Direct imaging of atomic-scale ripples in few-layer grapheme

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Graphene has been touted as the prototypical two-dimensional solid of extraordinary stability and strength. However, its very existence relies on out-of-plane ripples as predicted by theory [1] and confirmed by experiments [2,3]. Evidence of the intrinsic ripples has been reported in form of broadened diffraction spots in reciprocal space [2,3], in which however all spatial information is lost. Here we show direct real-space images of the ripples in a few-layer graphene (FLG) membrane resolved at the atomic scale using monochromated aberration-corrected transmission electron microscopy (TEM). The thickness of FLG amplifies the weak local effects of the ripples, resulting in spatially varying TEM contrast that is unique up to inversion symmetry. We compare the characteristic TEM contrast with simulated images based on accurate first-principles calculations of the scattering potential. Our results characterize the ripples in real space, and suggest that such features are likely common in ultra-thin materials, even in the nanometer-thickness range.

References:

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