Interaction of Electromagnetic Waves with Multilayer Bi-Anisotropic Graphene Structure

Si-Yi Wang[1], Tian Zhang[2], Wen-Yan Yin[2,1], and Liang Zhou[1]
[1]Center for Microwave and RF Technologies, Shanghai Jiao Tong University
Shanghai 200240, CHINA
[2]Centre for Optical and EM Research (COER), Zhejiang University
Hangzhou 310058, CHINA

Graphene is a two-dimensional version of graphite with the arrangement of single-atom-thick in a honeycomb form, and its electromagnetic properties strongly depend on its surface conductivity. As the graphene sheet is biased by either a static electric field E_{bias} or a magnetic field B_{bias}, its anisotropic surface conductivity ($\overline{\overline{\sigma}}$) can be expressed by a set of closed-form expressions at room temperature and below THz regime (R. Kubo, J. Phys. Soc. Japan, vol.12, no.6, pp.570-586, 1957; G.W.Hanson,J.Appl.Phys.,vol.103,p.064302,2008).

It is known that, based on the anisotropic surface conductivity model of the graphene sheet, an equivalent circuit model has been derived from the Maxwell's equations (G.Lovat, IEEE Trans. on Electromagn.Compat.,vol.54, no. 1, Feb. 2012). Such circuit model is implemented into the analysis of electrostatic biasing field-dependent transmission and reflection properties of the graphene sheet illuminated by a plane wave, which can provide some physical insights into the interaction of an electromagnetic wave with graphene structure.

On the other hand, it should be mentioned that the transmission and reflection properties of monolayer graphene sheet as well as multilayer graphene-dielectric structure at low-THz frequencies have been studied more recently (C. S. R. Kaipa, A. B. Yakovlev, G. W. Hanson, D. C. Skigin Phys. Rev. B 85, 245407, 2012), where the method of transfer matrix has been used. However, only the electrostatic biased situation is considered.

The purpose of this study is to further explore electromagnetic properties of composite multilayer bi-anisotropic graphene structure biased by a magnet statically or an electrostatic field. By utilizing the generalized transfer matrix approach as well as an improved FDTD method developed by ourselves, both transmission and reflection characteristics of the bi-anisotropic graphene-dielectric multilayer structure are captured over an ultra-wideband in the presence of an incident plane wave with an arbitrary polarization state and incident direction. It is numerically demonstrated that the transmission characteristics of such composite structure can be artificially controlled or adjusted, where double gyrotropies do exist and they have strong effects on the wave propagation.