

Electrical contacts in graphene devices - 2D vs. 1D contact architecture

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Abstract

One key bottleneck on the route to improve graphene devices for electronic and optoelectronic applications are the graphene/metal contacts. Currently, 2D side contacts prepared by optical lithography are state of the art, where the metal electrode is on top of or below the graphene layer. These contacts show resistances up to several $k\Omega\mu\text{m}$, thus limiting the device performance. It is therefore crucial to microscopically understand and finally overcome the current limitations of contact architectures in devices prepared by optical lithography.

For a systematic investigation, we prepared several devices with 2D contacts by means of optical lithography. We used a combination of atomic force microscopy (AFM) patterning, Kelvin probe force microscopy (KPFM) and micro-Raman mapping to study the impact of the lithography process on the contact resistance. Significant contact resistance values of $\gg 1 k\Omega\mu\text{m}$ (Fig. 1, left) were measured, which could be attributed to a residual optical resist layer with a thickness of 3-4 nm in-between the metal and the graphene. Removing the residual layer by AFM tip shows no damage of the graphene as being confirmed by Micro-Raman mapping. Therefore we conclude that the residual layer was only physically bonded to the graphene [1].

To circumvent the influence of the optical resist residues and to improve the contact resistance 1D contacts are prepared by optical lithographic process. In this type of contacts, the charge transfer from graphene to metal is at the graphene edges. Using KPFM voltage drop measurements, we could demonstrate a significantly lower voltage drop at the metal/graphene contacts with contact resistance values less than $200 \Omega\mu\text{m}$, which is an improvement of at least one order of magnitude compared to 2D contacts prepared by optical lithography (Fig. 1, right). The homogeneous potential drop distribution between the drain and the source contact indicates a high quality of the 1D contact.

References

[1] C. Alvarado Chavarin, A. A. Sagade, D. Neumaier, G. Bacher, W. Mertin, Appl. Phys. A, **122** (2016) 1-5.

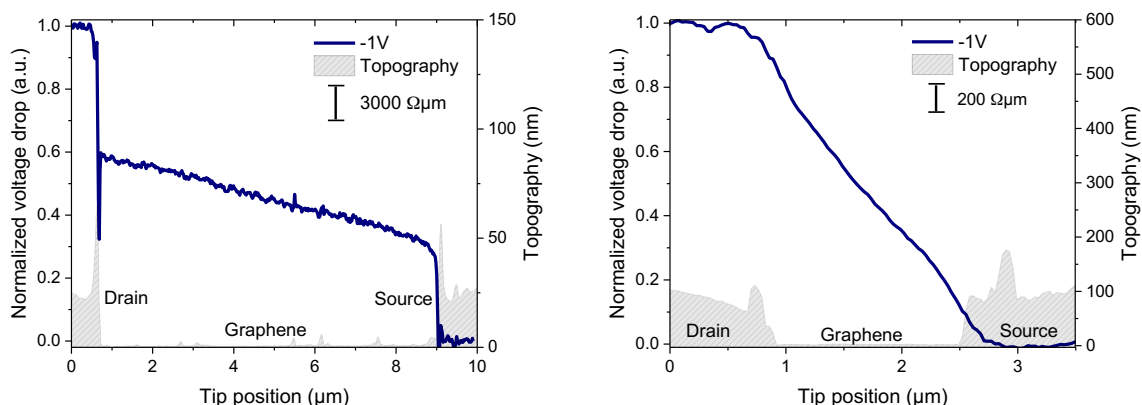


Fig. 1: Normalized voltage drop along the graphene channel for a 2D contact (left) and a 1D contact (right). The voltage drop at the metal/graphene junction defines the contact resistance.