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Graphene-based van der Waals Heterostructures towards a New Type of Quantum-Cascade Terahertz Lasers

Abstract
Current-injection or optical pumping makes population inversion of graphene carriers enabling lasing and/or amplification of terahertz (THz) radiation [1-3]. We've recently demonstrated 1-8-THz broadband amplified spontaneous THz emission as well as single-mode THz lasing at 5.2 THz both at 100K [3]. Introduction of a gated double-graphene-layered (G-DGL) van der Waals heterostructure in which gate-bias tuned THz radiation emission is obtained via plasmon- and/or photon-assisted quantum-mechanical resonant tunneling is a promising rout to further increase operation temperature as well as output intensity (Fig. 1) [4-5]. We experimentally demonstrated the proof of concept of such an operation mechanism [6]. The important physics behind is the acoustic plasmon modes in the DGL that can enormously enhance the quantum efficiency by orders for dc electric power to THz photo radiation power conversion in comparison with that for a simple graphene-channel transistor laser structure (Fig. 1) [5]. We have proposed a cascading of the G-DGL unit element working as a new type of THz quantum-cascade lasers (Fig. 1) [7]. The laser cavity can be structured along with the in-plane direction of the G-DGL mesa structure. The vertical G-DGL cascade structure can enlarge the mode field of the THz photon radiation to match the free-space impedance. Numerical analyses demonstrate further increase of the quantum efficiency of THz lasing by order of magnitude in comparison with a single G-DGL structure. Experimental verification is now under going. This work is financially supported by JSPS KAKENHI #16H06361, Japan.

References

[1] V. Ryzhi et al., J. Appl. Phys. **101** (2007) 083114.
[2] M. Ryzhii and V. Ryzhii, Jpn. J. Appl. Phys. **46** (2007) L151.
[3] D. Yadav et al., Nanophoton. **7** (2018) 741-752.
[4] V. Ryzhii et al., Opt. Exp., **21** (2013) 31569.
[5] D. Svintsov et al., Phys. Rev. B **94** (2016) 115301.
[6] D. Yadav et al., 2D Mat. **3** (2016) 045009.
[7] A.A. Dubinov et al., Opt. Exp. **24** (2016) 279307.

Figures

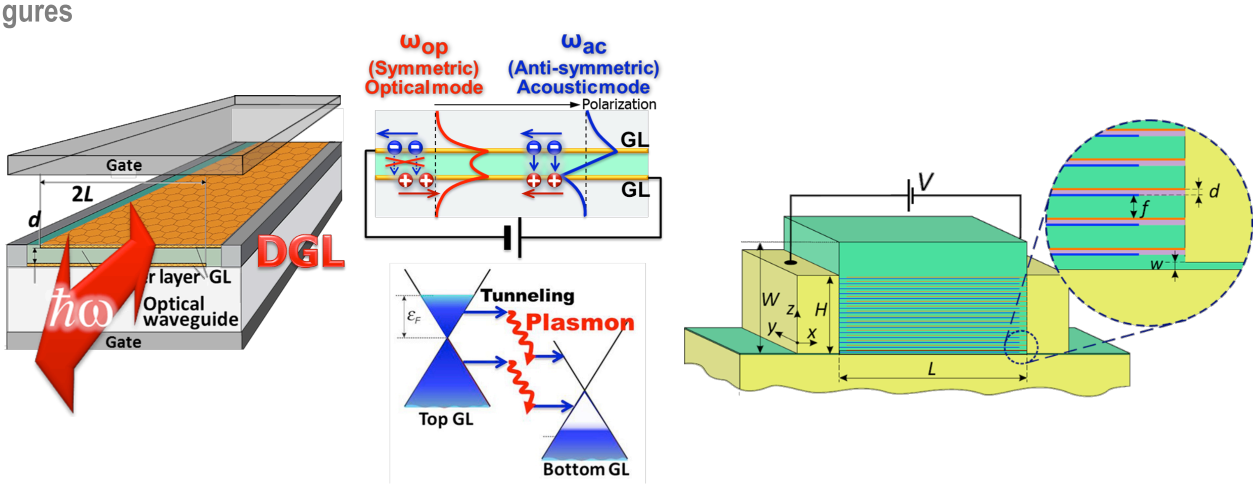

Figure 1: G-DGL structure (left), its plasmon modes and plasmon-assisted tunneling (center), and G-DGL cascade (right).