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Graphene-enabled terahertz applications

The teraherz (THz) range of the electromagnetic spectrum is technologically relevant for many application fields, such as sensing, security and medicine, as well as for potential future applications such as ultrafast wireless communication. However, currently no THz detectors are available that operate at room temperature, have good sensitivity, are sensitive to a broad range of THz frequencies, and have a short response time. Recently, we have developed a graphene-based THz detector that meets all these requirements simultaneously in a single device [1]. In particular, we find a noise-equivalent power (NEP) below 200 pW/Hz$^{1/2}$, and a response time below 40 ns (setup-limited), which could be as short as 10 ps (RC-time-limited). These device specifications go well beyond the current state of the art.

Our device contains a high-quality, hexagonal BN-encapsulated graphene channel with source and drain contacts, combined with a capacitively coupled dipolar THz antenna with a very narrow gap. In our approach, we exploit the photo-thermoelectric effect, where absorbed light incident on a junction between a p-doped region and an n-doped region of the graphene channel leads to an increase in the temperature of the charge carrier distribution in graphene, subsequently creating a photoresponse [2]. As an essential ingredient for the detector, we note that low-energy THz photons lead to efficient heating, as we have shown earlier [3]. Importantly, our THz photodetector device operates without bias voltage, leading to zero dark current, low noise (governed by Johnson noise), and low power consumption. We expect that this graphene-enabled THz detector will find applications in thickness measurements for industrial quality control (through time-of-flight measurements) and in novel spectroscopic tools.

References

[1] S. Castilla et al. *under review*
[2] J.C.W. Song et al., Nano Lett., 11 (2011) 4688
[3] Z. Mics et al., Nat. Commun., 6 (2015) 8655

Figures

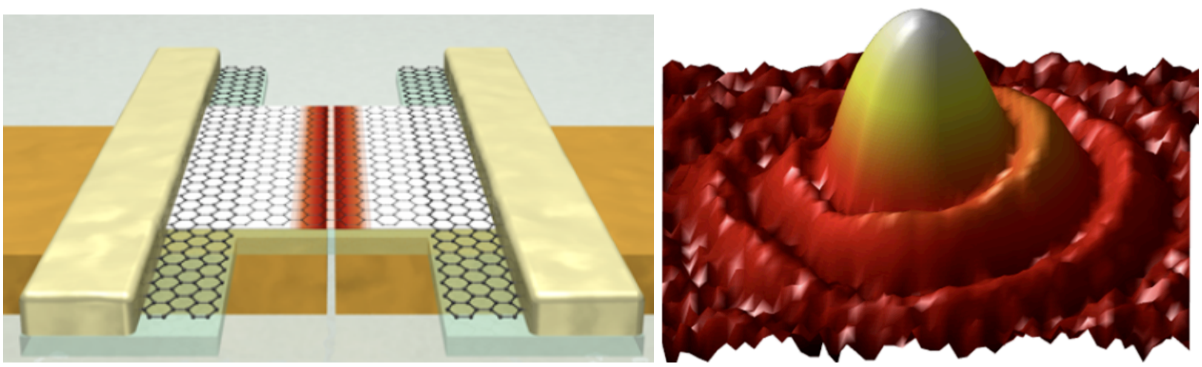

Figure 1: Schematic overview of the ultra-sensitive, ultrafast THz detector based on graphene (left). Typical photocurrent mapping of a THz focus (right) by scanning the device in the THz focus plane. The observation of Airy rings illustrates the high sensitivity of the device.