Improved graphene-based photodection realized on a photonic crystal defect waveguide

Simone Schuler[1], Daniel Schall[2], Daniel Neumaier[2], Benedikt Schwarz[3], Kenji Watanabe[4], Takashi Taniguchi[4], and Thomas Mueller[1]

[1] *TU Wien, Institute of Photonics, Gußhausstraße 27-29, 1040 Vienna, Austria*
[2] *AMO GmbH, Otto-Blumenthal-Straße 25, 52074 Aachen, Germany*
[3] *TU Wien, Institute of Solid State Electronics, Floragasse 7, 1040 Vienna, Austria*
[4] *National Institute for Materials Science, 1-1 Namiki, Tsukuba, 305-0044 Japan*

simone.schuler@tuwien.ac.at

The continuously increasing amount of data requires new concepts for data transmission and processing. The conversion of light into an electrical signal is done by photodetectors.
The integration of optics and electronics on a single silicon chip would allow for fast processing and reduced power consumption.
Commonly, germanium or III-V semiconductors are used but these materials are reaching their physical limits. Graphene turned out to be an attractive candidate since it allows for a compact design, it can be integrated on any arbitrary substrate and provides the properties for both, optical and electrical components. This fascinating material has already been proven to be an ideal material for integrated photodetection and modulation. Record bandwidths up to 76 GHz have already been achieved [3]. In order to further improve the performance in terms of detector response, sophisticated concepts are necessary.
Nowadays, the different conversion mechanisms in graphene are well understood. Based on this knowledge, we designed and fabricated a graphene-based photodetector relying on the photo-thermoelectric (PTE) effect. The detector is based on a photonic crystal defect (PhC) waveguide, where the defect is realized by inserting a slot [2]. The PhC confines the light in vertical direction due to the refractive index difference while in horizontal direction the light is confined due to the band-structure of the PhC waveguide. Thus, silicon slabs on both sides of the waveguide can be attached to increase the gating area. The light is guided in the narrow slot in order to enhance the light-matter interaction. Furthermore, the waveguide is utilized to control the carriers in the graphene layer to create a pn-junction and thus enhance the response due to the PTE effect [3]. We achieved a responsivity of 4.7 V/W under zero bias while under a moderate bias the response was even further enhanced to 170 mA/W due to the photoconductive effect [4].

References

[1] D. Schall, C. Porschatis, M. Otto, and D. Neumaier, Journal of Physics D, Vol. 12, (2017)
[2] T.F. Krauss, Physica status solidi A, Vol 197, (2003), 688-702
[3] N.M. Gabor, J.C. Song, Q. Ma, N.L. Nair, T. Taychatanapat, K. Watanabe, and P. Jarillo- Herrero, Science, 334 (2011), 648-652
[4] S. Schuler, D. Schall, D. Neumaier, B. Schwarz, K. Watanabe, T. Taniguchi, and T. Mueller, submitted (2018)

Figures

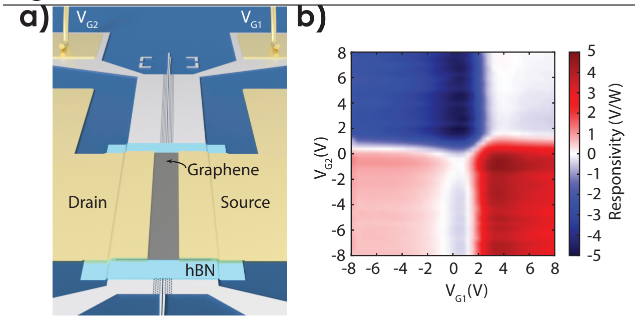

Figure 1: a) Sketch of the device. **b)** Measured device response at zero bias.