

Quantized conductance of graphene constrictions patterned by atomic force microscope-based lithography

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Signatures of quantized conductance already have been reported in suspended graphene [1], however with limited control on constriction width. In graphene nanoconstrictions sandwiched by hexagonal boron nitride evenly spaced modulations (kinks) have been found and interpreted as size quantization signatures, superimposed on the linear conductance at the zero external magnetic field [2]. After all, these kinks only appear far away from the Dirac point at elevated conductance values mainly due to the charging of localized trap states from the rough edges of the patterned devices limiting the precise observation of charge quantization in graphene. Besides, there have been no report on conductance plateaus in graphene on silica to this day.

Instead of reactive ion etching, using atomic force microscope-based technique to pattern narrow constrictions can lead to unique insight of charge quantization. Here we report on the observation of quantum confinement through graphene constrictions prepared by AFM-based lithography. As a result of the capability of measuring the precise atomic orientations in graphene, attentively etched lines have been formed, aligned in specific atomic orientations resulting unprecedented smooth edges. The roughness of the edges can be estimate under 2 nm according to atomic force microscope-based measurements. The conductance through the constrictions have been measured as a function of back gate voltage applied on the Si substrate to tune the carrier density in the graphene layer at temperatures near 1.5 K. At zero external magnetic field even-spaced plateau-like features have been identified, roughly spaced by 2 times e^2/h . Applying high magnetic field, even to $B = 8T$, plateaus, spaced even by roughly 1 e^2/h have been observed due to the degeneracy lifting. With this first observation of conductance plateaus in graphene on silica we are one step forward to the long standing goal of graphene based quantum computing.

References

- [1] N. Tombros et al., Nat. Phys. 7, 697-700 (2011).
- [2] B. Terrés et al., Nat. Comm. 7, 1-7 (2016).

Figures

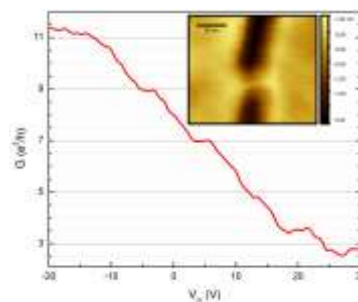


Figure 1: two-probe conductance through constriction ($T \sim 1.5$ K, $B = 0$ T) showing conductance quantization steps by 2 e^2/h , inset: AFM topographic image of a graphene constriction