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TERAHERTZ LIGHT EMISSION AND LASING IN CURRENT-DRIVEN GRAPHENE-BASED 2D NANO- AND PLASMONIC-STRUCTURES

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 cm²/Vs. The teeth-brush-shaped DG forms the DFB cavity having the fundamental mode at 4.96 THz. THz emission from the sample was measured using a Fouriertransform 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. Carrierinjection 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-capacitor structures can promote the generation and amplification of THz waves, leading to intense, room-temperature THz lasing.

Biography

Taiichi Otsuji is a Professor at the Research Institute of Electrical Communication (RIEC), Tohoku University, Sendai, Japan. He received the PhD degree in Electronic Engineering from Tokyo Institute of Technology, Tokyo, Japan in 1994. From 1984 to 1999, he worked for NTT Laboratories, Kanagawa, Japan. In 1999, he joined Kyushu Institute of Technology. He joined RIEC, Tohoku University, in 2005. His current research interests include terahertz electronic, photonic and plasmonic materials/devices and their applications. He has authored and co-authored 250 peer-reviewed journal papers and more than 150 invited presentations in academic international conferences. He was awarded the Outstanding Paper Award of the 1997 IEEE GaAs IC Symposium, and has served as an IEEE Electron Device Society Distinguished Lecturer since 2013. He is a Fellow of the IEEE, OSA and JSAP, and a Member of the MRS, SPIE, and IEICE.

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