Polarization independent optical modulator in integrated waveguide with graphene

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Abstract
Several researches have been performed using graphene as active element to the development of optoelectronic devices [1, 2]. Graphene's electronic and optical properties, such as the absence of a band gap and the electronic linear dispersion nearby the Dirac point have been exploited for the development of integrated optical modulators [3] using graphene embedded in waveguides. However, the demonstrated devices are highly polarization dependent for TE- [4] or TM-modes [5]. In graphene-waveguide structures, such polarization dependence occurs because optical absorption in graphene takes place only for the fraction of the electric field parallel to graphene's plane, and because this fraction is generally different for transverse-electric (TE) and transverse-magnetic (TM) radiation as function of the waveguide design [6]. In this work, a graphene integrated waveguide modulator insensitive to the optical polarization state is designed in which numerical simulations were performed to determine the waveguide dimensions, materials, and graphene doping level to obtain an optimized modulator capable of polarization independent operation in the TE and TM modes. Analysis of the modulator extinction ratio, frequency response, and gate voltage, taking into account the dielectric breakdown field, were performed. The optimization was carried through analytical modeling and numerical simulations using the software *COMSOL.* The modulator design is shown in the Figure 1(a) and, the Figure 1(b) shows the modulation depth as function of dielectric thickness for both polarizations, TE and TM-modes. As a result, TM mode is highly dependent of dielectric thickness and considering 79.87 nm, it is possible to obtain a polarization insensitive point that shown a modulation depth of 45 dB/mm. At this point, for a modulation depth of 10 dB the frequency response is 7.89 GHz.

References:
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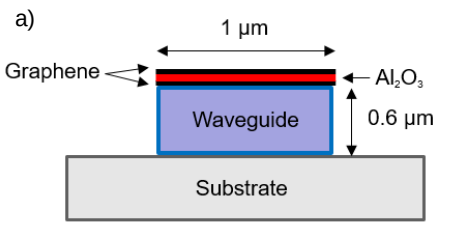
Figures



	Material	Er	n
Substrate	SiO_2	2.07	1.44
Waveguide	SiN	4.00	2.00
Dielectric	Al_2O_3	2.69	1.64

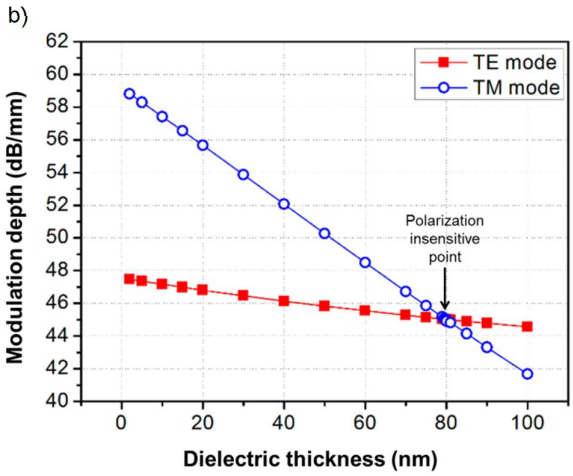


Figure 1: (a) Waveguide setup and parameters. (b) Relation between modulation depth for TE and TM modes (for TE equal TM, the modulator is polarization insensitive).

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