Electric and Magnetic Dipole Modes Analysis of 3D Array of Two-Spheres Unit-Cell Configuration

Hossein Mosallaei and Shabnam Ghadarghadr
ECE Department, Northeastern University, Boston, MA, USA
hosseinm@ece.neu.edu

Metamaterials have a great interest in RF and Optical communities. The traditional approach for metamaterial realization has been based on the metallic ingredients unit-cells configuration. Recently, a novel approach for metamaterial development using all-dielectric particles was introduced (O. G. Vendik, *Proc. of 34th European Microwave Conference*, pp. 1209-1212, 2004). This has the advantages of being free of conduction loss, and potential for fabrication in both RF and Optical Spectrums.

To accomplish this idea, the array of unit-cells constructed from two different dielectric spheres, having different sizes or different materials, are considered. One sphere operates in the resonant electric mode and the other operates in the resonant magnetic mode. The metamaterial structure provides ($\pm\varepsilon,\pm\mu$) effective material parameters tailored to the application of interest. In this abstract, to provide a physical insight of the configuration, each sphere is considers as the pair of electric and magnetic dipole modes, and then the effects of all other spheres at the location of that sphere are calculated. From this, the electric and magnetic dipole modes coefficients are obtained through a rigorous analysis. The fast-convergence techniques are used to speed-up the analysis. Applying Floquet's theorem boundary condition for the periodic array of spheres allows determining the engineered dispersion diagram kd-βd.

From kd-βd diagram, the band-gap performance and the generation of forward and backward waves for several metamaterial configurations are highlighted. The possibility of using one set of highly-coupled spheres for the development of backward wave structure is explored. The physical phenomena of the designed structures are detailed. The proposed metamaterial have the potential for fabrication from RF to Optics.