Plasmonic-Enhanced Graphene/III-V Hybrid Optical Diode

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In this paper, a new plasmonic-enhanced graphene/III-V hybrid optical diode is reported. Different from existing graphene-based optical diodes which require large tuning voltages while the tuning range is small, the proposed graphene device is constructed by heterogeneous integration of graphene and III-V heterostructures by remote epitaxy growth techniques. Moreover, plasmonic structures are applied to further enhance the tuning range of the resulting devices. It is expected that the proposed devices can open up new pathways for realizing fully electrically controlled tunable graphene devices with low tuning voltages and large tuning range, impacting the broad areas of optical communications, THz technology, and RF photonics.

Graphene, an atomic monolayer formed by carbon hexagons, has recently emerged as a novel material with unique electrical and optical properties. Many exotic physical phenomena have been proposed and observed in graphene, such as anomalous quantum Hall effect, and extremely high carrier mobility [K. I. Bolotin et al., Solid State Communications, 146 (2008), 351-3552; A. S. Mayorov et al., Nano Lett., 11 (2011), 2396-2399]. In addition to the novel physical behaviors, graphene also holds great potential to develop novel optoelectronic devices, such as ultrafast optical switches, strong light-matter interactions, fast electro-optical modulators etc. So far, there are a lot of graphene-based applications demonstrated including optical absorbers, sensing, and optical switches. To enable the tuning, external gate voltage is applied on the graphene-insulator-seminconductor structures. However, due to the intrinsic limitations of the gate tunable structures, tuning efficiency and tuning speed are always limited. In this paper, a graphene-based optical diode based on a completely new tuning mechanism is proposed. The general schematic of it is shown in Fig. 1 (left). It is formed by placing at the depletion region of the III-V p-n junctions, sandwiched between n- top junction and p- bottom junctions. In this way, the bias voltage of the p-n junction can effectively tune the Fermi level in the hybrid junction by using the depletion electric field or current injection. An experimental prototype has been designed, fabricated, and characterized. The measurement results of the fabricated sample show that it can achieve a large tuning range with a biasing voltage of 6V or less, which is one order of magnitude smaller than the state-of-the-art. To further boost the tuning efficiency, plasmonic structures (shown in the right of Fig. 1) integrated with the proposed devices have been explored, which lead to stronger local field intensities and larger tuning range.

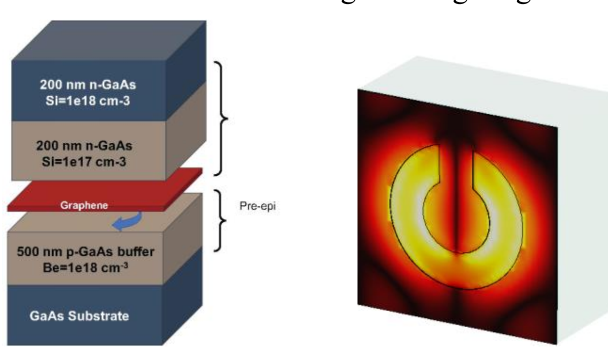

Fig 1. Schematics of proposed graphene/III-V hybrid optical diode (left) enhanced by plasmonic structures (right).