Detection of terahertz radiation with graphene-based plasmonic interferometers

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1. Introduction

Plasmons, collective oscillations of electron systems, can efficiently couple light and electric current, and thus can be used to create sub-wavelength photodetectors, radiation mixers, and on-chip spectrometers. Despite considerable effort, it has proven challenging to implement plasmonic devices operating at terahertz frequencies. The material capable to meet this challenge is graphene as it supports long-lived electrically tunable plasmons. In this talk we discuss plasmon-assisted detection of terahertz radiation by antenna-coupled graphene-based transistors that act as both plasmonic Fabry-Perot cavities and rectifying elements.

2. Resonant detection of terahertz radiation

First we discuss observed resonant enhancement of detector response when the channel using FETs based on high-quality van der Waals heterostructures [1]. 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. Antenna-mediated coupling of such FETs to freespace radiation results in the emergence of dc photovoltage that peaks when the channel hosts an odd number of plasmon quarter-wavelengths. 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. Thanks to the far-field radiation coupling, our compact devices offer a convenient tool for studies of plasmons in two-dimensional electron systems under non-ambient conditions (e.g. cryogenic environment and high magnetic fields) where other techniques may be arduous.

3. Helicity sensitive detector based on plasmon interference

Next, we discuss how plasmonic effects could be recognized even when CVD-grown graphene is used. By using a specially designed antenna and controlling ellipticity and helicity of the THz radiation [2] we can tune the phase difference between the plasma waves excited at the source and drain electrodes. With a channel length and radiation frequency from 700GHz to 2.5 THz our data unambiguously show that response of such detectors is determined by the interference of plasmons in the transistor channel. As a result, these devices operate as all-electric detectors of the helicity of circularly polarized terahertz radiation that can be further used in terahertz optoelectronics

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4. References

[1] D. Bandurin, et al, Nature communications, **9**, 5392 (2018).
[2] Matyushkin, et al., submitted.