Growth and atomic-scale characterization of graphene and graphene-h-BN hybrid on metal substrates

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Abstract

Under different growth conditions and over different metal substrates of single and polycrystalline, the thickness, stacking geometry and growth mechanism of graphene should be much different.[1-3] Scanning tunneling microscope (STM) may be the only *in-situ* technique for showing the disparity at an atomic scale. However, the STM characterization of traditional chemical vapor deposition (CVD) graphene sample is usually limited by the corrugated nature of the substrate (like Cu foils). We have performed systematic STM studies of the growth and the microscopic structure of graphene on Cu, Pt, Rh etc. foil substrates, and clarified their growth mechanisms along with the aid of traditional methods like Raman spectroscopy, scanning electron microscopy (SEM) and so on.[4] Interestingly, we found that randomly stacked bilayer or few layer segregated graphene on Rh foils usually exhibit various moiré patterns, on which angel-dependent van hove singularities was observed by STM/STS.[5,6] Moreover, we showed that h-BN, a structural analogue of graphene, can be patched onto graphene to form a monolayer hybrid on Rh(111). This hybrid formation was considered be promising for opening up a small band gap of graphene, and most of the efforts were performed by growing the sample on Cu foil substrates. In our work, we show that with the deliberately selected Rh(111) substrate, graphene and h-BN, as well as the interface of hybrid can be recognized by atomic scale STM images. [7] A preferred zigzag type interface between graphene and h-BN was identified by STM, as also verified by DFT calculations.

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Figures

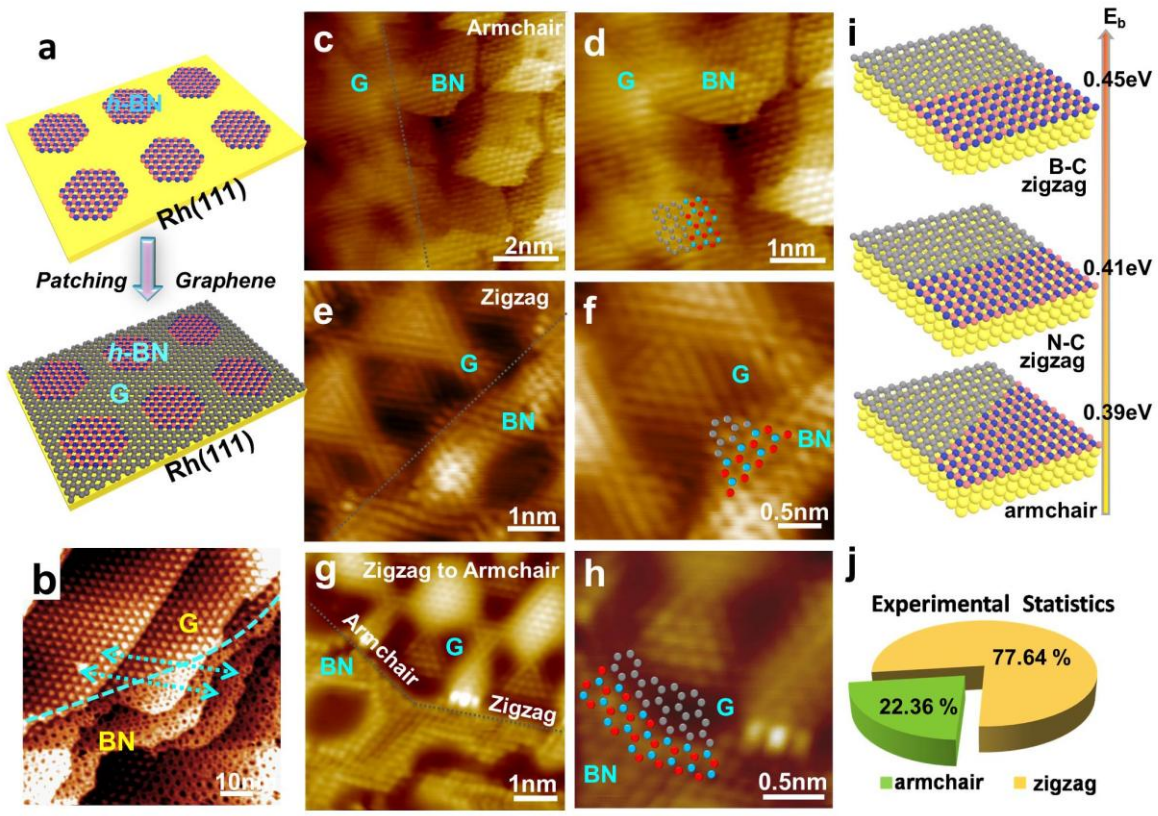

Figure 1 (a) Schematic view of a two-step patching growth of graphene-h-BN hybrid on Rh(111). (b) STM morphology of the hybrid interface. (c, d) (V_T= -0.002 V, I_T= 23.00 nA) Atomically-resolved STM images on an armchair linking edge. (e, f) (-0.081 V, 0.01 nA) STM images on a zigzag linking edge. (g, h) (-0.050 V, 0.02 nA) Transition from armchair to zigzag linking edges. (i) Experimental statistics of boundaries linking *h*-BN and graphene. (j) DFT calculations of E_b for B-C zigzag, N-C zigzag, and armchair linking edges.