Terahertz radiation detection with a tunable graphene based plasmonic interferometer

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Plasmons, collective oscillations of electron systems, can efficiently couple light and electric current, and thus facilitate developing many optoelectronic devices. Despite considerable effort, it has proven challenging to implement plasmonic devices operating at terahertz frequencies. With lowering the operation frequency down to the THz domain, momentum relaxation rate has to be below the plasmon frequency, which, in turn, requires ultra-high electron mobility. The material capable to meet this challenge is graphene that has been proved to support long-lived electrically tunable plasmons.

Here we report on plasmon-assisted resonant detection of terahertz radiation by antenna-coupled graphene transistors that act as both plasmonic Fabry-Perot cavities and rectifying elements. We demonstrate this long-sought resonant regime [1] using field effect transistors (FETs) based on high-quality van der Waals heterostructures. In particular, we employ graphene encapsulated between hexagonal boron nitride (hBN) crystals which have been shown to provide the cleanest environment for long-lived graphene plasmons [2-4]. Exploiting the gate-tunability of plasmon velocity, we switch our detectors between more than 10 resonant modes, and use this functionality to measure plasmon wavelength and lifetime [5].

In addition to their potential applications in high-responsivity detection and on-chip spectroscopy of the THz radiation, our devices also represent a convenient tool to study plasmons under conditions where other approaches may be technically challenging. Due to their compact size and far-field coupling, our photodetectors can easily be employed to carry out plasmonic experiments in extreme cryogenic environments and in strong magnetic fields, as well in studies of more complex van der Waals heterostructures. As an example, we apply our approach to probe plasmons in graphene/hBN superlattices and unveil collective modes of charge carriers in moiré minibands.

References

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