Lithographic band structure engineering of graphene

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Materials with a low intrinsic dimensionality, such as the two-dimensional material graphene, allow direct access to all the atoms constituting the crystal, making engineering of the band structure by nanolithography particularly attractive. However, contamination and edge disorder have for many years limited experimental realisation.

On this poster, we show the fabrication of a 35nm-period superlattice of etched holes in graphene separated by as little as 12-15nm [1]. The graphene is encapsulated in hexagonal boron nitride (hBN), to protect it from contamination, and situated on a graphite back gate. "Mezzanine" edge contacts are made taking advantage of selective etch processes to only etch the top hBN and graphene, see figure 1. The nanostructure is defined by electron beam lithography, where we find the best results, regarding both resolution and low roughness, are obtained using single-shot exposures. One part of the graphene is left pristine while another part is shaped into the densely patterned superlattice, allowing simultaneous measurement and thereby a direct comparison of patterned and non-patterned graphene in a single device.

We observe the clear hallmark of a distinct magnetotransport regime, with a nonlinear Landau level fan for the nanostructured graphene, with a band gap of 156meV that can be tuned by a magnetic field. The measurements are accurately described by transport simulations and analytical calculations, see figure 2.

References

[1] B. S. Jessen, L. Gammelgaard, *et al.*, Nat. Nano. 14 (2019) 340-346

Figures

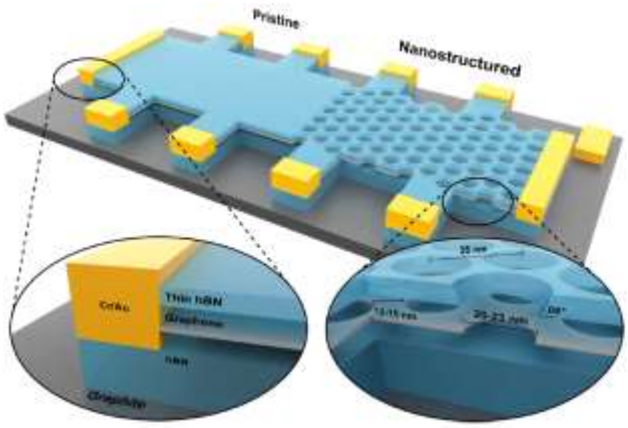

Figure 1: Illustration of the device architecture of hBN encapsulated graphene with a graphite back gate. The device has two regions, one of nanostructured graphene and one of pristine graphene, for direct comparison.

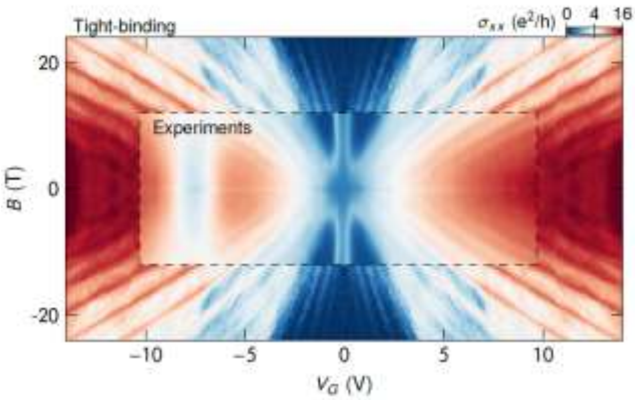

Figure 2: Comparison of σ_{xx} from tight-binding transport simulations and the experimental transport measures of the nanostructured graphene at 4K.