Transfer length investigation in graphene-contacted 2D nanoparticle networks

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Abstract

Nanoparticle network devices find growing application in sensing and electronics [1,2], where one recurring challenge is ensuring a stable interface via robust yet unobstructive electrodes. Charge transfer from electrodes into micro- and nanoscale electronic devices is commonly characterized by macroscopic or global methods [3]. However, we find that traditional contact characterization using the transmission line model [4], an indirect method which requires extrapolation, is insufficient for network devices; these systems can appear highly uniform on a macroscopic scale yet are inherently discrete as one approaches the length scale of their building blocks. Top access to the nanoparticle network in these devices, by using a bottom-contact geometry, can facilitate the direct and local characterization of the nanoparticle networks. An ideal electrode material for this is graphene, which provides a pristine and highly inert surface with atomically sharp borders, allowing us to fabricate virtually coplanar devices. We can then use Kelvin probe force microscopy (KFM) to characterize the contact resistance by imaging the surface potential with nanometer resolution. We then perform scanning probe lithography to directly investigate the contact transfer length, a figure of merit which dictates the minimum electrode overlap required for optimal charge injection into the network. We have determined transfer lengths in our devices to be 200-400 nm, thus apt for further device reduction which is often necessary for on-site sensing applications. Simulations from a two-dimensional resistor model support our observations.

References

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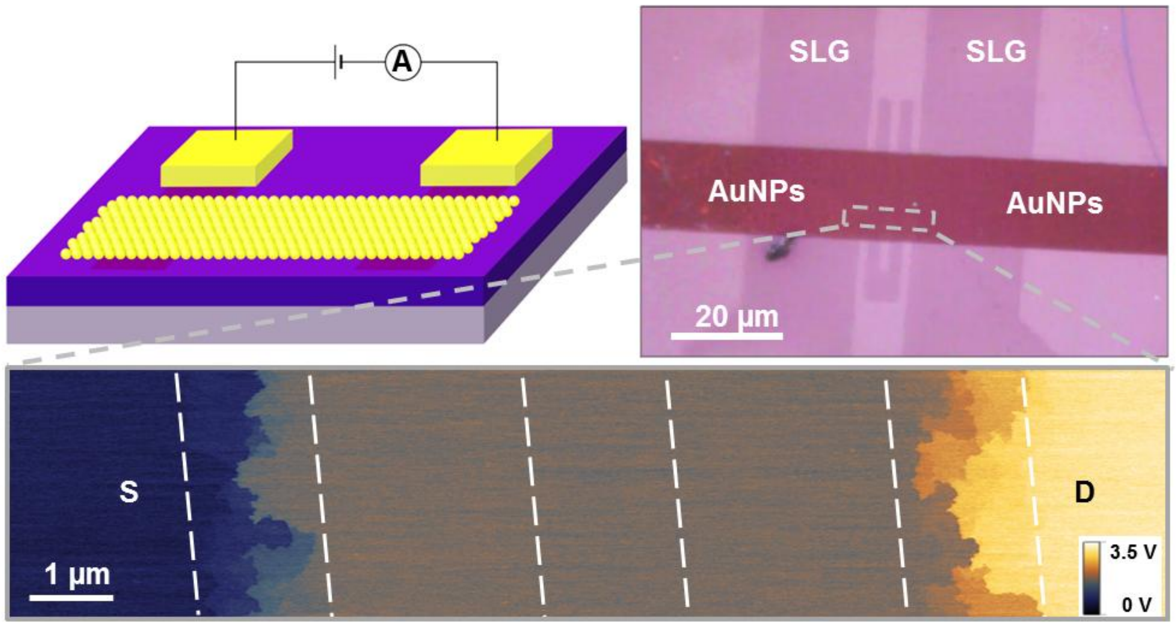

Top: Schematic and optical image of graphene contacted device. Bottom: KFM image of the nanoparticle network region shown in the optical image. In addition to the outer source and drain, an equipotential floating graphene structure flattens the potential landscape in the middle three sections.