A self-consistent framework for modeling graphene-based optoelectronic devices

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Graphene based optoelectronics require an accurate description of the interactions between light and graphene carriers. The interplay between graphene's electrical, optical and thermal properties must be self-consistently treated, to design and optimize devices based on graphene. Here, we present a multi-physics simulation framework, developed in the Univeristy of Ioannina, for the versatile and efficient modeling of grahene-based photodetectors, sensors and modulators operating from the mid-IR to the THz spectral regime.

In the mid-IR, we demonstrate a thermionic graphene/Si Schottky photodetector. We show that under proper device optimization, the external responsivity can be pushed to the 1 A/W regime, resulting to detectivity up to 10^7 Jones in an ultrafast photodetection platform [1]. In the far-IR, we exploit plasmonic resonances in graphene nanoribbons forming a series of graphene/Si Schottky junctions, capable to electrically detect graphene plasmons with an external responsivity up to 110 mA/W and noise equivalent power of 190 pW/Hz$^{0.5}$ [2]. Finally, in the THz regime, we present the self-induced ultrafast absorption modulation of a Salisbury screen type of a graphene-based device. Upon strong (up to 654 kV/cm), our calculations show a 30 dB absorption modulation, in excellent agreement with the experimental findings [3]. The presented framework can be used to design different optoelectronic devices reliably and realistically, across a broadband spectral regime, using a plethora of materials alongside graphene.

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References

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