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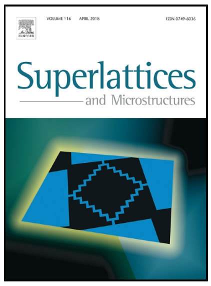

Radiation characteristics of Leaky Surface Plasmon polaritons of Graphene

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Radiation characteristics of Leaky Surface Plasmon polaritons of Graphene

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Abstract: High efficient coupling of graphene surface plasmons to far field radiation is possible by some techniques and can be used in the radiating applications. Besides of the coupling efficiency, the angular distribution of the radiated power is an important parameter in the radiating devices performance. In this paper we investigate the gain of the far field radiation related to the coupling of graphene surface plasmons via a high permittivity medium located close to the graphene. Our results show that high directive radiation and high coupling efficiency can be obtained by this technique and gain and directivity of radiation can be modified by graphene characteristics such as chemical potential and also quality of the graphene. Raising the chemical potential of graphene leads to increase the gain of the radiation as the result of amplifying the directivity of the radiation. Furthermore, high values of relaxation time lead to high directive and strong coupling which raises the maximum value of gain in efficient coupling angle. Tunable characteristics of gain and directivity in this structure can be important designing reconfigurable THz radiating devices.

Keywords: Graphene, Leaky Surface Plasmons, Radiation, Gain, Directivity

I. Introduction:

Surface Plasmon Polaritons (SPPs) are surface electromagnetic waves propagate along the interface of dielectric and materials with free electrons [1, 2]. Bound SPPs, which are the most studied in plasmonics literatures [2-5], are inherently non-radiative waves which trapped strongly near the interface and recognized by the field peaks at the interface and decays exponentially in perpendicular direction [5, 6]. However, in some special structures (mostly layered structures) the efficient coupling of SPPs into the free space radiating modes is possible through the satisfying of momentum matching conditions [7, 8]. As a result, SPP radiates its power into the space and forms a leaky mode which amplitude grows exponentially away from the boundaries [9]. Leaky SPP modes have been studied in some references [8-13] and an acceptable physical interpretation has been presented by Burke et al. in Ref. [10].

For decades noble metals have been used for SPP-based structures and devices [11, 14-19], however; recently ability of graphene in supporting surface plasmon polariton waves attracts considerable attentions [20-22]. Graphene which is a two-dimensional sheet of carbon atoms arranged in a honeycomb lattice has outstanding optical and electrical characteristics [23-25]. In the THz and infrared ranges of frequency, intraband contribution is dominant in the conductivity of graphene and doped graphene sheet is able to support TM polarized SPPs [22, 26, 27]. On the contrary of the metals, graphene surface plasmon polaritons (GSPPs) have low losses in the THz range of frequency and particularly, GSPPs characteristics are tunable via chemical and electrostatic techniques [28-30]. Due to its tunable properties, graphene has been attracted significant attentions in design and developing reconfigurable THz devices [31-38].

Recently graphene based leaky wave antennas (LWAs) have been extensively improved and have been attracted because of their reconfigurable features [35-41]. There are two challenges in excitation of leaky waves in these devices: the excitation of wave-guiding leaky modes [35, 36], and the excitation of leaky type GSPPs [38, 41]. One of the methods to coupling of GSPPs to far-field radiation is the periodic modulated conductivity of graphene which have been used in Ref. [38, 41]. In this method, as the result of