Unreconstructed bilayer graphene superlattices at twist angles below one degree

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In twisted bilayer graphene, at some 'magic' angles the Dirac velocity vanishes and flat bands emerge, leading to enhanced density-of-states near the Fermi level [1]. Various strongly correlated phases, including unconventional superconductivity, have been identified near the first magic angle of 1.1°, opening the field of graphene twistronics [2]. However, even stronger correlations and potentially richer electronic phases are predicted to emerge at lower magic angles. The realization of such large moiré superlattices so far has been hindered by the atomic reconstructions occurring at lower twist angles, due to the competition between interlayer coupling and intralayer elastic deformation [3].
Here, we show that unreconstructed twisted bilayer graphene superlattices can be realized below 1 degree twist angles, even down to the lowest predicted magic angle of 0.2°. By weakening the mechanical coupling between the layers, the driving force for reconstructions can be supressed, while still keeping the electronic coupling between the layer strong enough for the flat bands to emerge. The absence of bubbles, containing contaminations trapped between layers is a telltale sign that the mechanical coupling between the graphene layers is not strong enough to squeeze the contamination into such bubbles. In such cases, unreconstructed moiré patterns can be observed, even for twist angle lower than 1 degree, by conductive atomic force microscopy or scanning tunneling microscopy. Fabricating such novel type of twisted bilayer graphene samples with weakened mechanical interlayer coupling can unlock the rich physics of strongly correlated systems, expected at lower magic-angles.

References

[1] Bistritzer, R. & MacDonald, A. H., *Proc. Natl Acad. Sci.* **108** (2011) 12233–12237.
[2] Cao, Y. *et al.*, *Nature* **556** (2018) 43–50.
[3] Yoo, H. *et al.*, *Nat. Mater.* **18** (2019) 448–453.

Figures

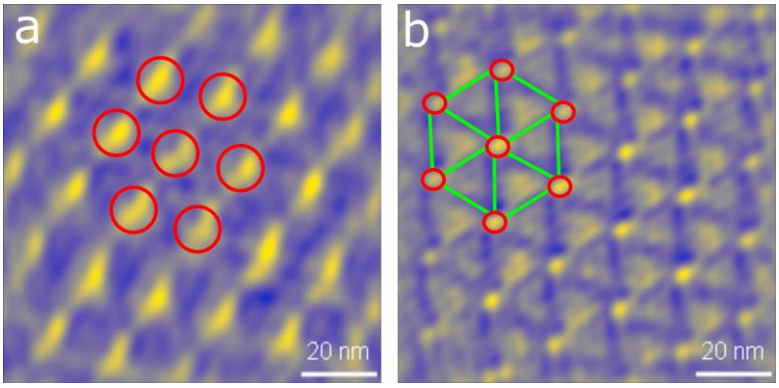

Figure 1: Conductive AFM current images of bilayer graphene with twist angle of ~0.7° with decreased atomic reconstructions (a) and fully reconstructed (b), as indicated by the size of AA regions (red circles) and soliton domain walls (green lines).