Artificial electromagnetic materials - new twist of light

We start with simple example that scatterometry technique is not new, since it has already been developed in microelectronics for dimensional measurements. The possible concept is that any change in the profile of diffraction grating is accompanied by the redistribution of light intensity between various spectral orders. From the other hand nowadays gratings can be considered as a particular type of the so-called artificial electromagnetic (EM) materials, e.g. photonic crystals, which are simply staggered spatially periodical one dimensional surfaces, or the so-called left-handed (negative index) materials. In the case of mentioned examples it is impossible to distinguish contributions of surface and volume light scattering processes. At the same time historically, the methods for the description of scattering from inhomogeneous (periodic) surfaces and volume dielectric media in the theory of multiple scattering of EM wave fields were developed independently. This disadvantage of the EM wave multiple scattering theory became especially evident now when a growing trend has appeared to study the resonance phenomena at light scattering by the artificial EM materials on the same unified footing. The crux of the problem is an energy transformation between propagating and evanescent (exponentially decaying or near-field) EM waves at scattering by dielectric structures. This problem has emerged in the studies of total internal light reflection on the boundary of two dielectric media and the interest to it has been stimulated nowadays by the development of near-field optics, where a scanning probe interacts with an optical near field.

In this report, a non-perturbative unified approach to the theory of multiple scattering of wave fields in two dimensional inhomogeneous media, the so called transfer relations' method, is applied to quantitative analysis of unique properties of the EM waves propagation through artificial materials.

In particular, we consider transmission/reflection spectra of diffraction grating and two dimensional photonic crystals composed of rods arranged in a lattice of some symmetry. Then we demonstrate that an opaque band in the transmission spectra is not destroyed even when filling fraction of volume occupied by rods as small as under half a percent and, hence, we construct practically from ñnothingò an optical filters or omnidirectional discrete dielectric reflectors. Besides, threadlike gratings promise developing the distant-spatial and interference-spatial spectroscopy of evanescent waves. Both these scenarios of evanescent wave spatial spectroscopy are related to the problem to access optical details beyond the diffraction limit.