A Novel way to Obtain Twisted Bilayer Graphene via Wet Transfer

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Twisted Bilayer Graphene (TBLG) has emerged as a fascinating frontier in condensed matter physics and materials science, with its electronic band structure significantly altered by the relative rotation between layers.[1] The Moiré pattern created by this rotation constrains electron trajectories to localized regions known as Moiré islands, whose size is inversely proportional to the rotation angle. At a rotation of approximately 1.1°, flat electronic bands emerge near the Fermi level, leading to strong correlation-driven phases.[2-4] Within these bands, electrons exhibit drastically reduced velocities, fostering strong correlation-driven phases. Many studies[5,6,7] have focused on this specific region; however, beyond the so-called magic angle, a broad range of twist angles gives rise to diverse band structures, opening avenues for the discovery of new physical phenomena.

Here, we introduce a straightforward wet-chemistry approach as an alternative to the conventional "tear-and-stack" method for fabricating TBLG with rotation angles between 3° and 22°. Our method involves several chemical etching steps to dissolve the catalytic copper substrate used for graphene monolayer growth via chemical vapor deposition (CVD) on both sides. As the copper is gradually removed, the monolayers naturally collapse onto each other, forming a range of twist angles. Using this technique, we successfully produced TBLG structures with twist angles ranging from 3° to 22°. High-resolution transmission electron microscopy (HRTEM) and electron energy loss spectroscopy (EELS) were employed for precise structural and electronic characterization. These analyses enabled accurate determination of interlayer rotation angles and the identification of hybrid Van Hove singularities induced by Moiré patterns. Our work presents a simple, scalable alternative to the tear-and-stack method, broadening the toolkit for TBLG fabrication and exploration.

References

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Figures

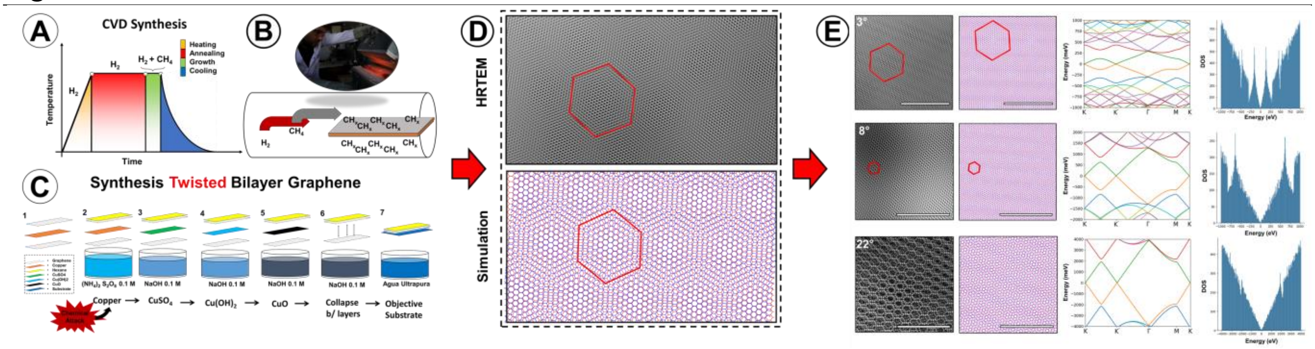

Figure 1: (A) Process of graphene synthesis and transfer; with its characteristic temperature curve for graphene synthesis, showing the heating, annealing, growing and cooling stages, with indication of the presence of H_2 and CH_4 gases. (B) CH_4 dehydrogenation process during the growth stage, with graphene growing on the Cu catalyst substrate on both sides. (C) Steps for the transfer of TBLG to a target substrate, detailing the seven stages of the process. (D) Schematic of the TBLG obtained, with Moiré patterns generated by the superposition of layers. **(E)** HRTEM image, structure simulation, band structure and density of states for different angles obtained of TBLG; upper-panel 3° (A), mid-panel 8° (B) and bottom-panel 22°; scale bar is 5 nm.