

Graphene-Based Infrared and Terahertz Devices: Concepts and Characteristics

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Graphene, i.e., a monolayer of carbon atoms densely packed in a two-dimensional honeycomb structure, graphene bilayers, as well as patterned graphene structures (forming arrays of graphene nanoribbons) have captured the great interest of researchers and device engineers. Unique transport properties of these graphene systems open up wide prospects for their applications in future electronics.

Owing to the gapless energy spectrum of electrons and holes in graphene and narrow bandgaps in graphene nanoribbons and graphene bilayers, graphene-based structures appears to be also very promising for different infrared (IR) and terahertz (THz) devices. We overview and analyze several proposals of such devices. The IR and THz devices under consideration include:

- Graphene and graphene bilayer lasers with optical pumping and cascade emission of optical phonons with or without the self-excitation of plasma oscillations [1-4];
- Graphene nanoribbon and graphene bilayer phototransistors with the gated structure similar to that of field-effect transistors utilizing the effect of the energy gap opening due the lateral size quantization and by the transverse electric field [5];
- Graphene tunneling transit-time devices based on electrically induced lateral *p-i-n* junctions with negative dynamic conductivity in the THz rang of frequencies [6];
- Detector of modulated THz radiation using combined mechanical and plasma resonances in gated graphene (similar to the resonant detectors with carbon nanotube/nanostring considered previously [7]).

The features of the physical processes responsible for the device operation (specifics of the energy spectra of electrons and holes, photogeneration and tunneling injection, energy relaxation and recombination, plasma properties), the device characteristics (threshold of lasing, spectral dependences, detector responsivity and detectivity, and voltage tuning) limiting performance, and the feasibility of their realization are considered and discussed.

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