In-plane structural features of graphene on SiC revealed by TEM observations

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Graphene has excellent electronic transport properties, therefore it is expected as a high quality semiconducting material. Thermal decomposition of SiC is one of the production methods of graphene. In this method, 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 and are rotated by 30 º with respect to the SiC substrate [1]. On the contrary, the structure of graphene layers formed on SiC (000-1) is still controversial. In this study, we observed graphene layers on SiC {0001} surfaces by transmission electron microscopy (TEM). We succeeded to observe in the range of from the atomic scale to the sub-micrometer scale directly by using TEM and to analyze the in-plane structure of graphene on the SiC {0001} surfaces.

Commercially available on-axis 6H-SiC (0001) and 6H-SiC (000-1) single-crystal wafers were used. SiC (0001) substrates were graphitized at 1500 ºC in a vacuum (10^{-4} Torr), and SiC (000-1) substrates were graphitized at 1500~1800 ºC in 6-atm Ar atmosphere. We used EM-002B TEM at an electron accelerating voltage of 200 kV. Specimens for TEM observations were prepared by Ar-ion thinning or by exfoliation from the substrate. The number of graphene layers was counted directly by TEM observations along cross-sectional direction and the in-plane structure of graphene was analyzed by using plan-view observations and a fast Fourier transformation (FFT) treatment of the observed TEM images.

Figure 1(a) shows the planar TEM image of graphene layers on SiC (0001) and Figure 1(b) shows the FFT pattern of TEM plan-view image shown in Fig. 1(a). The FFT pattern shows one set of six-fold spots corresponding to graphene 1-100 reflections (indicated by yellow circles in Fig. 1(b)). This means that the graphene layers stacked with a 30 º rotation with respect to SiC. Figure 2(a) shows a TEM image of graphene layers transferred from SiC (000-1) substrate to the TEM micro-grid. Figure 2(b) shows an FFT pattern of a square area of about 100 nm in a TEM image of transferred 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(b). Presence of two sets 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 [2]. Dark field TEM images of graphene on SiC {0001} surfaces were also taken in order to observe the grain structure.

References:
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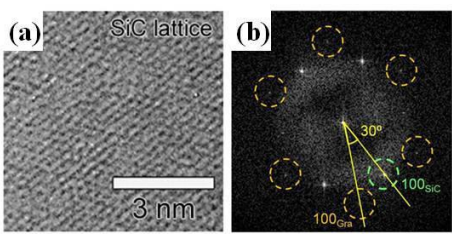

Fig. 1: (a) Planar TEM image of graphene on SiC (0001). (b) FFT pattern of TEM image Fig. 1(b).

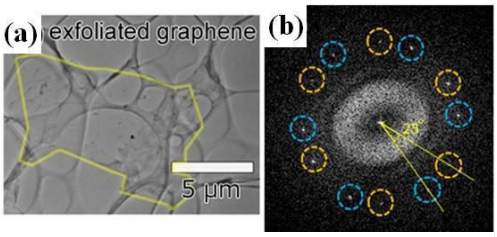

Fig. 2: (a) TEM image of graphene transferred from SiC (000-1) to carbon micro-grid. (b) FFT pattern of TEM image of exfoliated graphene.