Photo-thermo- vs. photo-electric effects in metal-graphene-metal photodetectors

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The electrical and optical properties of graphene make it an ideal material for photonics and optoelectronics [1]. Graphene based photodetectors with a bandwidth up to 16 GHz have been demonstrated and integrated into an optical communication link operating at 10 Gbit/s [2], proving their suitability for high-speed photodetection over a wide wavelength range. However, the underlying physical mechanism is still under debate as both photo-thermoelectric [3,4,5] and photoelectric effects [6,7,8] are being suggested. We carry out wavelength and polarization dependent photovoltage mapping of metal-graphene-metal junctions, demonstrating that both effects simultaneously contribute to the photoresponse. These measurements allow us to quantify the wavelength dependent ratio of thermo- vs. photoelectric effects from the visible to the near-infrared.

Fig. 1 shows the optical micrograph of a typical metal-graphene-metal photodetector. Gold contacts are prepared to contact exfoliated single-layer graphene by means of e-beam lithography, metal evaporation and a lift-off step. Subsequently, photovoltage-mapping is carried out by scanning linearly polarized laser light with diffraction limited spot size over the sample and recording the position dependent photoresponse of the device. By varying the incident laser light wavelength and polarization, information about the contributing mechanisms to the overall photoresponse can be acquired. Fig. 2 shows the photovoltage in dependence of the polarization angle Φ with respect to the metal contact long edge (0 deg denoting perpendicular to the edge). It can be observed that the photovoltage follows a $\cos^2(\Phi)$ dependence. This behavior can be explained by considering the pseudospin selection rule for anisotropic generation of electron-hole pairs in the driving term of the Boltzmann equation which is a clear proof for a photo-electric effect in graphene-based photodetectors. Further, the ratio of the oscillating vs. non-oscillating part of the photovoltage allows an estimation of the ratio of photo-thermal- vs photo-electric effects.

References

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Figures

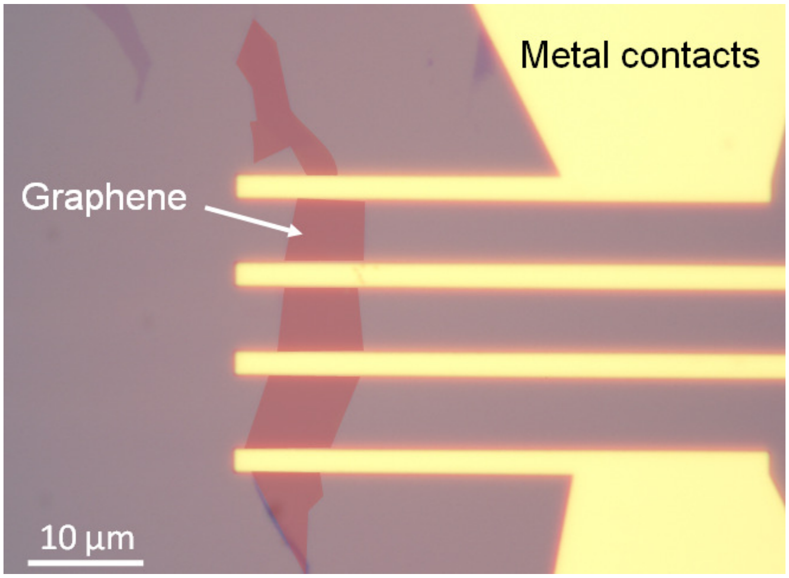

Figure 1: Optical micrograph of a metal-graphene-metal photodetector.

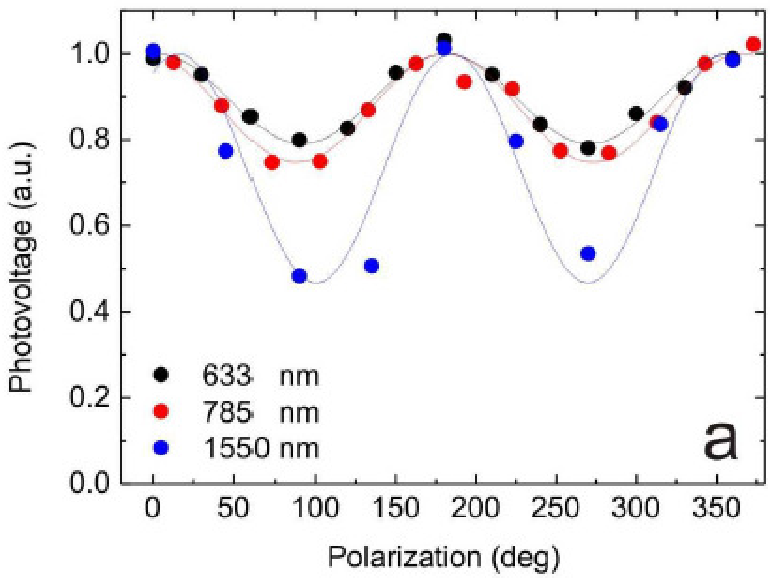

Figure 2: Normalized photovoltage in dependence of the incident laser light polarization angle for different wavelengths.