Epitaxial Graphene on SiC Thin Films on (100) and (111) Facets on Microfabricated Si(100) Substrate

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Graphene is a promising material for the next-generation electronic and photonic devices due to its excellent electronic properties. We have developed epitaxy of graphene on SiC thin films on Si substrates (GOS) toward fusion of graphene with Si-based electronics. We have found that structural and electronic properties of graphene are tuned by crystallographic orientation of the Si substrates [1,2]. This result indicates that, in combination with Si microfabrication technologies, the electronic properties of GOS may be tuned by microfacetting Si surface.

A Si(100) substrate was fabricated by combining electron-beam lithography and alkaline etching which produces (111) and (100) microfacet, as shown in the cross-sectional SEM image in Fig. 1. On the microfabricated Si(100) substrate, SiC thin films were grown by using gas-source MBE, followed by graphitization in vacuum at 1500 K. Microscopic characterization of graphene was performed by using 3D NanoESCA for microscopic XPS (μ-XPS) with a lateral resolution of 70 nm and low-energy electron microscope for microscopic low-energy election diffraction (μ-LEED) with a lateral resolution of < 1 μm.

The μ-LEED observation reveals that graphene is Bernal stacked on the SiC(111)/Si(111) facet, while it is non-Bernal stacked on the SiC(100)/Si(100) microfacet, as shown in Fig. 1. The observation is in consistent with the previous result on the epitaxy of graphene on non-fabricated SiC(111)/Si(111) and SiC(100)/Si(100). The variation of the stacking is explained by the μ-XPS observation (Fig. 1). The buffer layer which works as a template for the epitaxy of graphene exists only in between graphene and the SiC(111)/Si(111) microfacet. The existence of the buffer layer is confirmed by cross-sectional transmission electron microscopy observations.

Furthermore, Raman microscopy reveals that the band dispersion (splitting) changes depending on the variation of the stacking with the microfacet (Fig. 2). On the (111) microfacet, the graphene is semiconductive, while metallic on the (100) microfacet.

Our work can open a new way to microscopically tune control of structural and electronic properties of graphene, which can make graphene devices multi-functionalized.

References

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[2] H. Fukidome et al., Appl. Phys. Exp. **4** (2011) 115104.

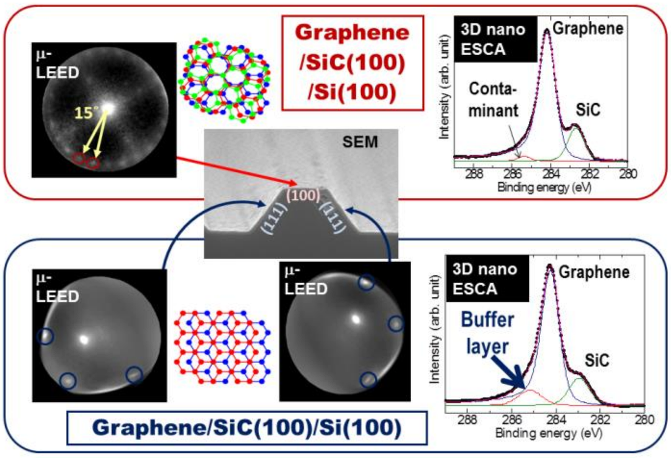

Fig. 1 Microscopic characterization of epitaxial graphene on (100) and (111) microfacets on Si(100) substrate

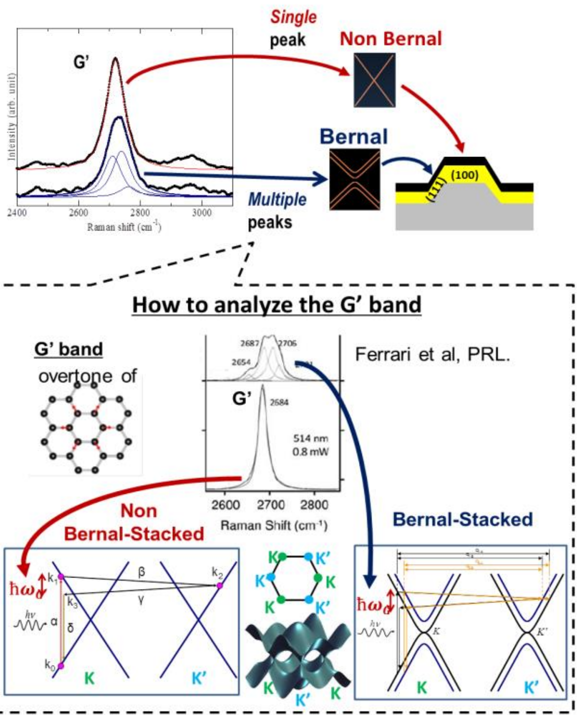

Fig. 2 Microscopic analysis of band dispersion of epitaxial graphene on (100) and (111) microfacets on Si(100) substrate by using Raman microscopy