MAR12-2011-002677

Abstract for an Invited Paper
for the MAR12 Meeting of
the American Physical Society

Low-loss multilayered metamaterial exhibiting a negative index of refraction at visible wavelengths[1]

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Over the last decade, metamaterials have attracted a great interest thanks to their potential to expand the range of electromagnetic properties found in natural materials. In particular, the possibility of achieving negative refractive index media (NIM) enables us to implement superlenses and optical storing devices. Since the first experimental demonstration at microwave frequencies, much effort has been put in extending negative refraction to the visible spectrum, where we can take full advantage of NIM properties. For instance, the superior imaging ability of NIM would be essential for visible microscopy. The desired features for NIM are low loss and isotropy. This last property includes polarization independence and negative-index behavior in all spatial directions. None of these features have been attained in previous experiments. Thus, the current challenge is to improve such aspects in order to make NIM suitable for practical applications. In this work, we experimentally demonstrate a low-loss multilayer metamaterial exhibiting a double-negative index in the visible spectrum, while presenting polarization independence at normal incidence. This has been achieved by exploiting the properties of a second-order magnetic resonance of the so-called fishnet structure, in contrast to previous works that used first-order magnetic resonances, both related to gap surface plasmon polariton (SPP) modes. The low-loss nature of the employed magnetic resonance, together with the effect of the interacting adjacent layers, results in a figure of merit as high as 3.34. A wide spectral range of negative index is achieved, covering the wavelength region between 620 and 806 nm with only two different designs. The fabricated metamaterials are the first experimental multilayer NIM in the visible spectrum, which entails an important step towards homogeneous NIM in this range. Finally, we found that the SPP modes determining the permeability resonance display weak angular dispersion.

[1]Financial support by the Spanish Ministerio de Ciencia e Innovacion (contract CSD2008-00066 and FPU grant) is gratefully acknowledged.