World Academy of Science, Engineering and Technology
International Journal of Electrical and Information Engineering
Vol:12, No:07, 2018

Tunable Graphene Metasurface Modeling Using the Method of Moment Combined with Generalised Equivalent Circuit

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Abstract : Metamaterials crossover classic physical boundaries and gives rise to new phenomena and applications in the domain of beam steering and shaping. Where electromagnetic near and far field manipulations were achieved in an accurate manner. In this sense, 3D imaging is one of the beneficiaries and in particular Denis Gabor's invention: holography. But, the major difficulty here is the lack of a suitable recording medium. So some enhancements were essential, where the 2D version of bulk metamaterials have been introduced the so-called metasurface. This new class of interfaces simplifies the problem of recording medium with the capability of tuning the phase, amplitude, and polarization at a given frequency. In order to achieve an intelligible wavefront control, the electromagnetic properties of the metasurface should be optimized by means of solving Maxwell's equations. In this context, integral methods are emerging as an important method to study electromagnetic from microwave to optical frequencies. The method of moment presents an accurate solution to reduce the problem of dimensions by writing its boundary conditions in the form of integral equations. But solving this kind of equations tends to be more complicated and time-consuming as the structural complexity increases. Here, the use of equivalent circuit's method exhibits the most scalable experience to develop an integral method formulation. In fact, for allaying the resolution of Maxwell's equations, the method of Generalised Equivalent Circuit was proposed to convey the resolution from the domain of integral equations to the domain of equivalent circuits. In point of fact, this technique consists in creating an electric image of the studied structure using discontinuity plan paradigm and taken into account its environment. So that, the electromagnetic state of the discontinuity plan is described by generalised test functions which are modelled by virtual sources not storing energy. The environmental effects are included by the use of an impedance or admittance operator. Here, we propose a tunable metasurface composed of graphene-based elements which combine the advantages of reflectarrays concept and graphene as a pillar constituent element at Terahertz frequencies. The metasurface's building block consists of a thin gold film, a dielectric spacer SiO_2 and graphene patch antenna. Our electromagnetic analysis is based on the method of moment combined with generalised equivalent circuit (MoM-GEC). We begin by restricting our attention to study the effects of varying graphene's chemical potential on the unit cell input impedance. So, it was found that the variation of complex conductivity of graphene allows controlling the phase and amplitude of the reflection coefficient at each element of the array. From the results obtained here, we were able to determine that the phase modulation is realized by adjusting graphene's complex conductivity. This modulation is a viable solution compared to tunning the phase by varying the antenna length because it offers a full 2π reflection phase control.

Keywords : graphene, method of moment combined with generalised equivalent circuit, reconfigurable metasurface, reflectarray, terahertz domain
Conference Title : ICCEA 2018 : International Conference on Computational Electromagnetics and Applications
Conference Location : Rome, Italy
Conference Dates : July 23-24, 2018