

Stacking Structure of Graphene Layers on SiC (0001) and (000-1)

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Graphene has excellent electronic transport properties, therefore it is expected as a high quality semiconducting material. The surface decomposition of SiC is one of the production methods of graphene and this method enables us to form graphene layers homogeneously at a wafer-scale. In this method, Si atoms sublime from the SiC surface and the remaining C atoms form graphene epitaxially on SiC {0001}. Graphene layers formed on SiC (0001) and (000-1) faces show different structures and properties. Regarding the stacking structure, previous studies reported that graphene layers on SiC (0001) exhibited ABC stacking.[1] On the contrary, the stacking structure of graphene layers formed on SiC (000-1) is still controversial. Hass, et al. investigated using LEED and STM techniques and reported that graphene layers stacked with rotation.[2] On the other hand, Johansson, et al. investigated using micro-LEED with the 400 nm probe and reported that any rotational disorder were not shown in the grain.[3]

In this study, we observed graphene layers on SiC (0001) and (000-1) by transmission electron microscopy (TEM). Figure 1 shows (a) the cross-sectional and (b) the planar TEM images of graphene layers on SiC (0001) and Figure 1(c) shows the FFT pattern of TEM plan-view image Fig. 1(b). The FFT pattern shows one set of six-fold spots corresponding to graphene {1-100} reflections (indicated by yellow circles in Fig. 1(c)) and this means that the graphene layers on SiC (0001) stack in a certain specific orientation. Figure 2(a) shows TEM image of graphene layers on SiC (000-1) and Figure 2(b) shows TEM image of exfoliated graphene. Figure 2(c) shows FFT pattern of TEM image of exfoliated graphene. The FFT pattern shows two sets of six-fold spots corresponding to graphene {1-100} reflections indicated by blue and yellow circles in Fig. 2(c). Presence of two of spots indicates graphene sheets with two different orientations and this means that graphene layers on SiC (000-1) stack with rotation within a single grain.

[1] W. Norimatsu et al., Phys. Rev. B. **81**, 161410 (2010).

[2] J. Hass et al., Phys. Rev. Lett. **100**, 125504 (2008).

[3] L. I. Johansson et al., Phys. Rev. B. **84**, 125405 (2011).

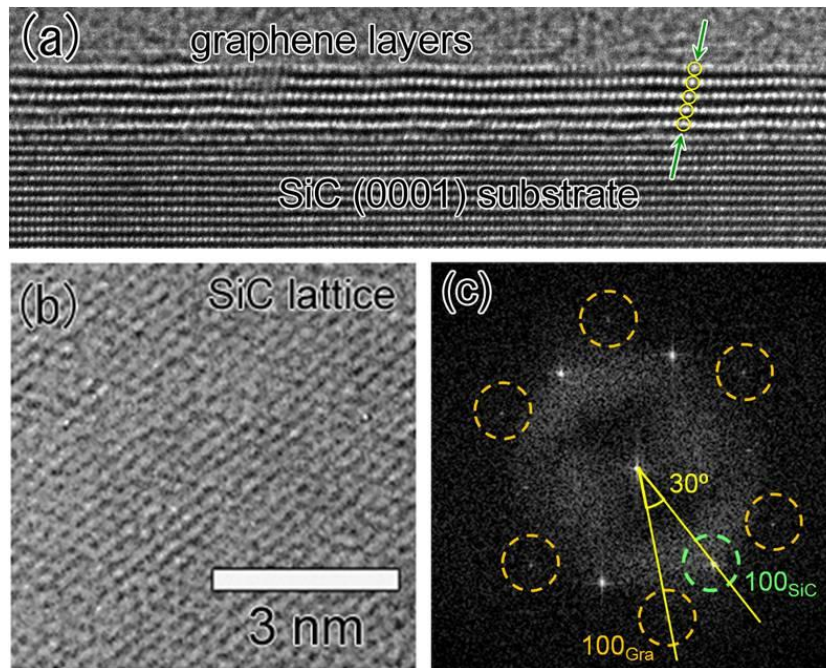


Figure 1 (a) Cross-sectional and (b) planar TEM images of graphene layers on SiC (0001). (c) FFT pattern of plan-view TEM image Fig. 1(b). Green circle indicates SiC 1-100 reflection and yellow circles indicate graphene {1-100} reflections.

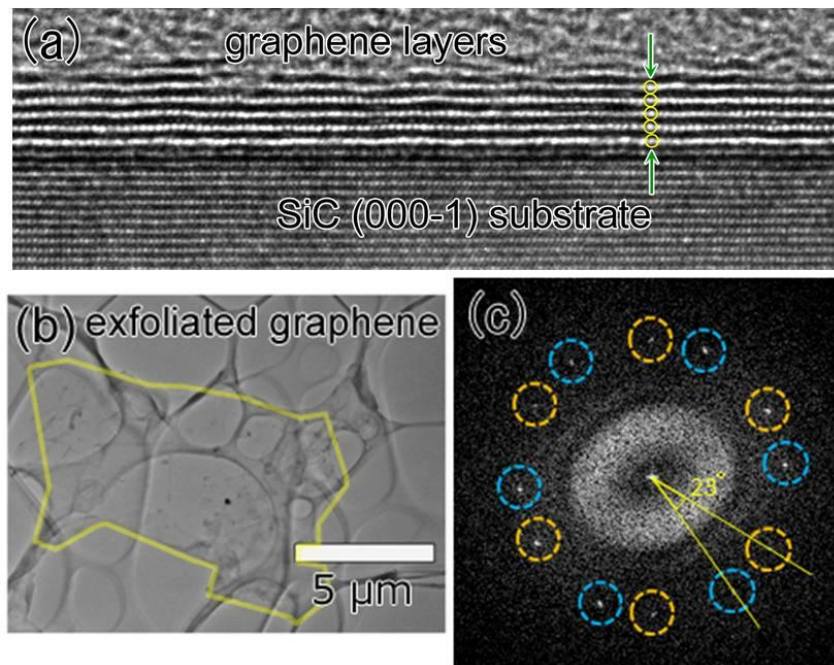


Figure 2 (a) Cross-sectional TEM image of graphene layers on SiC (000-1). (b) TEM image of exfoliated graphene. (c) FFT pattern of TEM image of exfoliated graphene. Yellow and blue circles indicate graphene {1-100} reflections respectively.