In-plane injection of electrons into graphene: extended diffusive modes and light emission

Heiko B. Weber
Christian Ott, Matthias Popp
Department of Physics, Staudtstr. 7. 91058 Erlangen, Germany

Heiko.weber@fau.de

We employ graphene-graphene tunnel junctions to study the interplay of the extremely local effect of electron tunnelling and micrometer-sized long-range modes in the electrodes. The material system epitaxial graphene on SiC (0001) is ideally suited for such experiments due to the extreme mechanical and thermal stability of both graphene and SiC, its well-known structure and the almost full transparency of the system.

We study in-plane injection of electrons into epitaxial graphene by graphene-graphene tunnel junctions [1], in contrast to previous studies with out-of-plane injection from metallic tips [2]. In the very-low energy regime, at low temperatures, we find purely electronic tunnelling and no detectable phonon threshold. An energy- and temperature dependent zero-bias suppression of the current with its very characteristic scaling indicates that the charge of the tunnelling electron couples to extended diffusion modes [3].

The very same tunnelling junctions are subsequently used to study light emission in the visible and near-infrared spectral range. In the low-voltage regime, it is the granular nature of the tunnelling current that couples to extended bosonic modes and triggers light fields. In the high-voltage regime that reaches up to 7 volts (i.e. well beyond the work function) a surprising and non-trivial voltage dependence is discussed. Among the possible interpretations of electroluminescence, we find convincing arguments that the assignment of the spectra to black-body-radiation is unlikely. We discuss the data considering known line defects that generate rich phenomenology [4].

References

[1] K. Ullmann, P.B. Coto, S. Leitherer, A. Molina-Ontoria, N. Martin, M. Thoss, H.B. Weber, Nano Letters, 15, 3512-3518 (2015).
[2] R. Beams, P. Bharadwaj, L. Novotny, Nanotechnology, 25, 055206 (2014).
[3] F. Kisslinger, M. Popp, J. Jobst, S. Shallcross, H.B. Weber, Annalen der Physik, 529, 1700048 (2017).
[4] B. Butz, C. Dolle, F. Niekiel, K. Weber, D. Waldmann, H.B. Weber, B. Meyer, E. Spiecker, Nature, 505, 533 (2014).

Figures

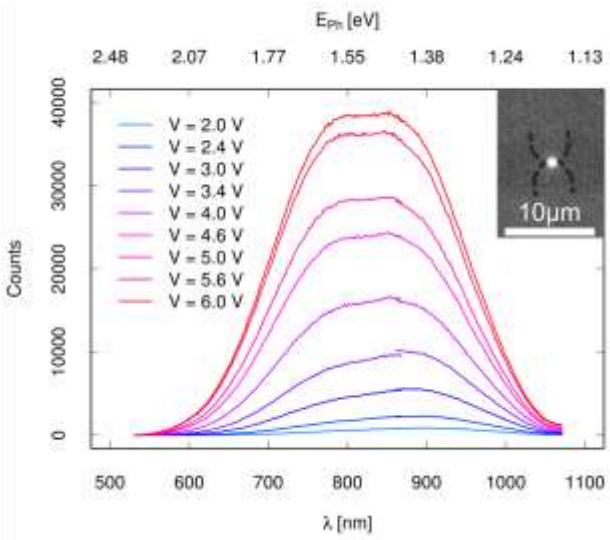

Figure 1: A graphene-graphene tunnelling junction emits light (inset), which is bright enough that it can be seen with the bare eye. The data shown are electroluminescence spectra for various applied voltages.