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Terahertz Light Emission and Lasing in Current-Driven Graphene-based 2D Nano- and Plasmonic-Structures

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Abstract

Graphene has attracted considerable attention due to its massless and gapless energy spectrum of Dirac Fermions as well as strong light-matter interactions via plasmon-polaritons. This paper highlights recent advances in terahertz (THz) light emission and lasing in current-driven graphene-based 2D nano-structures.The dual-gate graphene channel transistor (DG-GFET) structure promotes carrier population inversion in the lateral p-i-n junctions under complementary dual-gate biased and forward drain biased conditions, promoting spontaneous incoherent THz light emission. A laser cavity structure implemented in the active gain area can transcend the incoherent light emission to the single-mode lasing. We designed and fabricated the distributed feedback (DFB) DG-GFET. The GFET channel consists of a double layer (non-Bernal) epitaxial graphene, providing an intrinsic field-effect mobility exceeding 100,000 cm^2/Vs. The teeth-brash-shaped DG forms the DFB cavity having the fundamental mode at 4.96 THz. THz emission from the sample was measured using a Fourier-transform spectrometer with a 4.2K-cooled Si bolometer. Broadband rather intense (~10 μW) amplified spontaneous emission from 1 to 7.6 THz and weak (~0.1 μW) single-mode lasing at 5.2 THz were observed at 100K in different samples. Present structure offers a weak gain overlapping due to poor THz photon-field confinement, resulting in a wide variation from single-mode lasing to broadband incoherent emission depending on graphene quality (carrier momentum relaxation time). Further improvements are now under way.

Conclusion & Significance: Carrier-injection pumping of graphene can enable negative-dynamic conductivity in the THz range, which may lead to a new type of THz lasers. Current-driven plasmon instabilities in dual-grating-gate GFET structures as well as plasmon-assisted resonant tunneling in gated double-graphene-layered nano-capasitor structures can promote the generation and amplification of THz waves, leading to intense, room-temperature THz lasing.

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Speaker Publications:

1.Yadav D, Tamamushi G, Watanabe T, Mitsushio J, Tobah Y, Sugawara K, Dubinov AA, Satou A, Ryzhii M, Ryzhii V and Otsuji T.Terahertz light-emitting graphene-channel transistor toward single-mode lasing.Nanophoton.**7** 741-752 (2018).

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