Development of Graphene-Based Infrared and Terahertz Devices

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The overall goal of this work is to develop graphene-based optoelectronic devices that work in the technologically important mid-infrared (MIR) and terahertz (THz) ranges. Specifically, in this project, we prepare large-area graphene samples on various substrates and assess their MIR and THz properties in terms of sources and modulators. Graphene is a promising candidate for THz generation because it has been predicted that THz amplification will occur in graphene if population inversion is created under sufficiently strong optical pumping [1]. The gapless band structure causes the gain (or negative conductivity) to take place in the THz frequency regime. Therefore, we are investigating the conditions when THz and MIR stimulated emission occurs in graphene under optical pumping. We excite graphene through ultrafast interband optical pumping and probe subsequent carrier dynamics with a delayed MIR or THz pulse. Graphene is also ideal for the modulation of THz radiation due to its high electron mobility and nonlinear response to electromagnetic waves. Since graphene is highly absorptive in the THz range, it is a promising material for controlling THz waves by manipulating the free-carrier density through gating. A pertinent, exciting prediction is that an energy gap will appear at the Dirac point when graphene is irradiated by a circularly-polarized, intense laser field [2]. This provides a coherent and ultrafast means of for tuning the band gap, which will be used to modulate the transmission of THz radiation.

References

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