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Atom-by-atom Observation of Grain Boundary Migration in Graphene

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Grain boundary migration in polycrystalline solids is a great interest for materials scientists because grain boundaries (GBs) are strongly influencing the mechanical, electronic, thermal and chemical properties. For 3D materials however investigation of the underlaying mechanisms of GB migration has been reserved to computer simulations as experimental techniques are lacking the temporal and spatial resolution to capture the dynamics of individual atoms in the core region of a GB. For 2D materials, however these technical limitations can be overcome by bypassing the projection problem of transmission techniques. Here we use aberration-corrected TEM to study grain boundaries in polycrystalline graphene on atomic scale. We lowered the primary beam energy to 80kV to minimize knock-on damage [1] but the high energy electrons still offer enough energy to induce bond rotations [2] allowing the system to undergo structural relaxations (similar to local melting and recrystallization). For straight grain boundaries we do not observe a preferred movement, instead the atomic structure alters between more or less curved shapes. However for small grains (in the nm range) we find a distinct driving force towards reducing the grain diameter that can result in total annealing of the grain as we have observed for the flower defect [3]. [1] J. Meyer et al., PRL 108, 196102 (2012) [2] J. Kotakoski et al., PRB 83, 245420 (2011) [3] S. Kurasch et al., Nano Lett., 2012, 12 (6)