Paweł Zięba et al., J Material Sci Eng 2016, 5:9(Suppl)
http://dx.doi.org/10.4172/2169-0022.C1.052

New types of composite metamaterials

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All of the proposed designs of metamaterials are characterized by ever-increasing sophistication of fabrication methods. We propose a comparatively simple recipe for the fabrication of a metamaterial, which is both gyrotropic and of the simultaneously negative permittivity and permeability. The idea is to make a mixture of three ingredients, where one of them would be responsible for the negativity of μ, while the other two would be responsible for the negativity of ε. The first component of the mixture is the "Swarm" of single-domain ferromagnetic nanoparticles, immersed in a mixture of other two, silver and mercury cadmium telluride (MCT). The choice of silver is determined by the fact, that as it was shown, the permittivity of a mixture of silver and a dielectric material can be negative in some frequency domain. In addition, silver is a diamagnetic material. It means that considering the "Swarm" of single–domain ferromagnetic nanoparticles suspended in a mixture containing silver, we can neglect the interaction between their magnetic moments and treat the whole mixture as superparamagnetic. The choice of MCT is determined by the remarkable dependence of its energy gap on the fraction of cadmium in the compound. In its turn, it leads to the strong dependence of the electron concentration on this fraction as well as on the temperature. It enables to adjust each of the two frequency domains, where $\varepsilon<0$ and $\mu<0$ and makes them simultaneously negative. Similar dependence on the electron concentration exhibits $Pb_{1-x}Sn_xTe$. By carrying out the computer simulations, the domains where metamaterial to exist, relative to all parameters characterizing the model, that is, the temperature, external magnetic field, parameters of nanoparticles and the fraction of cadmium in MCT as well as the fraction of tin in $Pb_{1-x}Sn_xTe$ and relative concentrations of the mixture components are established.

Biography

Paweł Zięba is an Assistant Professor in University of Rzeszow, Poland. He has completed MSc in Physics, Pedagogical University in Rzeszów and PhD in Physics from University of Rzeszów. His research interests are methods for terahertz radiation generation, analysis and design of met materials, optical processing of information and holography.

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