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Invited talk

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Light modulating and detecting in on-chip plasmonic-graphene hybrid platforms

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Abstract

Graphene has offered a new paradigm for extremely fast and active optoelectronic devices. Here we present novel integrated graphene plasmonic devices for on-chip light modulating and detecting. The graphene plasmonic modulator shows high modulation depth and low insertion loss, and the graphene plasmonic waveguide photodetector has the bandwidth beyond 110 GHz and intrinsic responsivity of 360 mA/W.

1. Introduction

Graphene, a unique two-dimensional material, provides great potential in the realization of high-performance optoelectronic devices. In particular, significant efforts have been devoted to graphene modulators and photodetectors [1-6]. The distinct properties of graphene in terms of ultrahigh carrier mobility, zero bandgap property that enables wavelength-independent light absorption over a very wide spectral range, and tunable optoelectronic properties give rise to realize graphene devices with large spectral bandwidth and high speed. However, their performance is still limited by weak light-graphene interaction and large resistance-capacitance product. Here we present our recent results on graphene plasmonic hybrid platforms for on-chip light modulating and detecting, giving a promising way to realize on-chip interconnects with graphene plasmonic devices.

2. Results

Figure 1(a) shows the SEM image of our proposed graphene plasmonic waveguide modulator [7], where the plasmonic slot waveguide is coupled in/out by silicon waveguides with inverse tapering tips. The plasmonic waveguide can confine modes beyond diffraction limit, while at the same time suffering with large propagation loss. Here we propose plasmonic slot waveguides relying on the concept of leaky mode, giving us extremely low loss of 0.25dB/μm. The good alignment of the coupling part (between the silicon and plasmonic waveguide) leads to high in/out coupling efficiency of 1.45 dB.

Transmissions of the light at 1.55 μm through 20 μm-long leaky-mode graphene-plasmonic waveguides at different bias voltages are presented in Fig. 1(b) for two slot widths of 120 nm and 145 nm. One can find that the transmission through the graphene-plasmonic hybrid waveguides is

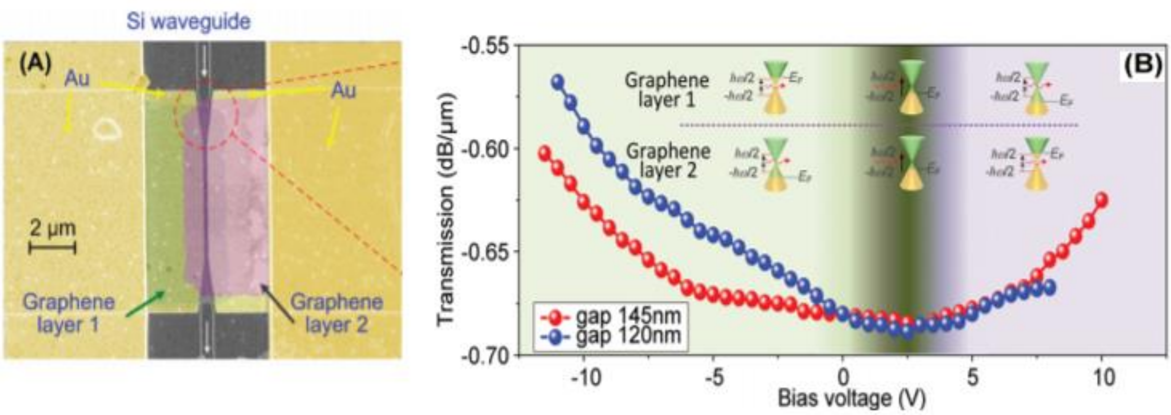

Figure 1: (A) False-color SEM image of the fabricated graphene-plasmonic slot hybrid waveguide. (B) Measured transmission as a function of bias voltage for 20 um-long plamonic slot waveguides with gaps of 145 nm and 120 nm.

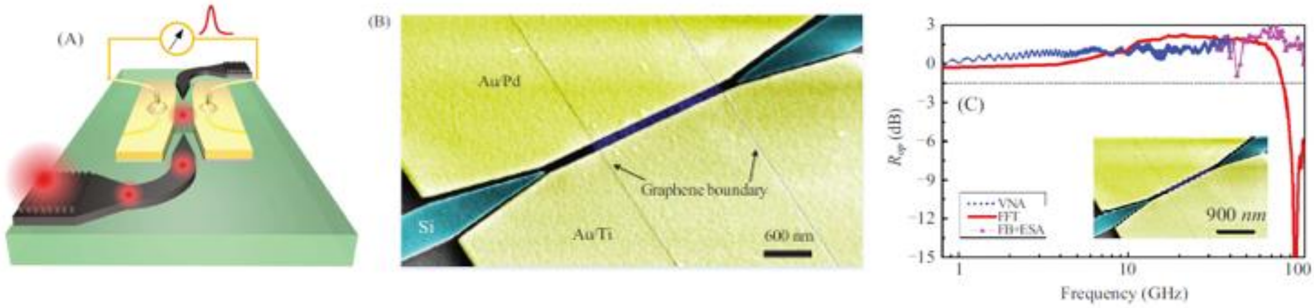

Figure 2. (a) Schematic of the proposed graphene-plasmonic hybrid photodetector (b) An example of fabricated graphene plasmonic photodetector with the graphene coverage length of 2.7 um (c) Its corresponding optical bandwidth measured by VNA, impulse response, and frequency beating with ESA at the bias voltage of 1.6V.

effectively tuned by applying bias voltages on the graphene. An efficient attenuation tunability of 0.13 dB/μm is achieved for the plasmonic slot width of 120 nm at low gating voltages. The modulation depth of 0.13 dB/μm achieved here exceeds that for reported graphene-plasmonic hybrid device [8].

Figure 2 shows our proposed ultra-compact, on-chip, and high-speed graphene photodetector based on a plasmonic slot waveguide [9]. The subwavelength confinement of the plasmonic mode gives rise to the enhanced light-graphene interactions, and the narrow plasmonic slot of 120 nm enables short drift paths for photogenerated carriers. The schematic of the proposed graphene plasmonic hybrid photodetector is shown in Fig. 2(A), where the light from a fiber is first coupled to a silicon waveguide through a grating coupler and further to the plasmonic slot waveguide by a short taper structure. Fig. 2(B) shows a fabricated graphene-plasmonic photodetector, where the dashed lines represent the graphene coverage boundary, and the corresponding optical bandwidth measured by VNA, impulse response, and frequency beating with ESA is presented at the bias voltage of 1.6 V, showing that the bandwidth is over 110GHz. Moreover, the use of chemical-vapour deposition (CVD)-growth graphene here allows for the scalable fabrication and we believe that our work greatly pushes the 2D material towards practical applications, e.g. in optical interconnects, high-speed optical communications, and so on.

3. Conclusions

We present novel integrated graphene plasmonic devices for on-chip light modulating and detecting, which shows a promising way to realize ultra-compact and high-speed optoelectronic devices for potential applications in on-chip interconnects.

4. Acknowledgements

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