Hot carrier-mediated thermoelectric effects in graphene fully encapsulated with hexa-BN

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Heat dissipation in electronic circuits is a key issue for the development of next generation devices. The generated heat has to be driven away from the electronically active region by engineering cooling mechanisms. The heat could also be recycled taking advantage of thermoelectric effects in which thermal gradients generated in the device are converted to electric voltages.
Two dimensional materials provide a fascinating yet under-explored platform for heat management and exploring thermoelectric effects due to the emergence of new phenomena that differ from those observed in three dimensional systems [1].
In this work I will show our recent research on hot-carrier generation and propagation in graphene using electrical means. The devices consist of graphene fully encapsulated with hexagonal boron nitride. Using two remote leads for electrical heating, a carrier temperature gradient is generated that results in a measurable thermoelectric voltage across the remaining detector leads. Due to the nonlocal character of the measurement, the non-local voltage is exclusively due to thermoelectric effects. As compared to our previous experiment on graphene on SiO_2 substrates [2], we observe an increase of the non-local signals and hot carrier propagation at remote distances as large as 6 um from the injection point. By studying the non-local signal as a function of the injected power we also get insight into the hot carrier cooling mechanisms involved in our devices. While at low injected powers the response appears to be associated to Joule dissipation, we immediately observe signatures of hot carrier cooling dominated by supercollisions when the power is increased [3]. We finally observe deviations from the simple supercollision model at higher powers that might be ascribed to a coupling of carrier in the graphene with (optical) phonon modes in the hexagonal boron nitride substrate [4].

References

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