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Influence of edge structure, substrate structure and grain boundaries on the electronic properties of graphene quantum dots and transferred graphene¹

JOSEPH LYDING, University of Illinois

We have used UHV STM to study the quantum size effect gap and the effects of edge electronic structure on graphene quantum dots (GQDs) and nanoribbons [1]. GQDs on H-Si(100) exhibit the expected size-dependent gap with the exception of those with predominantly zigzag edges, which are metallic. STM spectroscopy elucidates the predicted zigzag metallic edge state, which has a characteristic decay length of 1nm. Monolayer graphene deposited in UHV on cleaved GaAs(110) and InAs(110) substrates exhibits an electronic semitransparency effect in which the substrate electronic structure can be observed ‘through’ the graphene [2]. This effect is observed when the equilibrium graphene-substrate spacing is reduced by about 0.06nm. We have also studied the grain boundaries in graphene monolayers that have been grown on copper and then transferred to silicon dioxide substrates. On the annealed copper foils, we find many crystallographic facets, grain boundaries, and annealing twins, all of which affect the carbon species nucleation. Graphene does not grow as readily on the foil annealing twins and non-primary crystal facets, leading to varying nucleation and graphene grain boundaries in the transferred film. STM images show graphene misorientation angles of approximately 7° , 23° , and 30° at the grain boundaries. Standing wave patterns with a decay length on the order of 1 nm were observed adjacent to the grain boundaries and depend on the structure of the boundary. Spectroscopy across the boundaries showed enhanced conduction in empty states on the grain boundaries.

[1] K.A. Ritter and J.W. Lyding, Nat. Mat. **8**, 235 (2009).

[2] K.T. He, J.C. Koepke, S. Barraza-Lopez and J.W. Lyding, Nano Lett. **10**, 3446 (2010).

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