Bilayer graphene superlattices at twist angles below one degree: unreconstructed states

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Abstract (Century Gothic 11)

Twisted bilayer graphene (TBG) exhibits remarkable electronic properties at specific "magic" twist angles, where the Dirac velocity vanishes and flat bands emerge, enhancing the density of states near the Fermi level [1]. These flat bands give rise to strongly correlated phases, including unconventional superconductivity, particularly at the first magic angle of 1.1°, establishing the foundation of graphene twistronics [2]. Lower magic angles, such as 0.2°, are predicted to host even stronger electronic correlations and novel quantum phases. However, their experimental realization has been hindered by atomic reconstructions driven by the interplay between interlayer coupling and intralayer elasticity, which disrupt the formation of uniform moiré superlattices at low twist angles [3].

In this work, we demonstrate that TBG superlattices can be stabilized at twist angles below 1°, including the lowest magic angle, by reducing the mechanical coupling between graphene layers. This approach suppresses atomic reconstruction while preserving the strong electronic coupling necessary for flat-band formation. Evidence of weak mechanical coupling is provided, for example, by the absence of contamination-induced bubbles. The unreconstructed moiré patterns were characterized using conductive atomic force microscopy and scanning tunneling microscopy. These findings pave the way for fabricating pristine low-angle TBG samples, unlocking new opportunities to investigate the rich physics of strongly correlated systems predicted at these unexplored magic angles.

References

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[3] Yoo, H. et al., Nat. Mater. 18 (2019) 448–453.