Thermal infrared emission from large area graphene

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Thermal infrared emission has been used extensively over the last few years as a means of probing the electronic structure of graphene transistor devices under bias [1,2]. In such devices, the thermal infrared emission is not spatially uniform and a maximum in emission (a "hotspot") occurs at the place in the sample corresponding to the minimum in conductivity at the Dirac point.

So far, these studies have been confined to relatively small (tens of microns) samples fabricated using exfoliated graphene. In this paper we describe measurements made on large area (3mm x 3mm) devices fabricated from graphene grown by chemical vapour deposition and then transferred onto SiO_2/Si wafers. We have investigated the spatial characteristics of the thermal infrared emission, mapped using a scanning detector, as a function of current through the device, current direction and also of frequency. At relatively low frequencies a peak in emission occurs, as shown in Figure 1, the position of which can be altered by the application of a bias applied between the source and gate contacts, or by reversal of the current direction. We believe that this peak in emission is due to Joule heating at the Dirac point, as has been seen in smaller exfoliated devices, and the magnitude of the emission demonstrates a dependence on the current squared (electrical measurements made on the same device show a peak in device resistance as a function of applied gate bias). At high frequencies (up to 100kHz) a more complex spatial characteristic is observed, which we believe is due to the manifestation of mechanisms other than Joule heating. These are the currently the subject of further investigation.

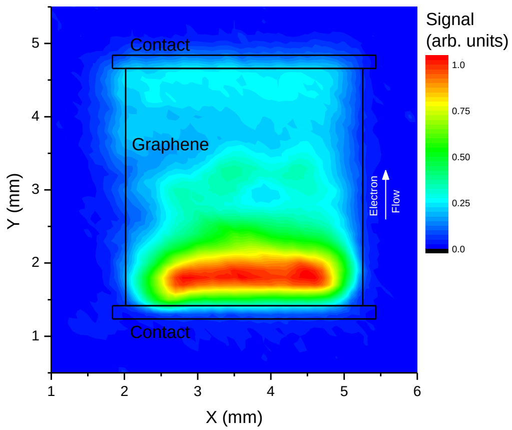

Figure 1: Thermal infrared emission mapped with the electron current going from bottom to top. Measurements were performed with the device under vacuum, and driven with a 1kHz square waveform (50% duty cycle) with a peak injection current of 20mA, and at room temperature.

[1] M. Freitag, H.-Ying Chiu, M. Steiner, V. Perebeinos and P. Avouris, Nature Nanotech. **5**, 497 (2010).
[2] M.-Ho Bae, S. Islam, V. E. Dorgan, and E. Pop, ACS Nano **5**, 7936 (2011).