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Doctoral thesis summary

The doctoral thesis entitled: 'Diffractive, refractive and absorptive elements based on sub-wavelength periodic metallic structures' prepared by myself at the Information Optics Department of the University of Warsaw's Faculty of Physics relates to photonic structures containing metallic elements with the characteristic lengthscale smaller than the wavelength. For the optical range those shall be the photonic and plafsmofnic nanostructures, whilst for the terahertz range sub-wavelength metal gratings of various geometries were studied. The key results refer to one-way transmission of electromagnetic radiation from the THz range, as well as the properties of meta-materials built of multi-layers described using the effective medium theory model. For both the visible radiation range and THz, the structures were analysed using electromagnetic modelling, mainly with the Finite Difference Time Domain Method (FDTD).

The thesis is divided into six chapters. The first one contains an introduction and formulates its primary theses. In the second chapter there is an introduction into the researched field. It discusses the numerical methods used, terms related to the linear time-invariant systems as well as material dispersion models and effective medium approximation.

The next part of the paper is based on the author's original works analysing sub-wavelength sized systems intended for operating within various wavelength ranges. The third chapter discusses the shaping of electromagnetic waves within the THz range. Two types of structures are presented. The first one is used as an electromagnetic radiation antenna placed on detector based on a field transistor. Using the mechanism of exciting waveguide modes in the dielectric base, it is possible to bring about electromagnetic radiation from a large area of the antenna to the detector and to increase its effectiveness by doing so. The second one suggests the possibility of achieving asymmetrical transmission through systems based on two consecutive diffractive grating. The asymmetry of transmission complies with Lorenz's principle of reciprocity, therefore it cannot be used to construct a typical optical insulator. However, the presented results indicate the possibility of constructing one-way diffractive lens for THz radiation with the use of the system presented.

Chapters four and five refer to the simulation results carried out for the visible range wavelength. In chapter four, a proposal for the construction of a meta-material is presented which performs the functions of a perfectly matched layer. It contains the numerical calculation results for the multi-layer described using literature data on the dispersion of selected materials. It also presents the results of electromagnetic simulations for structures in flat as well as in cylindrical geometry in which the described structures are of core-shell type.

In chapter five, the thesis discusses non-diffractive light propagation through metallic-dielectric multi-layers. It presents the possibilities of structure optimization as well as potential applications for carrying out geometrical operations (e.g. projecting) on light beams significantly smaller than wavelength. The further simulation results are related to verification of the possibility of experimental usage of systems of such type, especially focusing on the requirements on the layer surface smoothness.

Chapter six is a summary. Within this chapter, there are references to the paper's theses and previous chapters which indicate they have been proven.