Graphene Based Terahertz Emitter

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A specific design of a voltage tunable graphene based emitter and amplifier of electromagnetic radiation is developed [1]. The proposed device consists of a few layers of graphene and hexagonal boron nitride (BN) and is specifically structured in order to fulfill the threshold conditions for radiation and to optimize the efficiency of radiation. A detailed theory of the device is developed. The influence of different physical parameters (geometrical dimensions of the structure, electron/hole density, temperature, mean free path, voltage biases) on the device operation is analyzed and the optimal and realistic conditions of the device operation are found. It is shown that the proposed device is able to emit radiation in several frequency bands from ~0.1 up to ~30 THz. The estimated emitted power is of order of 0.5 W/cm^2 and the estimated efficiency (the ratio of the emitted power to the heating power) is about 1%. The operating temperature of the emitter can be close to room temperature, the heating of the device does not exceed several Kelvin under realistic experimental conditions due to the very large surface-to-volume ratio in two-dimensional graphene and to the high thermal conductivity of the BN or silicon substrate which can be used.

A slightly modified version of the basic structure can serve as an amplifier of a low frequency signal or as a terahertz transistor combined with a distributed plane antenna.

Other opportunities of using graphene for terahertz science and technology will also be discussed. The theoretically predicted [2,3] and later experimentally observed [4,5] nonlinear phenomena in graphene, such as the frequency multiplication and mixing, will be overviewed. A new predicted effect of a giant enhancement of higher harmonics due to plasma resonances will be presented [6].

References

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