Graphene grain boundaries

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Grain boundaries (GBs) in CVD graphene have a crucial role in defining the properties of large graphene sheets [1] important from the point of view of practical applications. Given the very large variety of the CVD conditions used: low pressure to atmospheric pressure, solid, or molten substrate, and a wide range of growth temperatures and gas mixtures used for growing CVD graphene on copper, GBs of very different structure may be produced. Some further points have to be observed concerning the structural differences of the GBs in graphene obtained by cleavage from bulk graphite (HOPG, or natural) [2] and CVD grown graphene [3]. The possible influences of the e-beam irradiation during H-RTEM observation of GBs in CVD grown graphene [4] cannot be neglected. Therefore STM [3] and AFM [5] are very versatile and convenient tools for the investigation of graphene GBs both in the as-grown state on the Cu substrate and after transfer to SiO_2 [6].
The CVD grown GBs may contain significant disorder [1, 7]. While the exact structural details of such disorder cannot be easily revealed by experimental techniques, the combination of experimental data with careful computer simulation may reveal the characteristic properties even for disordered GBs [8, 9]. The impact of disorder on charge transport through GBs is very clearly illustrated if comparing the transmission through an ordered (5-7) GB [10] and through an disordered GB: in the range -2 to 2 eV the transmission probability through the disordered GB is reduced to one third.
The atomic scale information on the structure and formation of GBs will be reviewed and compared to computer simulation results on graphene GB structure and properties.

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[1] L. P. Biró & Ph. Lambin, New J. Phys. **15**, 035024 (2013).
[2] J. Cervenka & C. Flipse, Phys. Rev. B **79,** 195429 (2009).
[3] L. Tapasztó et al., Appl. Phys. Lett. **100,** 053114 (2012).
[4] S. Kurasch et al., Nano Lett., **12,** 3168 (2012).
[5] P. Nemes-Incze et al., Appl. Phys. Lett. **99**, 023104 (2011).
[6] J. Koepke et al., ACS nano, **7**, 75 (2013).
[7] J. Kotakoski & J. C. Meyer, Phys. Rev B **85**, 195447 (2012).
[8] P. Nemes-Incze et al., under review in Carbon.
[9] P. Vancsó et al. under review in Carbon.
[10] P. Simonis et al., Surf. Sci. **511,** 319 (2002).