LEEM imaging of the moiré pattern of twisted bilayer graphene

Tobias A. de Jong[1]
T. Benschop[1], X. Chen[1], R.M. Tromp[2,1], M. De Dood[1], D. Efetov[3], F. Baumberger[4,5], M. P. Allan[1], S.J. Van der Molen[1]
[1]*Leiden Institute of Physics, Niels Bohrweg 2, Leiden, The Netherlands*
[2]*IBM T.J. Watson Research Center, Yorktown Heights, New York 10598, USA*
[3]*Institut de Ciencies Fotoniques, Castelldefels, Barcelona, Spain*
[4]*Department of Quantum Matter Physics, University of Geneva, Switzerland*
[5]*Swiss Light Source, Paul Scherrer Institute, CH-5232 Villigen PSI, Switzerland*
jongt@physics.leidenuniv.nl

The discovery that magic angle twisted bilayer graphene (MABLG) is a superconductor, yields the promise of exciting new solid state physics. In particular, gating enables exploration of the phase diagram not possible in cuprates [1]. However, the influence of inhomogeneity of twist angle, strain and defects on charge transport properties in these exfoliated, torn and stacked flakes remains an important open question.
Here, we demonstrate that Low Energy Electron Microscopy (LEEM) can directly image MABLG on the full device scale, identifying specific areas of the magic twist angle. This has enabled efficient Nano-ARPES measurements confirming the existence of flat conduction bands [2]. Furthermore, we show direct LEEM imaging of the moiré pattern near the magic angle and compare monolayer-on-monolayer to bilayer-on-bilayer graphene. By stitching high magnification images, we map the moiré pattern at 2 nm resolution over large areas of several micrometers. Using this data, local variations in twist angle and strain are extracted from the moiré pattern by geometric phase analysis [3]. The direct observability of these properties establishes the potential of LEEM to this field of physics.

REFERENCES

[1] Y. Cao, et al., Nature **556**.7699 (2018): 43-50.
[2] S. Lisi*, X. Lu*, T. Benschop*, T.A. de Jong* et al., *Nat. Phys.* (2020) doi:10.1038/s41567-020-01041-x
[3] T. Benschop*, T.A. de Jong*, P. Stepanov* et al., arXiv:2008.13766

FIGURES

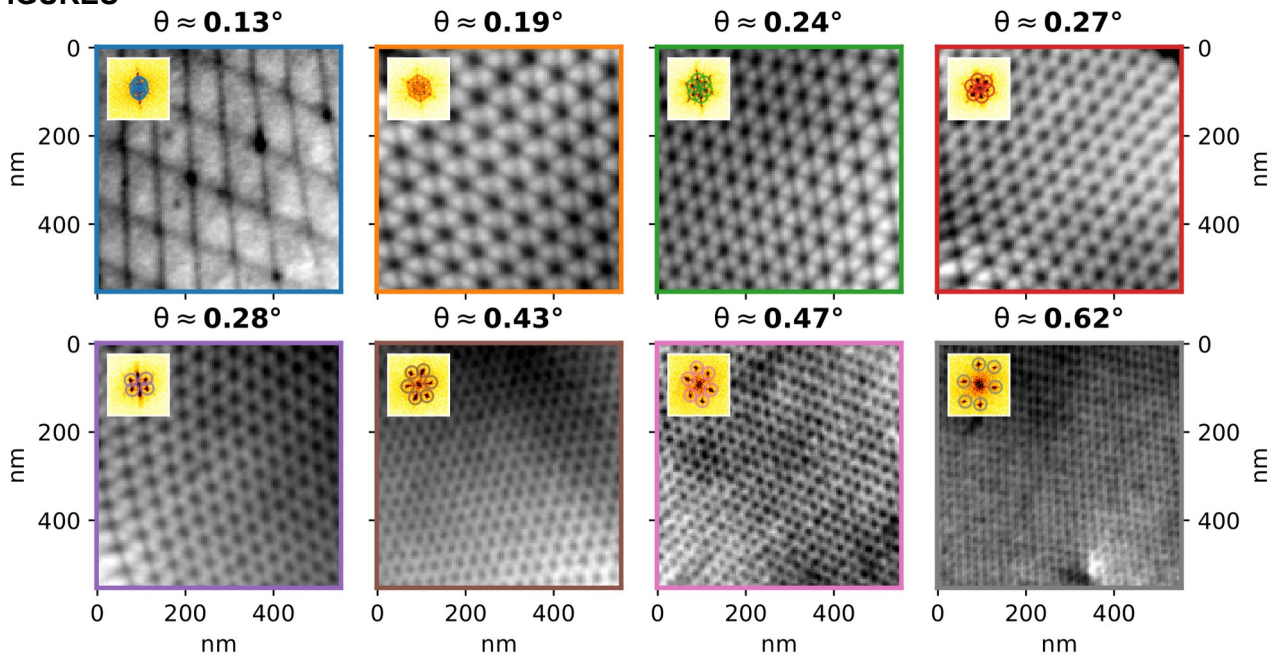

Figure 1: LEEM images of different areas of twisted bilayer graphene, showing moiré patterns of different twist angles, each with clear lattice distortions. Insets shows FFTs and extracted reciprocal super lattice vectors indicated by circles.