Optimizing Graphene Photothermoelectric Detectors

Aleandro Antidormi
A. W. Cummings
Catalan Institute of Nanoscience and Nanotechnology (ICN2),
Campus UAB, Bellaterra, 08193 Barcelona, Spain
aleandro.antidormi@icn2.cat

Owing to its unique properties, graphene is a promising material for a wide range of applications [1]. Particularly promising are applications that utilize several of graphene's unique properties in a single system or device. A perfect example of such devices are photodetectors based on the photothermoelectric effect (PTE) in graphene, which combine a broadband and fast photoresponse with high signal-to-noise ratio and minimal power consumption [2-5]. There are many design parameters impacting the performance of these devices, including the light profile, the device geometry, and the material quality.

In this talk, I will discuss the impact that these design parameters have on the performance of PTE-based graphene photodetectors, and I will demonstrate how their performance may be optimized[6]. Careful tuning of the light profile and device geometry can improve the photoresponse by more than one order of magnitude. Detector performance can also be improved with higher graphene material quality, but only to a point. When material quality is too high, Peltier cooling can degrade the photoresponse, indicating an upper bound on device performance and suggesting that ultraclean graphene may be unnecessary for, and actually detrimental to, the performance of these detectors.

REFERENCES

[1] A.C. Ferrari et al., *Nanoscale* **7**, 4598 (2015).
[2] X. Cai et al., *Nat. Nanotechnol.* **9**, 814 (2014).
[3] S. Schuler et al., *Nano Lett.* **16**, 7107 (2016).
[4] S. Castilla et al., *Nano Lett.* **19**, 2765 (2019).
[5] J. Muench et al., *Nano Lett.* **19**, 7632 (2019).
[6] A. Antidormi, A.W. Cummings, arXiv:2102.11225 (2021)

FIGURES

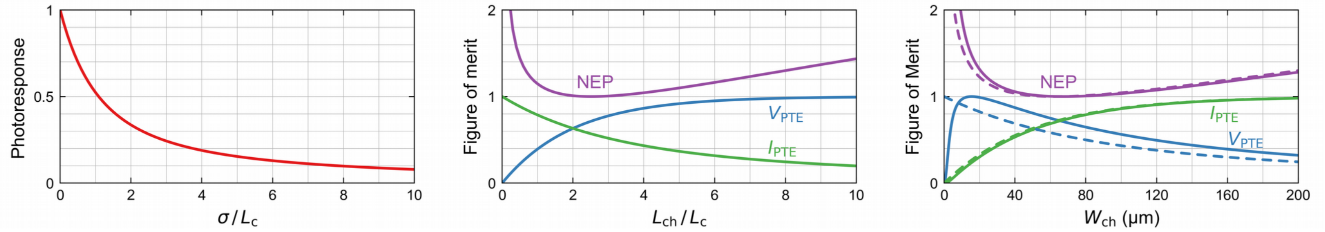

Figure 1: Graphene photodetector performance as a function of light profile size (left), channel length (middle), and channel width (right). NEP is the noise-equivalent power, I_{PTE} is the photocurrent, and V_{PTE} is the photovoltage. I_{PTE} and V_{PTE} are normalized to their maximum values, and NEP to its minimal value.