Graphene Plasmonic Crystals for Terahertz Radiation Amplification

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More than 40 years ago, a new direction in physics opened up with the arrival of plasma-wave electronics. The possibility that the plasma waves could propagate faster than electrons fascinated all. Therefore, it was initially expected that plasmonic devices, including detectors and generators of electromagnetic radiation, would be able to work effectively in the very high frequencies - terahertz (THz) range, inaccessible to standard electronic devices. However, numerous experimental attempts to realize such amplifiers or emitters failed: the intensity of radiation turned out to be too small, plasma resonances too broad, or devices operated only at cryogenic temperatures. Thus, the creation of compact, tunable, room temperature operating THz amplifiers and sources is still a challenging task.

We study THz radiation absorption by grating graphene nanostructures (see Fig.1) and demonstrate gate voltage tunable resonant plasmon absorption, that with an increase of the current, turns to THz radiation amplification with a gain going up to 9% [1]. The results are interpreted using a dissipative plasmonics crystal model, which captures the main trends and basic physics of the amplification phenomena. Specifically, the model predicts that increasing current drives the system into an amplification regime, wherein the plasma waves may transfer energy to the incoming electromagnetic waves. All results were obtained at room temperature. Therefore, they pave the way towards a future THz plasmonic technology with a new generation of all-electronic, resonant, voltage-controlled THz amplifiers [1].

[1] Boubanga-Tombet S, Knap W, Yadav D, Satou A, But DB, Popov VV, Gorbenko IV, Kachorovskii V, Otsuji T: Room-Temperature Amplification of THz Radiation by Grating-Gate Graphene Structures. Phys Rev X 2020; 10(3): 031004. [DOI: 0.1103/PhysRevX.10.031004]

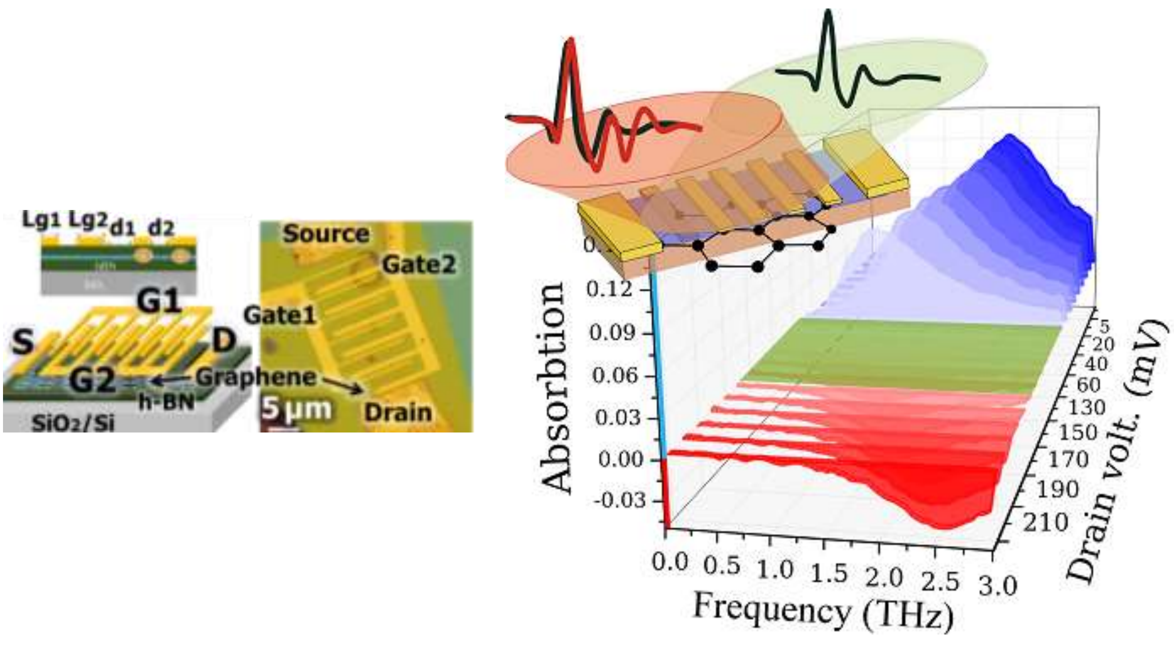

Figure 1: Schematic representing experimental configuration with a grating-gate graphene transistor structure along with incoming and outgoing THz beams. The 3D plot depicts experimentally recorded plasma resonances, highlighting that with increasing drain voltage/current, the resonant absorption (blue) turns to total transparency (green) followed by amplification ("negative absorption" – red)