Abstract

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Title: Active and Passive Elements of Microelectronics and Optics in Giga- and Terahertz Frequency Domains

The PhD thesis is devoted to study the active elements of microelectronics (generators) and passive elements of optics of metamaterials. The proposed generators as well as passive metamaterials could operate in giga- and terahertz frequency domains. In the first Chapter, the cooperative N^2-effect is considered, that results in emitting a radiation whose power is proportional to N^2, where N is the number of emitters, which in this case is equal to the number of electrons in a bunch traveling along the microstructure with grating (micro-undulator). The suggested effect originates from the combining of two others, namely Gunn-effect in gallium arsenide microstructure and undulator-like radiation which appears in the micro-undulator fabricated on the base of such structure. In the second Chapter, the modified microstructure was considered. It was shown that although the assumption concerning the initial correlations of electrons due to Gunn effect can be abandoned, one can still observe the N^2-effect, which this time is the result of interplay of the 'pumping wave' acting on the electrons due to micro-undulator field and the backward effect of radiation produced by electrons moving within such micro-undulator. As a consequence, the specific phase coherence (synchronization) develops in the ensemble of emitters and they start to generate as a single oscillating charge, while the power of emitted radiation becomes proportional to N^2. Both of these two effects can be used for the developing of a new semiconductor-based room temperature source of the GHz and THz-radiation. In the third Chapter of the thesis, a comparatively simple recipe for the fabrication of metamaterials, is proposed. This metamaterial is gyrotropic and of the simultaneously negative real parts of permittivity and permeability. The idea is to make a mixture of three ingredients, where one of them would be responsible for the negativity of real part of the permeability, while the other two would be responsible for the negativity of the permittivity. 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. It was shown in the thesis, that such metameterials can be produced in this way. By means of computer simulations, the domain of their existence, relative to all parameters characterizing the model, that is, temperature, external magnetic field, parameters of nanoparticles, and the fraction of cadmium in the Hg_xCd_xTe-compound as well as relative concentrations of the mixture components was established.