Analysis of 2D photonic crystal slabs of any rod shape and conductivity using a very fast conical integral equation method

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The boundary-integral-equation-based method [1,2] has been used to calculate the sensitive optical response of 2D photonic crystal slabs (PCS), including dielectric, absorbing, and high-conductive rods of various boundary shapes. It turned out that a small number of collocation points per boundary combined with a high convergence rate can provide adequate description of the dependence on diffracted energy of multilayered band gaps illuminated at arbitrary incident and polarization angles. The numerical results presented demonstrate the significant impact of rod shape on diffraction in various PCS supporting polariton-plasmon excitation and other types of anomalies (i.e. waveguiding anomalies, cavity modes, Fabry-Perot resonances, Rayleigh orders), particularly in the vicinity of resonances and at high filling ratios. The diffracted energy response calculated vs. array cell geometry parameters was found to vary from a few percent up to a few hundred percent. Thus, the simple effective medium theory cannot be applied to design and analysis of such PCS.

A comparison of dispersion curves of metallic subwavelength PCS performed in the visible and near IR photon ranges revealed a very strong effect of nanowire form-factor and arrangement, both on the position and amplitude of the energy peaks inside the plasmon resonances. The rectangular profile of the rods appears to be most sensitive out of the shapes considered, because of its low symmetry and strong dependence on absorption. The code developed and tested for different types of PCS is found to be very accurate and fast and applicable to studies of complex periodic structures, including almost perfectly-conductive rods, inclusions with edges, and multilayer gratings with any boundary profiles operating with arbitrary incident radiation.

References

1. Goray L. I. and Schmidt G., 2010, Solving conical diffraction grating problems with integral equations, *J. Opt. Soc. Am. A*, **Vol. 27,3**, pp. 585–597.

2. Goray L. I., 2009, Specular and diffuse scattering from random asperities of any profile using the rigorous method for x-rays and neutrons, Proc. of *SPIE*, **Vol. 7390**, pp. 73900V-1–11.