MAR05-2004-004321

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

Bicrystals Allow Negative and Total Refraction of Electronic and Optical Waves[1]

YONG ZHANG, National Renewable Energy Laboratory, 1617 Cole Blvd., Golden, CO 80401

Recently the so-called left-handed medium (LHM)[1,2] has attracted a great deal of interest primarily for these two reasons: one is that a LHM, when interfaced with a matched right-handed medium (RHM), is able to show an interesting phenomenon – total and negative refraction of light[2], which is generally believed not possible if only the RHMs are involved; and the other one is the that such total and negative refraction may lead to a very exciting application – superlensing[3]. Negative refraction or bending has indeed been experimentally demonstrated in a number of ways, but it is typically limited in the spectral region of the microwave and with significant loss[4]. Furthermore, it has now been realized that superlensing can at best be realized under certain extreme conditions. Thus, realistically, what a LHM can offer is a subwavelength resolution[4], which is nevertheless readily achievable using a RHM (e.g., a so-called solid-immersion lens)[5]. One would like to ask: can the phenomenon of total and negative refraction be achieved without using a LHM? Besides the subwavelength resolution, are there any other novel applications for this phenomenon? We will firstly compare different approaches that have been used or proposed for achieving total and negative refraction in terms of their underlying physical mechanisms, then, focus on its realization in a bi-crystal structure[6]. In the bi-crystal approach, none of the components of the permittivity (ε) and permeability (μ) tensors is required to be negative. The effect relies purely on the dielectric anisotropy in anisotropic RHMs. This approach has offered an experimental demonstration of negative refraction yet with negligible (extrinsic) loss, and it is in principle applicable for any frequency of electromagnetic waves and even for ballistic electrons in semiconductors. A few interesting applications will be discussed for both electrons and light. [1].V. M. Agranovich and V. L. Ginzburg, *Spatial dispersion in crystal optics and the theory of excitons*(1966);V. M. Agranovich, et al., PRB**69**,165112(2004). [2]V. G. Veselago, Sov. Phys. Usp.**10**,509(1968). [3]J. B. Pendry, PRL**85**,3966(2000). [4]J. B. Pendry and D. R. Smith, Physics Today**57**,37(2004). [5]I. Ichimura, et al., Appl. Opt.**36**,4339(1997). [6]Y. Zhang, et al., PRL**91**,157404(2003).

[1]In collaboration with B. Fluegel and A. Mascarenhas