Electron cooling mechanisms in graphene

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Abstract

An important consideration in graphene-based devices is thermal cooling of charge carriers, which can be overheated by the current applied to operate them. This heat must be dissipated to avoid thermal breakdown [1]. The main cooling mechanisms are: direct transfer of heat to the metallic contacts forming the source and drain of the device via diffusion of electrons [2]; transfer of heat to the graphene lattice via scattering of electrons by acoustic phonons [3]; and transfer of heat directly to the underlying substrate via scattering of electrons by surface mode phonons of the substrate [4].

We probe the heat dissipation mechanisms in monolayer graphene devices supported on silicon dioxide [5] through measurements of the (differential) resistance, *R*, as a function of DC source-drain bias, *V*, and temperature, *T*. *R*(*V*) is shown to become increasingly non-linear as the temperature of the surrounding system is decreased from 300 K down to 4 K. By combining numerical modelling with measurements of *R*(*T*), we demonstrate that this non-linearity is caused by significant overheating of the electron gas above the lattice temperature. The form of the bias dependence is shown to contain information about the influence of the different dissipation mechanisms on electron cooling.

References

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