Dielectric optimization of graphene photodetectors

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Among its many useful properties, a particularly intriguing feature of graphene is its tunability through interaction with its environment. Choice of substrate, dielectric screening, chemical impurities, and proximity to other 2D materials can strongly modify its electrical, optical, or spintronic properties, to name a few. Recently, it has been shown that a high dielectric environment can significantly enhance the carrier mobility in graphene by screening out charged impurity scattering [1].

We use numerical simulations to examine the impact of dielectric environment on the performance of graphene photothermoelectric (PTE) detectors. Such detectors rely on the optical generation of hot carriers that are then detected via the Seebeck effect. In addition to the Seebeck coefficient (Fig. 1) and the hot carrier cooling time (Fig. 2), a number of other material and geometrical parameters play a role in the performance of graphene PTE detectors [2]. We examine the role of these various parameters, and make estimates of the gains in photoresponse that can be obtained by embedding graphene in a high dielectric environment.

References

[1] D. Domaretskiy et al., *Nature* **644**, 646-651 (2025)
[2] A. Antidormi and A.W. Cummings, *Phys. Rev. Appl.* **15**, 054049 (2021)

Figures

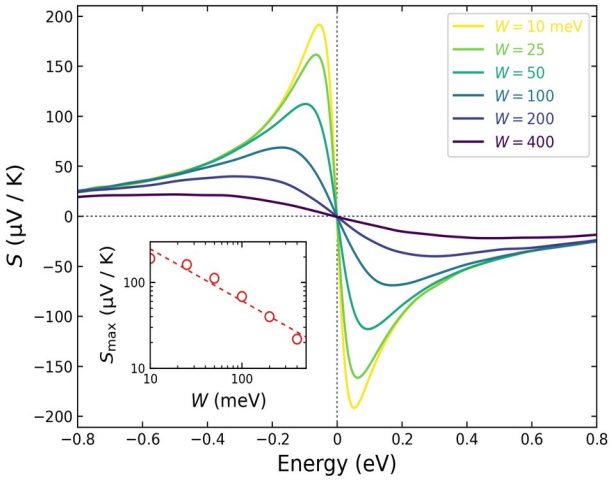

Figure 1: Seebeck coefficient of graphene for different electron-hole puddle strengths, tuned by the surrounding dielectric. Inset: peak value of the Seebeck coefficient at each puddle strength.

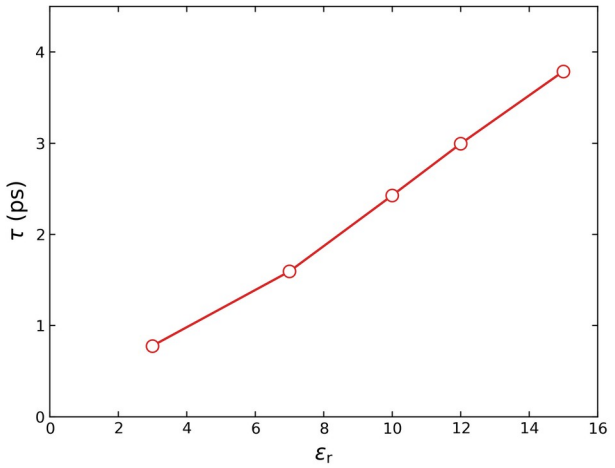

Figure 2: Hot carrier cooling time in graphene as a function of the surrounding dielectric.