnetic circulation patterns never before seen; (2) heterostructure arrangements of uniaxial bicrystals [2] have been discovered to produce electromagnetic fields with asymmetric distributions in guided wave structures; (3) a frequency band exists where propagation using SRR metamaterials [3] is essential lossless. Finding (1) opens up the possibility of creating new electronic devices because of the reconfiguration of the field distributions. Finding (2), based upon the property of broken crystal symmetry of the $SO(2)$ rotation group, offers the possibility of all electronic nonreciprocal devices, something not possible in the last fifty years because of the microwave community's reliance upon the ceramic spin precession physical operation of ferromagnetic materials. Finding (3), using the concepts of effective parameters like rescaled plasma frequencies with direct carrier density dependence removed or severely mitigated, using the associated magnetic and electric linewidths, can have miniscule loss with dispersion in a finite frequency band for the potentially highly dispersive and lossy split ring-rod assemblies employed as unit cells. The theoretical modeling is done analytically and numerically to obtain all of these results, with simulations completed in the microwave and millimeter wavelength regimes, from 5 to 105 GHz using an ab initio anisotropic Green's function solver. [1] C. M. Krowne, "Physics of Propagation in Left-Handed Guided Wave Structures at Microwave and Millimeter Wave Frequencies," Phys. Rev. Letts 92, 053901, Feb. 3, 2004. [2] C. M. Krowne, "Negative Refractive Bicrystal with Broken Symmetry Produces Asymmetric Electromagnetic Fields in Guided-Wave Heterostructures," Phys. Rev. Letts. 93, 053902, 29 July 2004. [3] C. M. Krowne, "Guided Wave Propagation in Left-Handed Microstrip Structure Using Dispersive SRR Metamaterial," submitted PRL Aug. 2004.