Application of Spectroscopic Photoemission Microscopy to Nanocharacterization

A spectroscopic photoemission and low-energy electron microscope (SPELEEM), based on a design by Veneklasen and Bauer [1], has been introduced at BL17SU of SPring-8 within the framework of the Nanotechnology Support Project of Ministry of Education, Culture, Sports, Science and Technology (2002-2006). Its powerful performance for nanoscale spectromicroscopy has been applied to a wide variety of scientific fields. Three different imaging modes (real space imaging, reciprocal space imaging and energy dispersion modes), and three different excitation sources (highly brilliant circularly polarized soft X-ray, low-energy electron beam and UV light from a mercury lamp) are available at BL17SU. BL17SU covers a broad photon energy region from 300 to 2000 eV. The lateral resolution of SPELEEM is high as 14 nm in low-energy electron microscope (LEEM) mode and 22 nm in photoemission electron microscope (PEEM) mode.

Investigation of Epitaxial Few-Layer Graphene using SPELEEM

Few-layer graphene has recently attracted considerable attention as a material for use in future electronic devices. In particular, epitaxial few-layer graphene grown on SiC is promising for device applications. However, it is necessary to determine how the SiC substrate affects the electronic properties of few-layer graphene. Because it is still difficult to grow few-layer graphene over a wide area with a specified thickness, it is desirable to investigate the electronic properties using techniques that can resolve the number of layers microscopically. Thus, the dependence of electronic properties of epitaxial few-layer graphene on the number of layers has been investigated using SPELEEM [2]. Because the number of graphene layers can be determined digitally from electron reflectivity measurements using LEEM, the electronic properties for each number of graphene layers can be evaluated. The LEEM and C 1s PEEM images in Fig. 1 indicate that regions with different numbers of layers are seen at different intensity levels. Figure 1(d) shows the C 1s photoemission spectra obtained from sequential PEEM images. The C 1s PEEM images indicate that the C 1s core level shifts to lower binding energies as the number of graphene layers increases, which is consistent with the reported thickness dependence of the Dirac point energy [3]. These results indicate the feasibility of using the LEEM/PEEM technique to address some of the fundamental issues regarding the determination of the local electronic structure of few-layer graphene.

References :
[1] Ultramicroscopy **36**, 76 (1991); Rev. Sci. Instrum. **63**, 5513 (1992). [2] Phys. Rev. B **79**, 79, 125437 (2009). [3] Science **313**, 951 (2006).

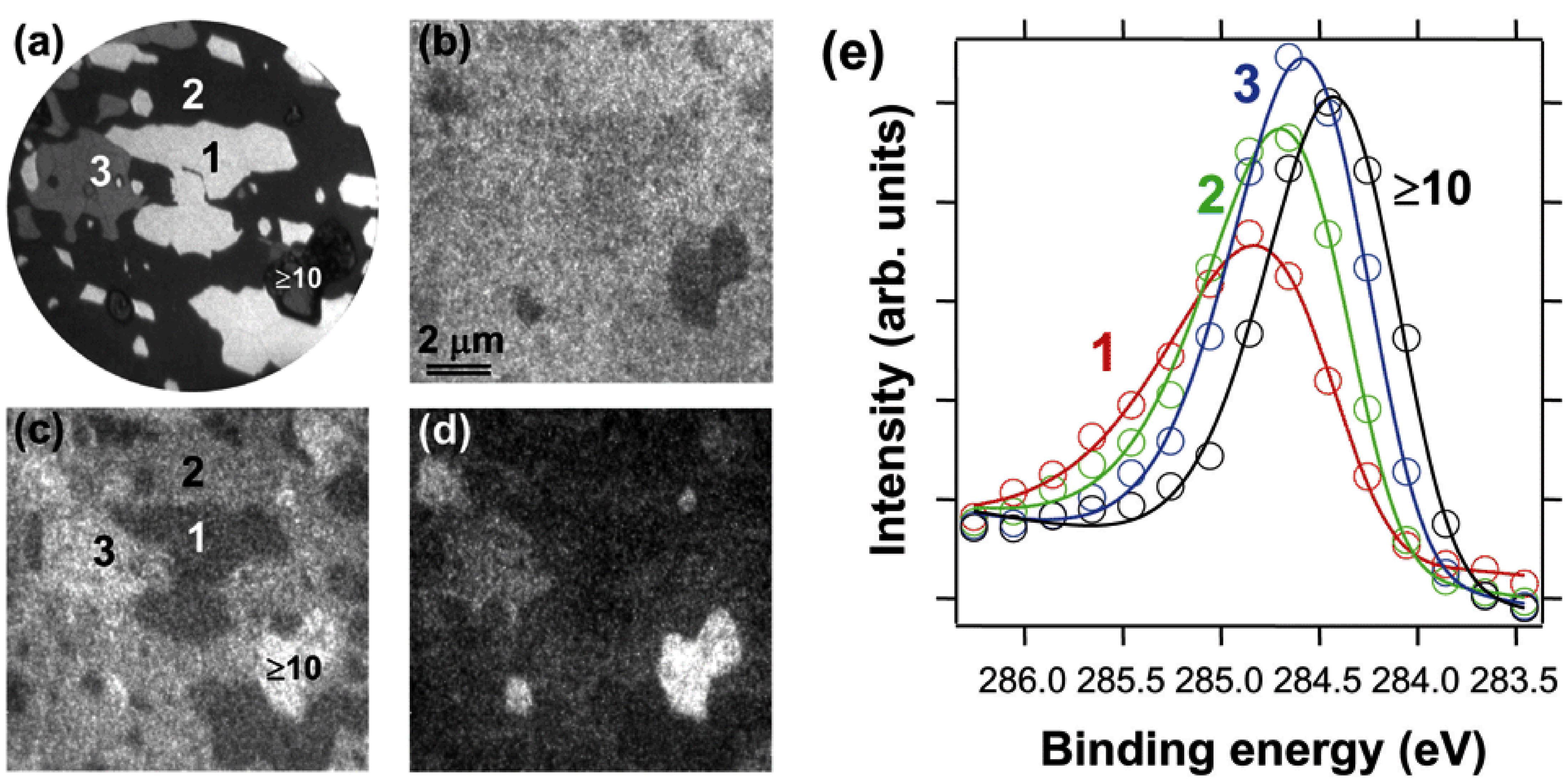

Fig. 1
(a) LEEM image of epitaxial few-layer graphene grown on 6H-SiC (0001) at a start voltage of 4.5 V. (b)-(d) C 1s PEEM images at the start voltages of 111.4, 111.8 and 112.2 V, respectively. The images were obtained under the irradiation of synchrotron radiation at an energy of 400 eV. The exposure time was 600 s for (b)-(d). The numbers in (a) and (c) correspond to the number of graphene layers determined by LEEM. (e) C 1s core-level spectra obtained from sequential C 1s PEEM images. Open circles denote the experimental data and solid lines show the results of fitting the data to an asymmetric Gaussian function with a linear background. The start voltage was converted to the binding energy by assuming that the binding energy of the thick graphene layers is the same as that of bulk graphite, 284.42 eV.