Photons, Plasmons and Electrons meet in 2d materials

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The optoelectronic response of two-dimensional (2D) crystals, such as graphene and transition metal dichalcogenides (TMDs), is currently subject to intensive investigations. Owing to its gapless character, extraordinary nano-photonic properties and ultrafast carrier dynamics, graphene is a promising material for nano-optoelectronics and high-speed photodetectors, whereas TMDs have emerged as potential candidates for sensitive photodetection [1] thanks to their enhanced photon absorption. Vertically assembling these crystals in so-called van der Waals heterostructures allows the creation of novel and versatile optoelectronic devices that combine the complementary properties of their constituent materials.

Here we present a various new device capabilities, varying from quantum nano-photonic devices to ultra-fast and broadband electrical detectors. We applied femtosecond time-resolved photocurrent measurements on 2d material heterostructures, which probes the charge dynamics across TMD and graphene layers directly in the time domain [2,3]. In addition, we apply for the first time infrared photocurrent nanoscopy to high-quality graphene devices[4]. Using this technique, we image the plasmon-voltage conversion in real space, where a single graphene sheet serves simultaneously as the plasmonic medium and detector [5,6].

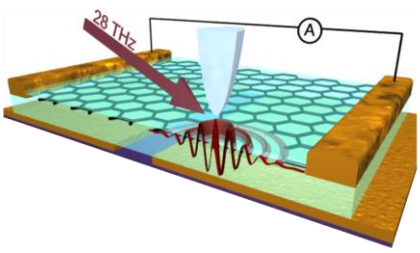

Figure 1: Electrical detection of propagation graphene plasmons

In addition, we will show working prototype demonstrators of several graphene-based photodetection applications. One tangible example we present is a wearable health monitor that is flexible and transparent, and fully integrated with hybrid graphene-quantum dot detectors. Additionally, we show the progress of monolithic integration of graphene with Si-CMOS electronics for infrared imaging applications (such as night vision).

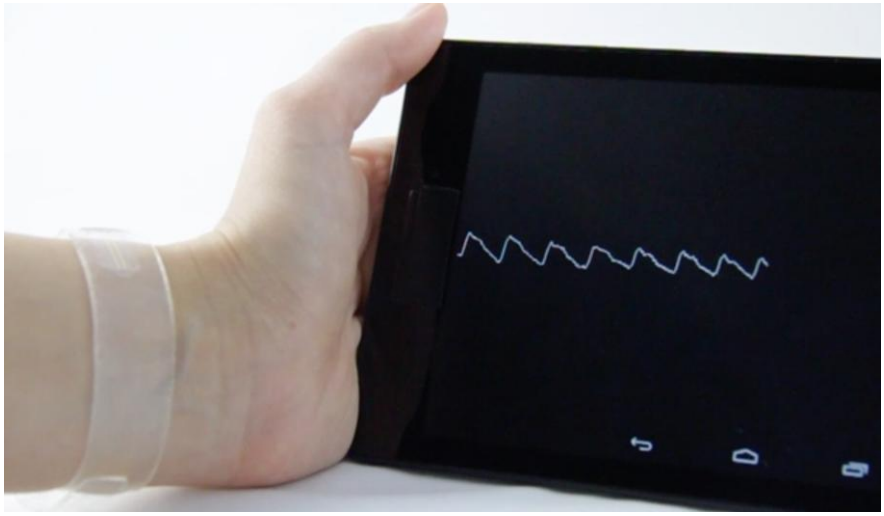

Figure 2: Prototype wearable fitness monitor based on graphene

References:

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[4] Near-field photocurrent nanoscopy on bare and encapsulated graphene. A. Woessner, Nature Communications (2016).
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[6] Ultra-confined acoustic THz graphene plasmons revealed by photocurrent nanoscopy
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