Polarization independent PAM4 optical modulator in an integrated waveguide with graphene

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Abstract

The novelty of this work is to present an optimized PAM4 (Pulse Amplitude Modulation, a multi-level amplitude modulation which encodes two bits per symbol) graphene integrated waveguide modulator insensitive to the optical polarization state. Integrated optical devices based on graphene-waveguide structures are usually highly polarization dependent for TE or TM-modes [1], however such dependency is controllable as function of the waveguide design [2]. Numerical simulations by finite element method is used to determine the waveguide dimensions, materials, and graphene doping level. Analysis of the modulation depth, frequency response, and gate voltage, taking into account the dielectric breakdown field, were performed. The modulator designed for the maximum frequency operation is shown in the Figure 1(a). Figure 1(b) consists of a waveguide with two capacitor-like segment graphene structure [3], corresponding to the MSB (Most Significant Bits) with 70 μm length and LSB (Least Significant Bits) with 35 μm, that modulate the optical signal with binary driven voltages of 28 Volts in four levels and reaching 6 dB modulation depth. Figure 2 shows the modulation depth and frequency response as a function of waveguide height for a polarization insensitive device. As a result, for waveguide height equal 0.525 μm and dielectric thickness equal 69.7 nm, it is possible to obtain a frequency response of 19.4 GHz and bit rates higher than 50Gbps with polarization independent operation in the TE and TM modes.

References

[1] G. Kovacevic and S. Yamashita, Frontiers in Optics/Laser Science, FTh2B.3 (2015).

[2] R. E. P. de Oliveira and C. J. S. de Matos, Sci. Rep. 5, 16949 (2015).

[3] M. M. de Carvalho et al., p. 30, Graphene 2016.

Figures

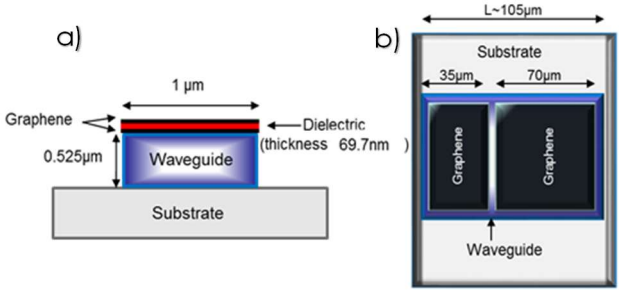

Figure 1: Modulator setup and parameters: a) Frontal view and b) Up view. Substrate SiO_2 (η = 1.44), waveguide SiN (η = 2) and dielectric (η = 1.64).

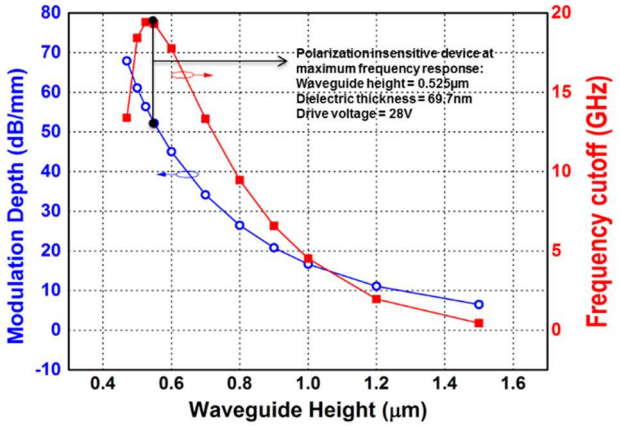

Figure 2: Relation between modulation depth and frequency cutoff versus waveguide height for polarization insensitive modulator.

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