Graphene ribbon self-assembly in the presence of self-assembled stripe absorbates

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Abstract: Adhered graphene strips anchored to a host sheet by a pleat-like fold can self-assemble in ambient conditions into long ribbons micrometers in size through combined processes of self-tearing, substrate peeling and ultra-low friction sliding [1], a process we refer to as "auto-kirigami". Nominally enabled by low friction of structural superlubricity expected for incommensurate atomic lattice contacts [2], we report evidence here that a ubiquitous stripe-like structure previously observed on graphene surfaces [3] remains within the interface during sliding of an auto-kirigami ribbon and its host sheet. This structure consists of an adsorbate layer of alkane chains which forms within 4-5 days of exposure of pristine surfaces to air [4] and is associated with friction force microscopy domains on graphene surfaces [5]. Atomic Force Microscopy (AFM) PeakForce Quantitative Nanomechanical Mapping was used to characterise self-assembled pleats, revealing the presence of the ordered adsorbate structure on all exposed surfaces. That pleat self-assembly was not supressed by the presence of stripes indicates that these adsorbates do not appreciably degrade low friction superlubricity. Rotating the self-assembled ribbons with the AFM tip revealed that the stripe-formation adsorbates stably exist within graphene-graphene interfaces, in disagreement with claims that attractive vdW forces squeeze out contaminants from within interfaces [6].

References

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[3] Wastl, D. et al., ACS Nano, 11 (2013) 10032-10037
[4] Pálinkás, A. et al., Nature Communications, 1 (2022) 6770
[5] Gallagher, P. et al., Nature Communications, 1 (2016) 10745
[6] Geim, A. K. and Grigorieva, I. V., Nature, 7459 (2013), 419–425.

Figures

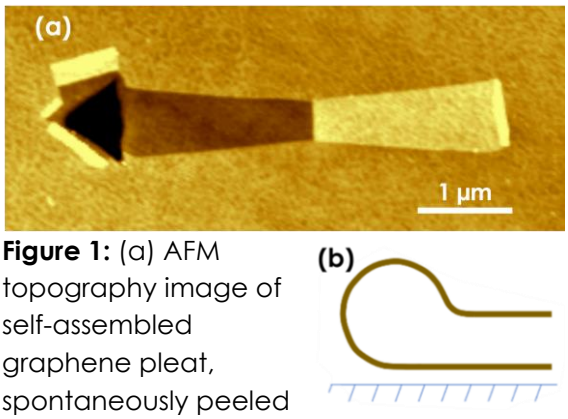

Figure 1: (a) AFM topography image of self-assembled graphene pleat, spontaneously peeled from 300 nm SiO_2/Si substrate. (b) Sideview sketch of pleat fold.

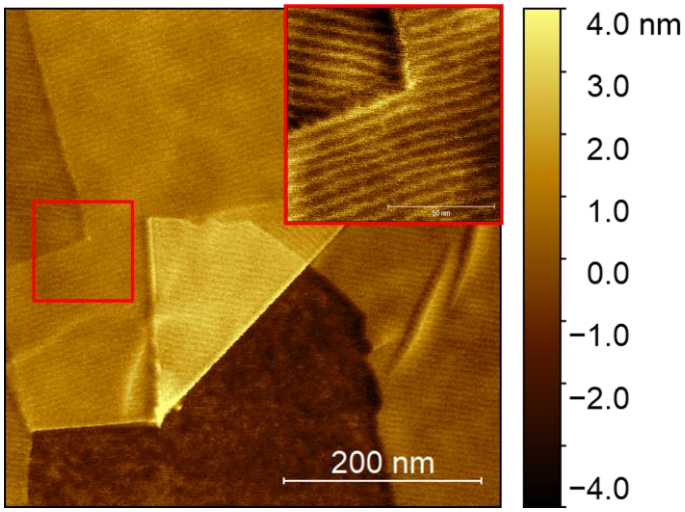

Figure 2: AFM topography image of pleat fold within 180 minutes of AFM manipulation resulting in further folding of a corner of pleat. Self-assembled stripe adsorbates are observed on all graphene surfaces including areas newly exposed by micromanipulation. Inset top-right: zoom of area highlighted in red in main image