Infrared and terahertz photodetectors based on van der Waals/graphene heterostructures: Can they be superior?

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The gapless energy spectrum of graphene layers (GLs) enables their use in interband detectors and sources of infrared (IR) and terahertz (THz) radiation. The incorporation of GLs into van der Waals (vdW) heterostructures [1], based on such materials as hBN, WS_2, InSe, GaSe, and similar materials can enable the creation of novel IR and THz devices with the improved characteristics. In contrast to heterostructures grown epitaxially using traditional materials, vdW heterostructures do not require the lattice-match condition. This is owing to the weak inter-layer bonding, so that the layers with different lattice constants can be stacked together. The latter allows a wide family of such materials with diverse electronic properties to form heterostructures with desirable properties.

In this presentation we will review in detail the fabrication and characterization of vdW/GL heterostructures and their use in different transistors, photodetectors, and light-emitting devices. Special emphasis will be put on the analysis of the concept and characteristics of proposed IR and THz detectors based on vertical vdW/GL heterostructures (in particular, those reported recently [2, 3]) and their comparison with devices based on traditional heterostructures.

1. A. K. Geim and I. V. Grigoreva, *Nature* **499**, 419 (2013).
2. V. Ryzhii, M. Ryzhii, D. Svintsov, V. Leiman, V. Mitin, M. S. Shur, and T. Otsuji, *Infrared Phys. Technol.* **84**, 72 (2017).
3. V. Ryzhii, M. Ryzhii, V. Leiman, V. Mitin, M. S. Shur, and T. Otsuji, *J. Appl. Phys.* **122**, 054505 (2017).