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Imaging the Structure of Grains, Grain Boundaries, and Stacking Sequences in Single and Multi-Layer Graphene[1]

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Graphene can be produced by chemical vapor deposition (CVD) on copper substrates on up to meter scales [1, 2], making their polycrystallinity [3,4] almost unavoidable. By combining aberration-corrected scanning transmission electron microscopy and dark-field transmission electron microscopy, we image graphene grains and grain boundaries across six orders of magnitude. Atomic-resolution images of graphene grain boundaries reveal that different grains can stitch together via pentagon-heptagon pairs. We use diffraction-filtered electron imaging to map the shape and orientation of several hundred grains and boundaries over fields of view of a hundred microns. Single, double and multilayer graphene can be differentiated, and the stacking sequence and relative abundance of sequences can be directly imaged. These images reveal an intricate patchwork of grains with structural details depending strongly on growth conditions. The imaging techniques enabled studies of the structure, properties, and control of graphene grains and grain boundaries [5].

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[2] S. Bae *et al.*, *Nature Nanotechnol.* **5**, 574 (2010).
[3] J. M. Wofford, *et al.*, *Nano Lett.*, (2010).
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