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MODELING OF PHOTONIC BANDGAP (PBG) DEVICES USING MRTD ADAPTIVE SCHEMES

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Photonic crystals are periodic dielctric or metallic materials that have the property to forbid the propagation for the electromagnetic waves whose frequency is included within their frequency bandgap. This frequency bandgap depends on the permittivity of the dielectric materials used, their dimensions, their periodicity, and the incidence angle of the electromagnetic waves. Another well-known characteristic of these periodic structures is the ability to excite localized electromagnetic modes inside the frequency gap by introducing defects in the periodic lattice. Initially, the PBG materials were employed in optical applications, such as high-quality optical mirrors or microcavities. Lately, there has been a growing interest in the antenna domain, especially in the area of patch antennas with enhanced directivity.

Various numerical techniques in time- and frequency-domain are used now-a-days for the modeling of Photonic Bandgap (PBG) materials. The finite-difference-time-domain (FDTD) scheme is one of the most powerful and versatile time-domain techniques, but it requires very substantial computer resources in order to model such electromagnetic problems with medium or large computational volumes. In addition, the fine detail of the multiple dielectric interfaces as well as the non-orthogonal shape of the periodic perturbations augment further the memory requirements.

On the contrary, MRTD (MultiResolution Time Domain Method) has demonstrated similar qualities to FDTD in 2D and 2.5D applications, while reducing significantly the computational requirements. The two-fold MRTD field expansion in scaling and wavelet functions with respect to time/space allows for the accurate modelling of smoothly-varying fields (scaling functions), while in regions characterized by strong field variations or field singularities, higher resolution is achieved through the use of multiple resolutions of wavelets. In this way, time and space adaptive grids can be developed by using local thresholding for the wavelet coefficients. In addition, the fact that the constitutive relationships can be sampled using Galerkin's technique leads to the efficient numerical implementation of grid cells containing more than one dielectrics with arbitrary shapes. Thus, any memory constraints due to the details of dieletric regions play no significant role in the MRTD simulations. In this presentation, the extension of Haar-based MRTD technique to 3D will be presented and results describing the frequency characteristics of various PBG structures will be demonstrated for a variety of geometrical and dielectric characteristics.