Coherent-potential-approximation Multiple-scattering Scheme for the Study of Photonic Crystals with Substitutional Disorder

V. Yannopapas
University of Patras, Greece

Photonic crystals of spherical scatterers have been theoretically studied using the the layer Korringa-Kohn-Rostoker (LKKR) method [1, 2] which is ideally suited for the calculation of the transmission, reflection and absorption coefficients of an electromagnetic (EM) wave incident on a composite slab consisting of a number of planes of non-overlapping particles with the same two-dimensional (2D) periodicity. For each plane of particles, LKKR calculates the full multipole expansion of the total multiply scattered wave field and deduces the corresponding transmission and reflection matrices in the plane-wave basis. The transmission and reflection matrices of the composite slab are evaluated from those of the constituent layers. In this study we present a photonic version of the coherent-potential approximation (CPA) [3, 4] for the study of photonic crystals with substitutional disorder (photonic alloys) within the LKKR context. The CPA method has been extensively used in the study of the electronic properties of disordered atomic alloys [5, 6] and is expected to give reasonably good results at least in the case of moderate disorder. It is the best approach for studying the properties of a disordered photonic crystal by means of substituting it with an effective periodic one whose properties correspond, on the average, to those of the actual disordered photonic crystal. The CPA-LKKR method is applied to case of dielectric photonic crystals of both cermet, i.e., opals, and network topology, i.e., inverted opals, as well as to the case of metallo-dielectric photonic crystals in order to determine an effective permittivity in the long-wavelength limit. The method is also used for the calculation of the transmission/ reflection and absorption coefficients of light incident on finite slabs of disordered photonic crystals.

REFERENCES

1. Stefanou, N., V. Yannopapas, and A. Modinos, "Heterostructures of photonic crystals: frequency bands and transmission coefficients," *Comput. Phys. Commun.*, Vol. 113, No. 1, 49–77, 1998.
2. Stefanou, N., V. Yannopapas, and A. Modinos, "MULTEM 2: A new version of the program for transmission and band-structure calculations of photonic crystals," *Comput. Phys. Commun.*, Vol. 132, No. 1–2, 189–196, 2000.
3. Stefanou, N. and A. Modinos, "Scattering of electromagnetic waves by a disordered two-dimensional array of spheres," *J. Phys. Condens. Matter*, Vol. 5, No. 47, 8859–8868, 1993.
4. Modinos, A., V. Yannopapas, and N. Stefanou, "Scattering of electromagnetic waves by nearly periodic structures," *Phys. Rev. B*, Vol. 61, No. 12, 8099–8107, 2000.
5. Phariseau, P., B. L. Györffy, and L. Scheire (editors), *Electrons in Disordered Metals and at Metallic Surfaces*, Plenum, New York, 1979.
6. Gonis, A., *Green Functions for Ordered and Disordered Systems*, North-Holland, Amsterdam, 1992.