Photo-detection from photo-thermionic emission at Graphene/WSe2 interface

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Conventional photodetectors and solar cells based on semiconductors (or metal/semiconductor interfaces) suffer from two important performance limitations: they are insensitive to photons with energies lower than the bandgap (or Schottky barrier height), while excess photon energy is converted into thermal energy and considered as loss [1]. Here we introduce and experimentally demonstrate a novel way of detecting and harvesting light which overcomes both of the previous issues: the photo-thermionic (PTI) effect [2].

In our photodetectors based on a graphene/WSe_2/graphene heterostructure, photo-excited carriers are created in graphene upon near infrared light excitation; they redistribute their energy among other carriers and create a thermalized Fermi-Dirac distribution of so-called hot electrons. This enables a significant fraction of carriers to be injected over the energy barrier at the graphene/WSe_2 planar interface via thermionic emission, thus generating a photocurrent. We study a wide range of optical (wavelength, power, time delay) and electrical (bias voltage, gate voltage) parameters, and obtain a comprehensive understanding of the PTI effect.

We demonstrate a picosecond photo-response with 1% internal quantum efficiency at telecom wavelength. Thanks to the mechanism involved, performances should be conserved in mid-infrared and terahertz range. Moreover we identify clear strategies for reaching efficiency above 10%. This work paves the way for future optoelectronic applications that show size-scalable active area, electrical tunability, broadband and ultrafast response.

References

[1] C. Scales *et al.* IEEE Journal of Quantum Electronics, 46, 633 (2010)
[2] M. Massicotte *et al.* Nature Communications 7, 12174 (2016)

Figures

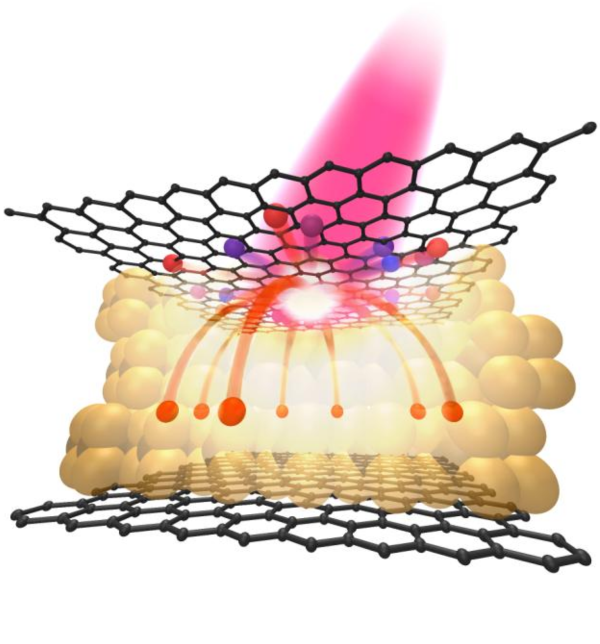

Figure 1: Artistic view of the photo-thermionic effect in our graphene/WSe_2/graphene device.