DEVELOPMENT OF A DOUBLE-SIDED "IDEAL" ABSORBER OF MICROWAVE AND THZ WAVES BASED ON METAMATERIALS AND METAL-POLYMERIC POLYDISPERSE LAYERS

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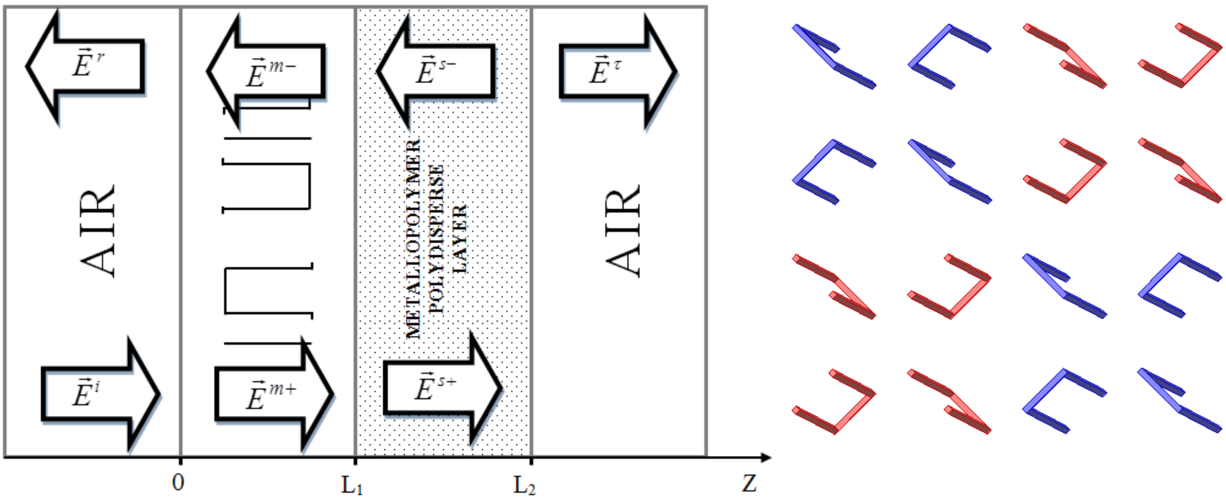
In recent years the artificial structures of bianisotropic elements have been actively studied. In such materials, along with the electric anisotropy, there might be magnetic anisotropy, as well as a magnetoelectric coupling. Scientists show particular interest to planar layered structures. Planar layered structures, in which anisotropic materials of various nature (dielectrics, semiconductors, conductors, magnets, liquid crystals, composite materials) are used, have got widespread practical applicability in optoelectronics. Filters that allow to pass or reflect the selected spectral regions; low-reflection coatings; converters of optical radiation controlled by external electric or magnetic field; thin-film magnetic storage devices, the information from which is derived with the help of the magneto-optical Kerr effect; planar waveguide structures and integrated optical elements serving to process optical information and control radiation – all these have been produced on the basis of such structures. But of late layered structures of bianisotropic materials have been widely studied. They might have magnetic anisotropy as well as a magnetoelectric coupling in addition to the electric anisotropy. The magnetoelectric coupling is expressed in the presence of cross terms in the material equations for electric and magnetic fields. In other words, under the influence of the electric field of the incident wave, magnetic moments can be induced in such structures, and vice versa, under the action of the magnetic component of the incident radiation, electric dipole moments in the structure can be induced. Bianisotropic materials are represented by electro- and magneto-optical crystals, liquid crystal, composite and optically active media. In connection with this, the problems, describing the propagation and transformation of electromagnetic waves in layered structures with various types of bianisotropy, are current and topical. Metamaterials are artificial structures consisting of periodic arrays of electrically small elements with arbitrary electromagnetic properties and shape. Varying the properties of such elements, you can adjust the macroscopic parameters of the entire structure.

We plan to develop and create a metamaterial that has low reflection and almost complete absorption of microwave and THz waves during their incidence on a metamaterial from one or both sides. Omega elements of classical or rectangular shape are offered to be used as elements of the metamaterial. Equally significant an electric dipole moment and a magnetic moment are induced in each omega element under the influence of an electromagnetic wave. Therefore, the metamaterial, produced on the basis of optimal omega elements, shows not only dielectric, but also magnetic properties. Near the resonance frequency relative permittivity and relative permeability of the metamaterial are approximately equal. This equality ensures the matching of the input impedance of the metamaterial with the wave impedance of free space, i.e. the absence of a reflected wave. The advantage of optimal omega elements is their equally effective activation by both electric and magnetic fields. In addition, the optimal properties of omega elements are shown not only in external fields, but also in their mutual influence. Therefore, the necessary properties of the metamaterial will be maintained even with a high concentration of elements. Previously, we showed the possibility of significant absorption of electromagnetic radiation using a metamaterial containing omega elements of a rectangular shape, but in this paper, in order to achieve maximum absorption, in addition to omega-structured metamaterials we suggest using a metallopolymer polydisperse layer with significant absorption. As a result of passing through all the layers of such structure (two-or three-layer), including repeated passing through an omega-structured metamaterial, the electromagnetic wave will be completely absorbed, and the wave reflection will not take place. In this absorber, the metamaterial performs two roles: 1) matching the input impedance of the structure with the impedance of free space, which results in the absence of wave reflection at the air-metamaterial boundary; 2) waves absorption in the metamaterial layer, including waves reflected from the boundary "metamaterial - metallopolymer polydisperse layer". The polymer layer, in its turn, has the function of an absorber of electromagnetic waves with a controlled frequency bandwidth of



a b

the absorption band (Fig.1).

Fig. 1. a – the structure consisting of a metamaterial containing omega-elements of a rectangular shape, and a metallopolymer polydisperse layer having a significant absorption;
b – the geometry of the location of the rectangular omega-shaped inclusions in a metamaterial

We solved the boundary problem for a structure consisting of a metamaterial containing omega-elements of a rectangular shape and a metallopolymer polydisperse layer (Fig. 1), which has a significant absorption and serves as a substrate. An analytical calculation of the transmittance and reflection coefficients of an electromagnetic wave from such a structure is carried out. It is shown that the metamaterial and the absorbing substrate, when used together, lead to a stronger absorption of the transmitted and reflected electromagnetic wave and, consequently, to a decrease in the transmission and reflection coefficients at the resonant frequency.

Optimal parameters of an omega-element of a rectangular shape are calculated. Subsequently, the reflection and transmission coefficients of electromagnetic waves for a two- or three-layer sample containing omega-structured metamaterials and a metallopolymer polydisperse layer will be determined. The scientific novelty is the design of samples based on metamaterials with omega elements and metal-polymer polydisperse layers that have the property of a single- or double-sided "ideal" absorber in the microwave and THz bands. The modeling and production of experimental samples of metamaterials that have the property of an "ideal" absorber are planned.

The application field of the obtained results is the microwave electromagnetics. The results can be used for theoretical and experimental studies of artificial composite media with inclusions of various shapes. The developed technique will allow to predict the behavior of new complex composite materials and to investigate the electromagnetic properties of such media. The studies that have been carried out will allow turning to manufacturing of experimental samples of new artificial metamaterials and the development of theoretical bases of new types of frequency filters, converters of polarization and deflectors of electromagnetic waves on the basis of composite media with inclusions of the various form.

The results of the research will also be used in materials science while creating new radio absorbing materials and coatings (as experimental samples) that convert the energy of electromagnetic radiation on mechanisms of multi-level absorption, the use of which will solve urgent problems of electromagnetic safety, electromagnetic compatibility and engineering ecology.

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