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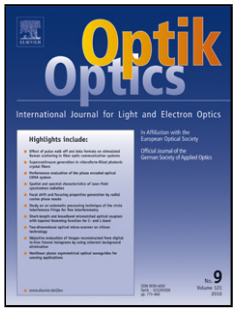

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PII: S0030-4026(18)31193-8
DOI: https://doi.org/10.1016/j.ijleo.2018.08.071
Reference: IJLEO 61368

To appear in:

Received date: 13-6-2018
Revised date: 12-8-2018
Accepted date: 18-8-2018

Please cite this article as: Zhou D, Wang X, Zhu H, Shen F, Graphene-based tunable multichannel filter with arithmetic sequence quasiperiodic structure, *Optik* (2018), https://doi.org/10.1016/j.ijleo.2018.08.071

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Graphene-based tunable multichannel filter with arithmetic sequence quasiperiodic structure

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Abstract: A tunable multichannel mid-infrared filter based on monolayer graphene is proposed and investigated. The optical transmission spectra are numerically simulated by the method of finite-difference time-domain (FDTD). The numerical results denote that the filtering properties can be tuned by the chemical potentials of graphene, the depth of the air trench, the temperature, and the quasi-period number of the structure. The numerical results are discussed by deducing the effective refractive index of surface plasmon polaritons (SPPs) propagating on the multilayered structure of air/graphene/dielectric and air/graphene/air/dielectric. This work can provide a method to design tunable multichannel filter with a single layer of graphene. Due to its tunability and miniaturization, the proposed structure can be found application in high speed integrated photonic circuit.

Key words: graphene; tunable; multichannel; FDTD; filter

1. Introduction

Surface plasmon polaritons (SPPs) are electromagnetic oscillations that propagate in the interface between dielectric and metal. SPPs are localized electromagnetic modes [1] which are confined in the interface [2], whereas SPPs are attenuated exponentially in the vertical direction of propagation. SPPs are studied in various fields such as photo detectors [3, 4], reflectors [5, 6], optical switches [7] and filters [8, 9]. The SPPs in noble metals have favorable performances in the frequency regions from the visible to near-infrared, but they have large Ohmic losses in mid-infrared frequency range.

In the last decades, a lot of experiments have proved that graphene has unique electrical and optical characteristic [10-12]. A single layer graphene has superior properties such as the extreme confinement, high carrier mobility, low Ohmic losses, dynamic tenability and a relatively large conductivity in the mid-infrared region. Graphene can strongly enhance light–matter interactions and support both TE and TM modes contrast to the noble metal only supporting TM-type surface wave [2]. Meanwhile, the size of the photo devices based on monolayer graphene is very tiny [13]. The optical relaxation time of graphene is large, so it can support a long propagation distance [14]. The wave vector of the graphene SPPs is nearly 100 times higher than that in free space [15], and the confinement performance of graphene SPPs is excellent. Due to these remarkable properties, graphene has been considered a good material for plasmonic application in the mid-infrared and far-infrared frequency regions. Recently, graphene SPPs attract a lot of attention, and someoptoelectronic switching devices and filters are designed with graphene SPPs [16, 17].

In this paper, we propose and simulate a tunable multichannel filter based on monolayer graphene. As we know, the periodic arrangement of ‘A material’ and ‘B material’ with different refractive index can be used as one-dimensional photonic crystal (1D PC) to achieve band-pass filter. Our quasiperiodic filter is just an imitation of this 1D PC structure. The quasiperiodic stacks of plasmonic graphene-InSb

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