Structure and Transport Property of Epitaxial Graphene

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It has been found that the stacking structures of graphene epitaxially grown on the SiC(0001) crystal surface can be modified by various methods, thereby drastically altering their physical properties. So-called twisted bilayer graphene, in which two graphene layers are stacked with a small rotational angle relative to each other, is a well-known example that exhibits superconductivity [1,2], whereas pristine AB-stacked graphene does not. Intercalation of metal ions such as calcium between graphene layers is another route to induce superconductivity [3,4]. Metal-ion intercalation also changes the stacking sequence from AB to AA, resulting in the emergence of a Berry phase [5,6], although it often produces highly inhomogeneous domains with different stacking structures [7]. A small amount of boron adsorbed on the SiC substrate surface alters the growth mechanism of graphene, causing the azimuthal orientation of the grown graphene to rotate by 30 degrees compared with that grown without boron [8]. By combining graphene growth with and without boron modification of the SiC substrate surface, it is possible to fabricate so-called "quasicrystal" bilayer graphene, in which the two graphene layers are rotated by 30 degrees relative to each other [9,10]. This quasicrystal bilayer graphene exhibits much lower electrical conductivity than pristine AB-stacked bilayer graphene [10]. Thus, various types of structural modifications lead to significant changes in electrical transport properties, which are of interest not only in condensed matter physics but also for potential device applications.

References:
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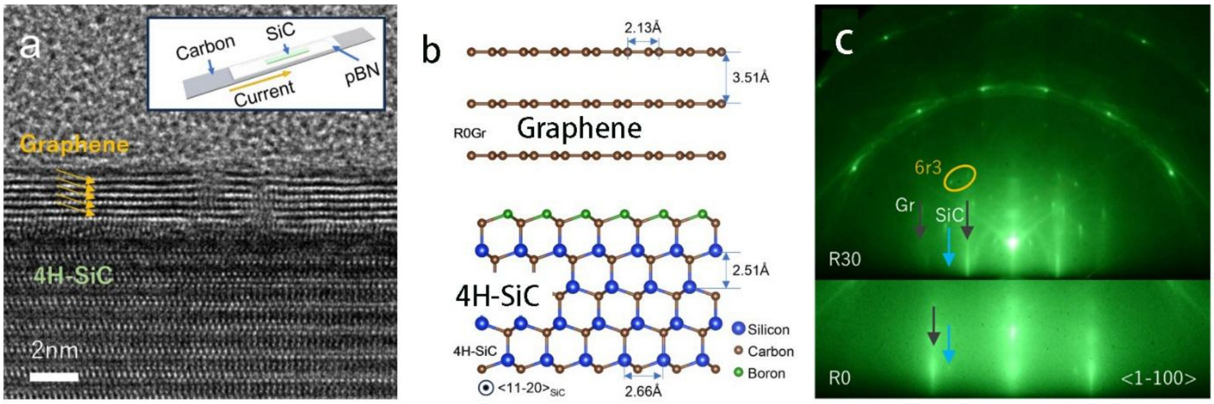

Fig. 1: (a) Cross-sectional TEM image of multilayer graphene grown on a 4H-SiC(0001) substrate with boron modification, viewed along the $<11\bar{2}0>$ direction of SiC. The periodic contrast in each graphene layer, arising from zigzag carbon chains in the honeycomb lattice aligned along the electron beam direction, confirms that the graphene is aligned without a 30° rotation ("R0") relative to the SiC substrate. Inset: Schematic illustration of the setup for graphene growth on SiC via thermal decomposition with boron modification. A pBN plate is placed between a carbon heater and the target SiC substrate. (b) Schematic illustration of the structural model, showing only the layer stacking, representative interlayer distances, and possible boron locations; it is not intended to represent a definitive atomic structure. (c) RHEED patterns of graphene grown with boron modification ("R0", lower panel) and pristine graphene without boron modification ("R30", upper panel), respectively, taken along the $<11\bar{2}0>$ direction of SiC. The different positions of the graphene streaks (black arrows) in the two patterns indicate a 30-degree rotation between R30 and R0. The R30 pattern exhibits additional $6\sqrt{3}$ spots (yellow ovals) associated with the buffer layer, whereas the R0 pattern does not, indicating that R0 graphene grows without the buffer layer. Adapted from Ref. [8].