Theoretical investigation of graphene-based waveguide integrated photonic and plasmonic modulators

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Abstract.

Theoretical investigations of graphene-based electro-optic plasmonic and photonic modulators will be analyzed and the results will be presented. The effect of different ridge materials and different spacer dielectrics is analyzed showing that a 3 dB modulation with 65 nm-long waveguide is possible with dielectric-loaded surface plasmon polariton waveguides (DLSPPWs) resulting in an energy per bit only 0.08 fJ/bit. The figure of merit defined as the ratio between an extinction ratio and insertion loss was found to be about 5.2 with a low refractive index ridge and increases to over 17.3 for a high refractive index Si ridge compared to 3.5 calculated and measured with photonic graphene-based waveguides. Additionally, it is shown that further improvement in terms of a figure of merit is possible with the rib photonic waveguides with a double-layer graphene placed between slab and a ridge where it is calculated to exceed 250! For such photonic waveguides, a 3 dB modulation is achieved with 6 μm-long waveguides with the energy per bit of 0.3 fJ/bit. Additionally, the wavelength dependence of the graphene sheet was analyzed showing a redshift with increasing chemical potential what influences on the attenuation of the waveguide which redshifts as well – increasing a gate voltage applied across a graphene layer shifts the attenuation curve to the shorter wavelengths with a 3 dB modulation bandwidth exceeding 15 THz for a 12 μm-long DLSPP waveguide.