EFFICIENT AND ACCURATE TECHNIQUES TO SIMULATE ELECTROMAGNETIC CRYSTALS

Femke Olyslager[1], Davy Pissoort[1], Jan Fostier[1]
, Ignace Bogaert[1], Jurgen De Zaeytijd[1], Eric Michielssen[2]
[1]Department of Information Technology, Ghent University, Belgium
[2]Electrical Engineering and Computer Science, University of Michigan

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In the optics community electromagnetic crystals (ECs) are usually simulated with FDTD. This technique is prone to phase errors and it was our purpose to develop accurate full-wave frequency domain techniques that are sufficiently fast.

In first instance we focused on two-dimensional problems consisting of a number of circular dielectric cylinders embedded in a host medium which were simulated by an angular Fourier decomposition of the field around each cylinder combined with a multiple scattering technique. In order to reduce the simulation time and memory consumption this was augmented by the MLFMA. To reduce the number of iterations different preconditioners were investigated. To simulate semi-infinite length EC waveguides, that excite the structure, a technique was developed to simulate this by a truncated finite length waveguide by continuing a few periods in the complex plane. To simulate an EC consisting of a number of cylinders omitted in an otherwise infinite periodic crystal a technique was developed to limit the unknowns to those corresponding to the omitted cylinders and to obtain immediately a very sparse interaction matrix that allows extremely fast simulations in the band gap. The technique was also extended to simulate a finite thickness dielectric slab pierced by a number of cylindrical holes. To take into account the radiation out of the plane of the slab a PML based technique was established.

In a second approach the two-dimensional scattering problem was treated using a Huygens source based boundary integral equation, where each cylinder boundary was divided into a number of segments, hence allowing for the inclusion of non-circular cylinders as well. Again this was augmented with the MLFMA and a special preconditioner was used. To gain more speed on the lowest levels of the MLFMA an SVD was used to compactly represent the translation matrices. Simulations with tens of thousands of cylinders were easily performed.

The developed techniques clearly demonstrate the possibility to simulate very large EC devices accurately using limited computation resources.

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Femke Olyslager
Department of Information Tech
Ghent University
Sint-Pietersnieuwstraat 41
Ghent, B
B-9000 Belgium
femke.olyslager@intec.
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   (c) +32 9 2649969
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