High Quality Graphene Superlattices via Ion Milled Etching Masks

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Moiré superlattices formed from twisted layers of graphene have been shown to host a range of phenomena including quantized anomalous Hall states, magnetism and superconductivity [1] however variations in the twist angle and resulting moiré period are a source of disorder. As an alternative to the uncertainty in reproducibility of moiré systems, a superlattice potential can instead be engineered in graphene using patterned gate electrodes to similarly produce a band structure with tunable characteristics [2].
This work presents the use of helium ion beam milling to produce etch masks with precise control of geometry and periodicity creating a superlattice potential in graphene with a pitch below 20nm [3]. Integrating the patterned gate arrays into van der Waals heterostructures allows the realisation of a superlattice without sacrificing the intrinsically high mobility of graphene. For the first time in gate patterned graphene superlattices we observe unambiguous ballistic transport through magnetic focussing measurements indicating mean free paths limited by device dimensions rather than disorder as well as the characteristic superlattice phenomena including secondary Dirac points and Hofstadter butterfly spectra.

References

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[2] Jessen, B.S., Gammelgaard, L., Thomsen, M.R. et al. Lithographic band structure engineering of graphene. Nat. Nanotechnol. 14, 340–346 (2019).
[3] Barcons Ruiz, D., Herzig Sheinfux, H., Hoffmann, R. et al. Engineering high quality graphene superlattices via ion milled ultra-thin etching masks. Nat Commun 13, 6926 (2022)

Figures

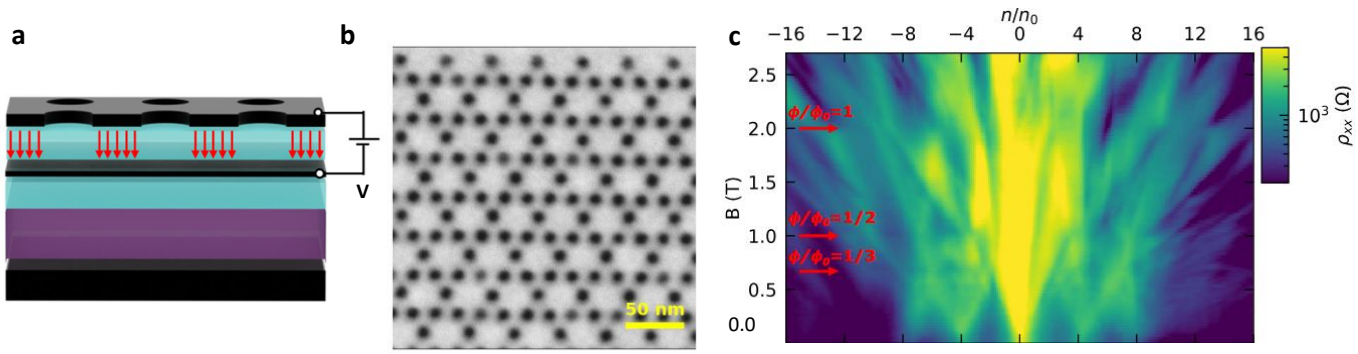

Figure 1: a) Schematic diagram of heterostructure showing the influence of the patterned gate on graphene. **b)** STEM image of the HE ion milled etching mask. **C)** Longitudinal magneto-resistance measurements, showing Hofstadter butterfly of a device with 47nm pitch square lattice geometry