Graphene for detection and creation of terahertz light

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The interaction between low-energy photons in the terahertz (THz) spectral range and graphene gives rise to a number of interesting physical phenomena that will likely become technologically relevant. As a first example, I will show our recent results on using graphene for detecting THz light [1]. We have demonstrated that the dominant mechanism that gives rise to a THz-induced photoresponse is the photo-thermoelectric effect: absorbed THz light leads to carrier heating in graphene, and if this happens at a *pn*-junction with an asymmetry in the Seebeck coefficients, this gives rise to an electrical photoresponse. We have developed a simple analytical model to describe this effect, and have used this to design and fabricate a novel, antenna-integrated, graphene THz photodetector. The detector (see Figure 1) exhibits excellent sensitivity (noise-quivalent power <100 pW/Hz$^{1/2}$), and a very short switching time (<30 ns, setup-limited). Furthermore, it operates at room temperature and for a range of THz frequencies that is only limited by the antenna. These specifications make the device already commercially competitive. As a second example, I will mention the recent demonstration of highly efficiently generated THz harmonics (up to 7th order) in graphene, which is enabled by THz-induced carrier heating-cooling dynamics in graphene and its back-action on incident THz radiation [2].

References

[1] S. Castilla et al. Nano Lett, ASAP (2019)
[2] H. Hafez, S. Kovalev et al., Nature 561 (2018) 507

Figures

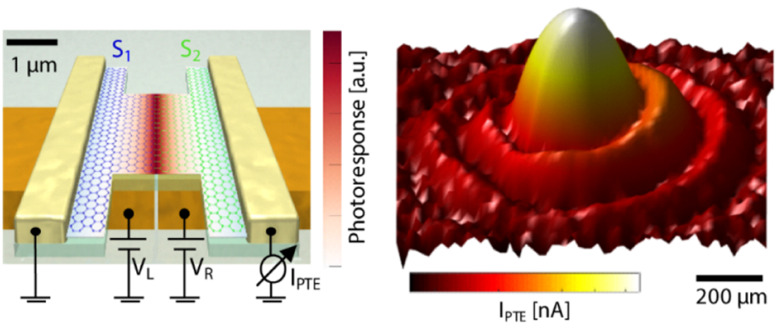

Figure 1: (Left) Schematic layout of the main part of the THz photodetector, showing an H-shaped graphene channel on top of the central part of the antenna, with the antenna gap. Voltages V_L (V_R) are applied to the left (right) antenna branch, thus creating the *pn*-junction with asymmetric Seebeck coefficients (S_1 and S_2), leading to a photo-thermoelectric photocurrent I_{PTE}. (Right) Measured photocurrent, scanning the device through a THz focal plane. The observation of multiple fringes of the Airy pattern illustrates the high sensitivity of the device.