Graphene/III-V Hybrid Diodes and Optical Devices by Heteroepitaxy

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Graphene, an atomic monolayer formed by carbon hexagons, has recently emerged as a novel material with unique electrical and optical properties. In order to change the optical properties of graphene, a gate voltage applied to this capacitor causes carriers to accumulate or deplete on the graphene sheet, change the graphene optical conductivity and switch the intraband absorption of the graphene. This change in absorption modulates the intensity of light travelling through it. Operation speed can be increased by using a thicker gate oxide, but the resulting lower capacitance leads to a smaller graphene optical conductivity change and reduced modulation depth and efficiency.

In this work, we demonstrate a hybrid graphene/GaAs diode and efficient modulation of THz radiations. The hybrid modulator diode is achieved by heterogeneous integration of graphene with GaAs heterojunctions enabled by the remote epitaxy technology, where graphene is placed at the depletion region of the GaAs p-n junctions, sandwiched between n-type GaAs top junction and p-type GaAs bottom junctions. The operation principle of the hybrid modulator diodes is similar to the modern semiconductor electro-absorption modulators (EAM), where the active quantum well (QW) region in placed in the III-V p-n junctions and p-n junction is electrically biased to change the absorption spectrum of the active QW region. In the hybrid modulator diode, the bias voltage of the GaAs p-n junction diode can effectively tune the Fermi level in the hybrid junction by using the depletion electric field or current injection. Figure 1b shows the reflection high-energy electron diffraction (RHEED) pattern of the GaAs layers grown on 2D graphene, it is found that a streaky GaAs 2x RHEED pattern is obtained after 400 nm GaAs remote epitaxy growth on graphene. The streaky and sharp pattern indicates smooth GaAs (100) surfaces resulted from the remote epitaxy growth. A micrograph image of the as-grown sample is shown in the inset of Figure 1b, and a mirror-like surface is obtained in the graphene region.

The details of the device characterizations over the broad spectrum from NIR to THz will be presented.

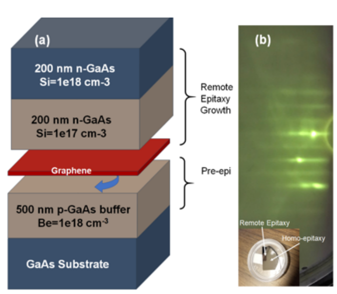

Figure 1: (a) Heterostructure of the graphene/III-V heterostructure hybrid diode; (b) RHEED image of the GaAs during the remote epitaxy growth; inset: micrograph image after growth

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