Theory and optimization of graphene photothermoelectric detectors

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This talk is part of the info session for the ULISSES project, which aims to develop a cheap, compact, efficient, and low-power multi-gas sensor. Here I will discuss the design and optimization of the photodetector component of the gas sensor, which is based on the photothermoelectric effect (PTE) in graphene [1-4]. There are many design parameters impacting the performance of this detector, including the light profile, the device geometry, and the material quality.

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. 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 [5].

References

[1] X Cai et al., Nat Nanotechnol 9, 814 (2014)
[2] S Schuler et al., Nano Lett 16, 7107 (2016)
[3] S Castilla et al., Nano Lett 19, 2765 (2019)
[4] J Muench et al., Nano Lett 19, 7632 (2019)
[5] A Antidormi and AW Cummings, Phys Rev Appl 15, 054049 (2021)

Figures

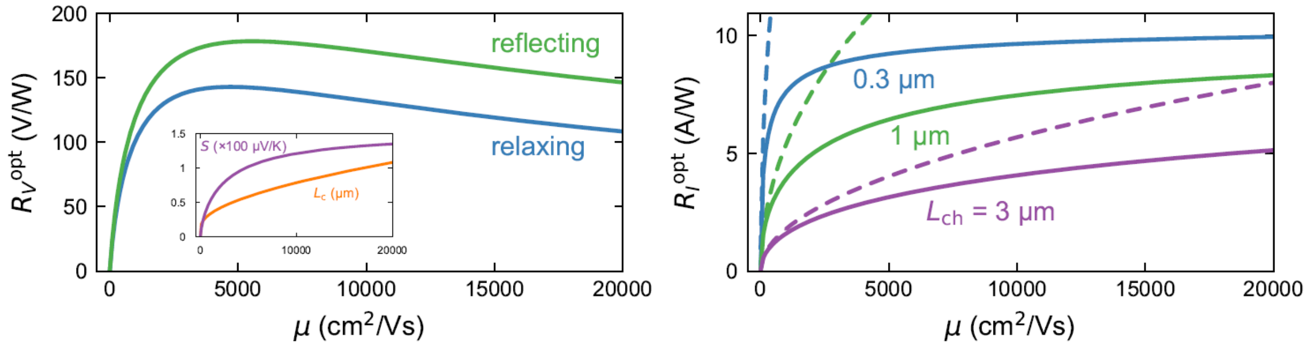

Figure 1: Optimal photovoltage (left) and photocurrent (right) as a function of graphene carrier mobility. In both cases, the photoresponse saturates for a mobility around 5000 cm2/Vs.