A Graphene-Channel Terahertz Light Emitter Transistor

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We report on experimental observation of amplified spontaneous terahertz (THz) emission from 1 to 7.6 THz at 100K in a population-inverted Distributed Feedback-Dual Gate-Graphene Channel Field Effect Transistor (DFB-DG-GFET) by carrier-injection [1, 2], demonstrating the birth of a new type of THz light-emitting transistors.

Graphene synthesized by the thermal decomposition of a C-face 4H-SiC substrate [3] was used to fabricate the GFET having a SiN gate insulator. Fig.1(a) shows the device image, a pair of tooth-brush-shaped gate electrode was patterned to form a DFB laser cavity in which the active gain area and corresponding gain coefficient are spatially modulated. With complementary biased gate1 ($V_{g1} < 0$) and gate2 ($V_{g2} > 0$) (Fig.1(b)), the carrier population can be inverted at the intermediate channel region by forward-biasing the drain-source voltage V_d. The background blackbody radiation was first observed under the zero-bias condition using a 4.2K cooled Si bolometer, which was subtracted from the one observed under biased conditions. A relatively intense emission at 100K than at any other higher temperatures (Fig. 2(a)) was observed in 1-7.6 THz range peaking at around ~5 THz when the device was population-inverted. The device also exhibited peculiar double-threshold-like behavior with respect to the current-injection level (Fig. 2(b)), which may be due to the carrier overcooling effect [2] as was discussed in [4]. A careful design of DFB cavity (higher DFB modulation and a larger number of DFB periods) is expected to result in single mode CW THz lasing with an output power of the order of ~10 μW as observed in another recent work of ours [4].

References

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Figures

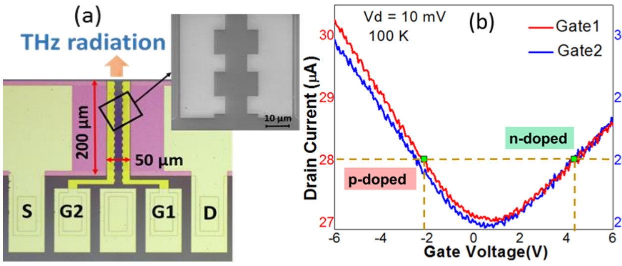

Figure 1: (a)Optical and SEM image of the fabricated device; grating period, the effective refractive index, the Bragg wavelength, and the principal mode are 12 μm, 2.52, 60.5 μm, and 4.96 THz, respectively (b) Measured *I-V* characteristics for Gate1 and Gate2. The square dots are typical points for symmetric electron/hole injection (V_{g1}=-2.28 V, V_{g2}=4.56 V).

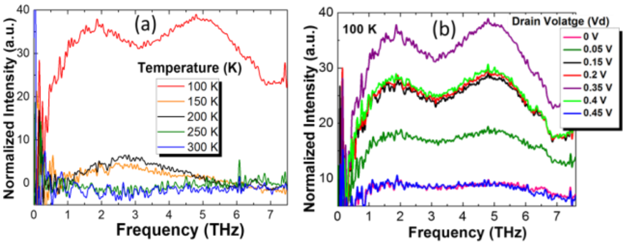

Figure 2: (a)Temperature dependence of the THz emission spectra, (b)Emission spectra from the device for different values of V_d at 100K.