Broadband Double layer Graphene Switch Integrated on Silicon and Silicon Nitride Waveguide

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Abstract

Several graphene based integrated photonics devices such as photodetectors [1] and modulators [2,3] were recently demonstrated. However, a broadband graphene switch with high extinction ratio and low insertion loss has yet to be shown. To design a structure with high extinction ratio, we analyzed the integration of double layer graphene capacitive stacks on both silicon and silicon nitride waveguides and optimized for operation in both C and O-band.

A schematic of the structures is shown in figure 1. The first graphene layer is transferred on the planarized waveguide and after deposition of a thin dielectric layer, the second graphene sheet is transferred on top. Finally, metal is deposited on both graphene layers to make electrical contacts.

We have simulated the absorption of the structures versus the applied voltage in COMSOL based on surface conductivity method with the conductivity of graphene extracted from the Kubo formula [4]. Based on these simulations, the extinction ratio (ER) and insertion loss (IL) were calculated. Figure 2a shows the IL and ER as function of device length for devices with an oxide thickness of 3 nm and a drive voltage of 4V. The DLG-SiN exhibits better IL while the DLG-Si shows better ER. To better understand this trade-off, we plot the figure of merit FOM = ER/IL in Figure 2b, as function of drive voltage, for different device designs and different oxide thicknesses. First of all we see that the FOM improves with increasing drive voltage. For a given drive voltage it improves for thinner oxides thickness. Note however that the dynamic performance of the device shows the opposite behavior and the bandwidth decreases for thinner oxides. Interesting to see is that the FOM is independent of the device structure and the same value is obtained for the DLG-SiN and the DLG-Si structures. Hence the choice for selecting one or the other structure can be made based on other requirements such as manufacturing cost or dynamic behavior (DLG-Si will be more compact hence faster). As an example, a DLG-SiN device of 200 µm length, operating under a drive voltage of 4V, can provide an ER of 23 dB for an insertion loss of 1dB only. All calculations were carried out for a wavelength of 1.55um but the results remain virtually constant over an optical bandwidth of more than 100nm.

References

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Figures

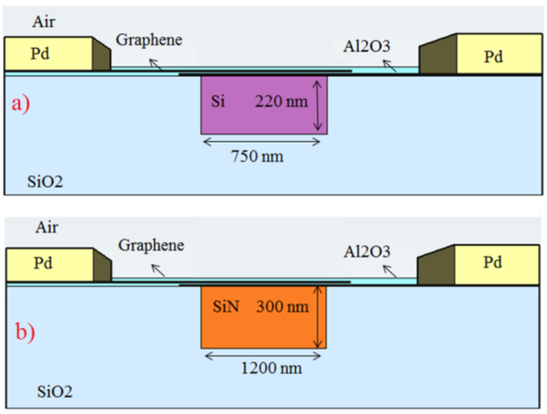

Fig1. Graphene based waveguide integrated electro-optical switch a) DLG-Si, b) DLG-SiN

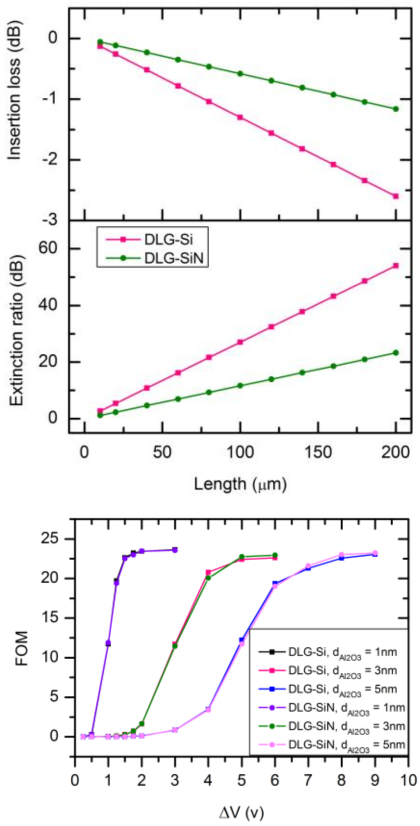

Fig2. a) IL and ER as function of the device length for gate oxide thickness 3nm b) FOM as function of applied voltage.