Recent advances in graphene heterostructures toward the creation of terahertz lasers

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Abstract

This paper reviews recent advances in graphene heterostructures toward the creation of terahertz (THz) lasers. Interband-transition-originated population inversion in the pumped graphene can produce a weak gain (up to 2.3%) in the THz range (Fig. 1) [1]. The current-injection pumping with the equivalent pumping photon energy as low as tens of meV can minimize carrier heating and increase the gain [2]. Excitation of graphene plasmon polaritons can dramatically enhance the THz gain (Fig. 2) [3, 4], which has recently been experimentally verified [5]. The graphene-channel FET structure with an asymmetric dual grating gate is a possible structure enabling current-injection plasmonic THz lasing (Fig. 3) [6].

We propose to use photo-emission-assisted resonant tunneling in a gated double-graphene-layer (DGL) capacitor as another physical mechanism to obtain a giant THz gain using current-injection pumping (Fig. 4) [7]. In such structures, the entire excess carriers in the n-type graphene layer can contribute to THz spontaneous emission (with the photon energy being equal to the band offset between the DGL) via interlayer radiative tunneling to the p-type graphene layer. Quantitative discussions of the lasing performance will be presented in detail.

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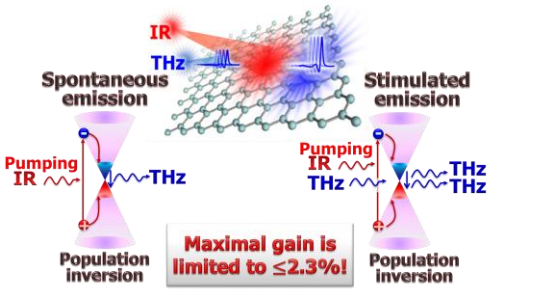

Fig. 1. Interband photoexcitation and resultant THz gain in optically pumped graphene.

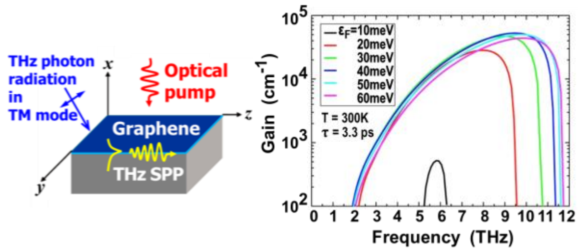

Fig. 2. Giant THz gain enhancement via excitation of surface plasmon polaritons in inverted graphene.

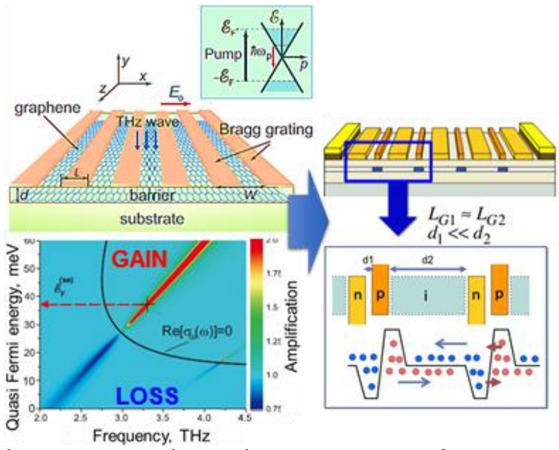

Fig. 3. A graphene heterostructure for current-injection plasmonic THz lasing.

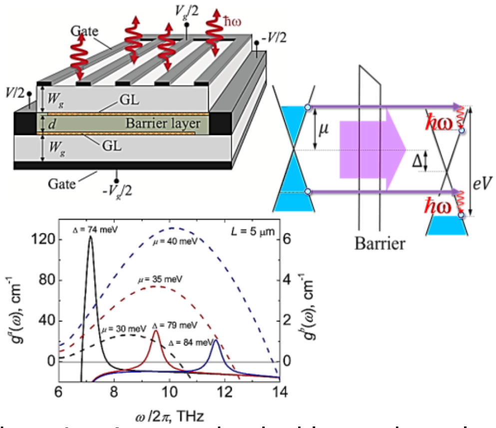

Fig. 4. A gated double-graphene-layer structure for current-injection photoemission-assisted resonant-tunneling lasing.