Exceptional ballistic transport in self-assembled sidewall graphene nanoribbons

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The patterning of graphene into graphene nanoribbons is an essential task for the development of future graphene based electronic devices. For such ribbons with a well-ordered edge geometry the presence of one-dimensional edge states has been predicted. We use a selective graphitization process on the sidewalls of SiC mesa structures to produce graphene nanoribbons with a width of 40 nm. The local electronic properties of the ribbons are investigated by means of a 4-tip scanning tunneling microscope (STM). In combination with a high-resolution scanning electron microscope (SEM), the precise positioning of all four tips on the nanometer range is possible to perform local transport measurements [1] (cf. Fig. 1(a)). Additionally, one of the STM tips can be used for scanning tunneling spectroscopy (STS) to gain an insight into the local density of states. The STS reveals two peaks in the local density of states at the edges of the ribbons which can be attributed to the zeroth subbands in the band structure of a ferromagnetic zig-zag graphene nanoribbon [2]. Transport experiments carried out on the very same ribbon show a conductance close to e^2/h for a wide temperature range from 30 K up to room temperature and probe spacings between 1 µm and 10 µm. Description within the Landauer formalism is possible assuming ballistic transport dominated by a single channel. Transport in the second zeroth subband is only detectable for probe spacings smaller than 1 µm due to the short localization length of carriers in this subband. This manifests in the increase of the conductance to 2 e^2/h at probe spacings below 200 nm (cf. Fig. 1(b)). As a consequence, it is possible to selectively measure transport in one or two ballistic channels. Remarkably, 4-point probe and 2-point probe configurations result in almost identical conductance values as expected for a ballistic conductor measured with fully invasive probes. This invasiveness of the probes can be used to give further evidence for the ballistic nature of transport, simply by introducing one or two additional passive probes in a 2-point probe configuration. Every additional passive probe doubles or triples the observed resistance, a clear indication for single-channel ballistic transport [3].

References

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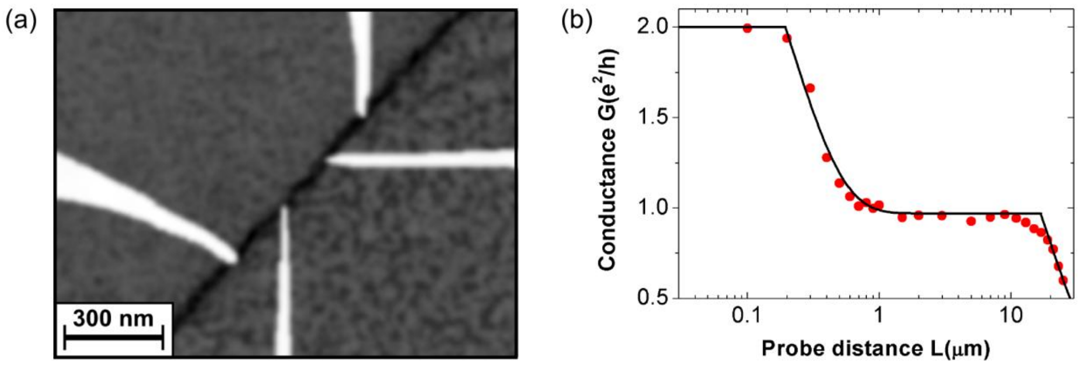

Fig. 1: (a) SEM image of four probes contacting a sidewall graphene nanoribbon. (b) Conductance as a function of probe spacing of a sidewall graphene nanoribbon.