The development of hybrid electronic/photonic devices based on Graphene-III-V semiconductor composited material

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We report our efforts on the development of multi-function devices based on graphene-III-V semiconductor system, and aim to utilize the merits of both materials for a single chip. We successfully integrate chemical vapor deposited (CVD) graphene on top of GaAs/AlGaAs heterostructure, and utilize the two unique two-dimensional electron gas (2DEG) systems separately formed within this composited material. Three devices with different functionalities will be demonstrated in this conference [1,2].

First, we present the realization of a dual-function field-effect transistor (DFET), consisting of a graphene FET (GFET) and a high electron mobility transistor (HEMT). Depending on the operation scheme, graphene can be used either as a gate electrode for HMET or as a channel material gated by 2DEG formed in the interface of heterojunction. The performance of this hybrid device not only comparable with that of GFET or HMET reported earlier but also bode a way to fabricate a novel integrated biFET device.

Second, we implement a micron-sized Hall probe on graphene for scanning Hall microscopy. Conventional Hall probe based on GaAs 2DEG suffers restricted spatial resolution due to finite spacer layer. Graphene Hall probe (GHP) can overcome this issue and supposedly provide superior field sensitivity in the vicinity of charge neutral regime. The electronic properties of GHP are characterized. We suggest a scheme based on a stacked double-Hall junction in graphene/GaAs/AlGaAs composite material to further extend the functionalities of Hall probes.

Third, we fabricate a Quantum Hall far-infrared (QHFIR) photon detector based on GaAs 2DEG with graphene as a top transparent electrode. Graphene gate-electrode can be used to tune the response (cyclotron) frequency of the QHFIR. Photon response can be observed from frequency 39 to 111 cm^{-1} with a band width of ~3 cm^{-1} by varying magnetic fields and gating voltages. The QHFIR exhibits a wide tunability, far exceeding that with earlier schemes. Preliminary data of QHFIR based on graphene alone will be presented and discussed.