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Application of Graphene in Photonic Integrated Circuits

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Graphene, two-dimensional one-atom-thick planar sheet of carbon atoms densely packed in a honeycomb crystal lattice, has grabbled appreciable attention due to its extraordinary mechanical, thermal, electrical, and optical properties. Based on the graphene's high carrier mobility, high frequency graphene field effect transistors have been developed. Graphene is useful for photonic components as well as for the applications in electronic devices. Graphene's unique optical properties allowed us to develop ultra wide-bandwidth optical modulator, photo-detector, and broadband polarizer. Graphene can support SPP-like surface wave because it is considered as a two-dimensional metal-like systems. The SPPs are associated with the coupling between collective oscillation of free electrons in the metal and electromagnetic waves. The charged free carriers in the graphene contribute to support the surface waves at the graphene-dielectric interface by coupling to the electromagnetic wave. In addition, graphene can control the surface waves because its charge carrier density is tunable by means of a chemical doping method, varying the Fermi level by applying gate bias voltage, and/or applying magnetic field. As an extended application of graphene in photonics, we investigated the characteristics of the graphene-based plasmonic waveguide for optical signal transmission. The graphene strips embedded in a dielectric are served as a high-frequency optical signal guiding medium. The TM polarization wave is transmitted 6 mm-long graphene waveguide with the averaged extinction ratio of 19 dB at the telecom wavelength of 1.31 μm. 2.5 Gbps data transmission was successfully accomplished with the graphene waveguide. Based on these experimental results, we concluded that the graphene-based plasmonic waveguide can be exploited further for development of next-generation integrated photonic circuits on a chip.

Keywords: graphene, waveguide, photonics