Plasmonic-Enhanced Photodetection in Graphene

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The electrical and optical properties of graphene make it an ideal material for photonics and optoelectronics [1]. Photodetectors based on graphene with a bandwidth up to 16 GHz have been demonstrated [2]. However, these have low responsivities [2,3].

Graphene-based photodetectors rely on a p-n junction whose electric field at the junction area separates the light generated electron-hole pairs [3]. One of the possible ways to introduce such a junction in graphene is to use a metal contact, where the deposited metal introduces a Fermi-level shift so that a pn-junction forms in the vicinity of the contacts [4].

The interaction of light with a metal particle results in collective oscillations of the free electron gas leading to a strong amplification of the electric field in the vicinity of such metal particles [5,6]

Combining graphene with plasmonic nanostructures allows for field enhancement exactly in the area of the p-n junction. As a result the photovoltage can increase. Also, the plasmonic response of metal nanostructures depends on their geometry and on the wavelength of the incident light [7,8]

Here we fabricate graphene-based photodetectors by mechanical exfoliation of graphene on $Si+SiO_2$ and subsequent contact and nanostructure definition by e-beam lithography, metal deposition and lift-off. Fig. 1 shows an optical micrograph of one of our devices. Nanostructured metal gratings with 300nm pitch are present. The inset shows an AFM micrograph of such a grating. The devices are characterized by photovoltage mapping at different gate voltages, laser powers, light polarization and wavelengths. Fig. 2 shows a photovoltage map of a typical device. At the nanostructure, enhancement of the photovoltage occurs. Depending on wavelength, a photovoltage enhancement of up to 20 times is measured. Further, our detectors show a dependence of the generated photovoltage on light polarization, allowing potential detection of the incoming light polarization.

References

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Figures

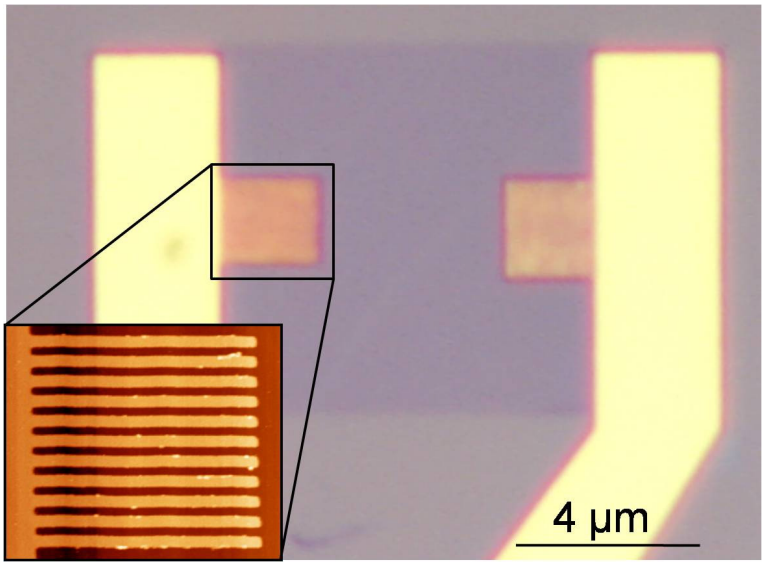

Fig. 1: Optical and AFM micrograph of a graphene-based photodetector with metal nanostructure.

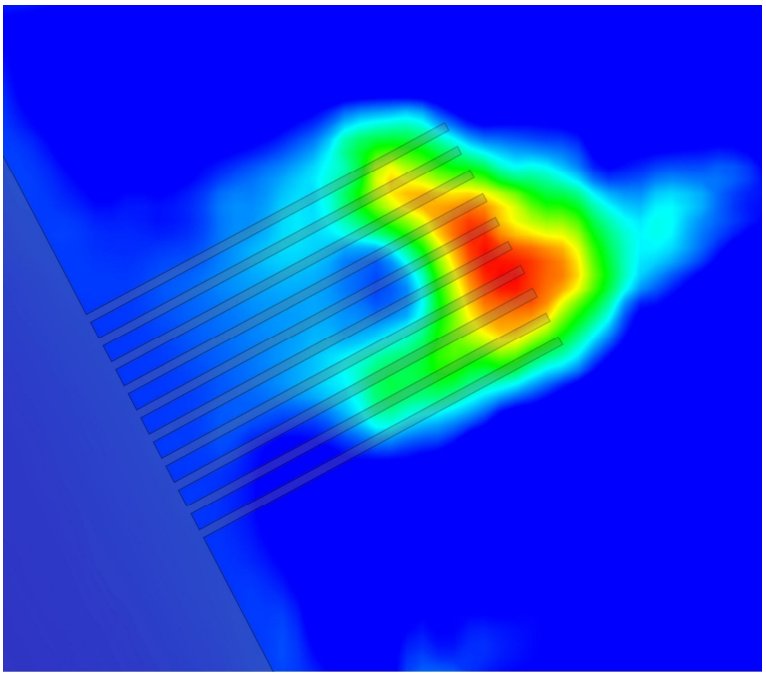

Fig. 2: Photovoltage map of a metal nanostructure enhanced graphene-based photodetector.