Impedance Matched Anisotropic Media Interfaces for Controlling Electromagnetic Waves

Gurkan Gok and Anthony Grbic[(1)]
(1) Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI, USA

Transformation optics and alternative method presented in (G. Gok and A. Grbic, Phys. Rev. Lett. 111, 233904, 2013) have shown the use of inhomogeneous anisotropic media in the control of electromagnetic waves in arbitrary ways. These methods outlined how to tile blocks of anisotropic medium in the design of a medium that can control the electromagnetic waves in a reflectionless manner. In the latter method, these blocks of anisotropic media were shown to be impedance matched to each other under certain condition on their material parameters, while providing the desired phase transition and power flow through the designed medium. Indeed, through these conditions, the anisotropic medium blocks were guaranteed to be impedance matched to each other for all angle of incidences of electromagnetic waves through their planar interfaces.

In this presentation, we will have a close look at the electromagnetic wave interaction of two homogenous, lossless anisotropic media with a planar boundary. The conditions on the material parameters of these two media for a reflectionless transition of electromagnetic are identified. Furthermore, the general form of material parameters of anisotropic media that are impedance matched to each other for all angle of incidences are derived. The relationship is drawn between the material parameters presented herein and those observed in transformation optics method where the material parameters are derived through coordinate transformation. The analytical expressions are verified through full-wave simulations showing reflectionless refraction between two matched anisotropic media. A physical explanation for impedance matching of two anisotropic media for all angles of incidences is given based on the electric and magnetic polarization of the anisotropic medium.

This study helps elaborate the electromagnetic wave behavior at the interfaces of two matched media. The analysis provides an alternative perspective to explain the matching condition of transformation optics designs. Cascaded/tiled media with the matched anisotropic material, which can be implemented using metamaterials, can foster the design of inhomogeneous anisotropic media that can control electromagnetic waves without coordinate transformation.