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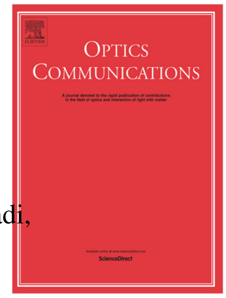

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Tunable Ultra-Wideband Terahertz Absorber Based on Graphene Disks and Ribbons

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Abstract

Terahertz frequency band has become one of the most interesting fields of research these days and the necessity of various modern applications in this area is THz absorbers. In this paper, we have proposed and investigated a novel ultra-wideband terahertz absorber by using periodic arrays of graphene disks and ribbons. Analytical circuit model of graphene arrays besides a developed transmission line theory is used to obtain analytical expressions for the input impedance of the proposed structure. The input impedance is adjusted to be closely matched to the free space impedance in a wide frequency range. Using three layers of patterned graphene, bandwidth of 90% absorption reached to 131% of central frequency. Regarding excellent performance of the proposed method in terms of computation time (showing more than 5 orders of magnitude reduction in runtime) and memory sources, this method with producing results with an acceptable agreement (with an error less than 5%) compared to the results of full-wave numerical modeling can be utilized in design of other graphene-based sub-wavelength devices.

Keywords— Graphene, Surface Plasmon Polariton, Terahertz, Absorber, Circuit model, Transmission line theory.

1. Introduction

Graphene, a two-dimensional layer of carbon atoms arranged in a honeycomb lattice, is drawing growing interest worldwide. Small dimensions, high electron mobility, low losses, and more importantly, tunable conductivity by manipulating the Fermi level via chemical doping or electrical gating are some of the unique optical properties of graphene [1-5]. Furthermore, due to the capability of graphene in supporting surface plasmon polariton-based absorption at THz frequencies, this material is one of the most suitable substances in designing THz absorbers [6–12]. Electromagnetic (EM) absorbers play a significant role in a wide range of structures and devices utilized in biosensing, imaging, and communications [13]. These highly efficient devices have been the subject of intensive research [14-22]. Until now, various configurations with different geometries have been reported including metal-dielectric multilayer composite [16], ring arrays [17], cascade metal-dielectric pairs [18], square graphene patch [19], and graphene stacks [20-21] structures. However, increasing their bandwidth and making their fabrication easier are still challenging tasks for researchers worldwide. Compared to other absorbers, graphene-based absorbers are tunable [9, 20] and can work at different frequencies without being refactored.

Absorption can be explained by means of circuit theory: a graphene layer is periodically patterned on a properly designed substrate, and the equivalent input impedance of the absorber structure is matched to the incident medium. So, the structure has no reflection. If the transmission channel is also closed, a perfect absorber will be realized. Circuit theory and the impedance matching concept have been used in [22, 23] to design perfect absorbers. Clearly, in these works, the circuit model which restricts the efficiency of the designing process has been obtained numerically. Also, some authors have used analytical circuit approaches to design narrow [24] or broad band [25] THz absorbers. In the broadband cases [16-18, 20-21, 25-28], the best achieved bandwidth of 90% absorption is