Plasmonic-polaritonic Photonic-prystal Superlattices as Left-handed Metamaterials

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Left-handed metamaterials come in two basic types, namely those based on purely dielectric periodic structures, or as periodic metallic microstructures exhibiting electric and magnetic resonances [1]. The purely dielectric metamaterials are characterised by rather low wavelength-to-structure ratio (typically less than 2:1). On the other hand, the metamaterials based on metallic microstructures, the most prominent example of which are those consisting of split ring resonators (SRRs) and wires, are truly subwavelength structures with wavelength-to-structure ratio at least 5:1. Here, we present a new set of artificial structures which can exhibit a negative refractive index band in excess of 6% in a broad frequency range from deep infrared to terahertz range [2]. The structures are composites of two different kinds of non-overlapping spheres, one made from inherently non-magnetic polaritonic and the other from a Drude-like material. The polaritonic spheres are responsible for the existence of negative effective magnetic permeability whilst the Drude-like spheres are responsible for negative effective electric permittivity. The resulting negative refractive index structures are truly subwavelength structures with wavelength-to-structure ratio 14:1, which appears almost by 50% higher than it has been achieved so far. Our results are explained in the context of the extended Maxwell - Garnett theory [3] and reproduced by the calculations based on the layer Korringa-Kohn-Rostoker method, an ab initio multiple scattering theory [4, 5].

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