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Numerical simulation on photonic-crystals

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A non-uniform dielectric material with a translational invariance in space is a photonic crystal. By creating an ad-hoc defect to break that order locally, it allows to control the propagation of an electromagnetic wave.
We have extended a numerical approach which allows the simulation of the behavior of bi-dimensional photonic-crystals, with or without defects, through the plane wave expansion method. The numerical code has been optimized to improve the numerical convergence in getting the results, thanks to a correct implementation of the Fourier series of the product of functions with complementary discontinuities[1].
In fact, to increase the numerical convergence, one has to consider the physical continuity of the electric field components of the electromagnetic wave in each boundary between different dielectric materials[2,3] .
That improvement could be useful to face the simulation of dielectric crystals with a particular property (for example with extremely flat bands). A potential application could be the simulation of bi-dimensional photonic-crystals with linear defect embedded in waveguide structures, which are interesting as photonic biosensors due to their enhanced sensitivity to refractive index alterations induced by bio-molecules.

References

1. L. Li, Use of Fourier series in the analysis of discontinuous periodic structures, Journal of the Optical Society of America A 13 (1996) 1870 .

2. E. Popov e M. Nevière, Grating theory: new equations in Fourier space leading to fast converging results for TM polarization, Journal of the Optical Society of America A 17 (2000) 1773.

3. A. David, H. Benisty e C. Weisbuch, Fast factorization rule and plane-wave expansion method for two-dimensional photonic crystals with arbitrary hole-shape, Physical Review B 73 (2006) 075107.