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Vertical Injection in Black Phophorus-Graphene Heterostructures for Terahertz Lasing

The heterostructures based on graphene-layers (GL) with optical and injection pumping can be used as active elements in the sources of terahertz (THz) radiation, including THz lasers [1-3]. One of the most important advantages of such lasers with lateral lateral carrier injection from the side p- and n-contacts in comparison with the lasers using the optical pumping is associated with relatively low energies of the injected carriers.
In this communication, we propose and evaluate the GL-based THz lasers with the lateral injection from the side n-contacts and the vertical hole injection. To prevent a marked heating of the electron-hole system in the GL due to the injection relatively hot holes, we propose to use a p^+-p- injector with the black phosphorus layers (PLs) [4]. The energy spacing between the GL Dirac point and the top of the PL valence band is about 0.1 eV. The latter value is smaller than the optical phonon energy in the GLs (about 0.2 eV). This can result not to the heating of the electron-hole system in the GL, but to a substantial cooling of the latter, promoting a strong interband population inversion and, hence, forming the conditions for the effective THz lasing.
Using the developed device model, we calculate the spectral dependences of the dynamic conductivity as functions of the structural parameters and the injection current and the gain of the plasmon-polariton modes propagating along the GL. We demonstrate that the heterostructures in question can surpass the GL-based heterostructures with the lateral double injection.

References

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