First results using New-DIANA for two-dimensional photoelectron and Auger electron spectro-microscopy at BL-7

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Abstract

New DIsplay-type ANAlyzer (DIANA) for two-dimensional photoelectron spectroscopy and microscopy experiment is constructed at the linear polarized vacuum ultraviolet beamline BL-7. An electron gun designed for scanning electron microscopy is installed in the analyzer. By combining the electron gun with DIANA, Auger electron spectroscopy measurement at the focused region became possible. Here we report the first results using this analyzer.

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1. Introduction

Photoelectron spectroscopy is a direct method for studying electronic structure of solids. photoelectron intensity angular distribution (PIAD) corresponds to the cross section of valence band dispersion at certain binding energy (E_B) and wave number (k). Furthermore, PIAD reflects the polarization direction of incident photon and the orientation of atomic orbitals. Therefore, PIAD gives us information not only on the valence band topology, but also on atomic orbital composition and their relations such as bonding or anti bonding. Apart from conventional analyzers, Display-type spherical mirror Analyzer (DIANA) enables measurement of PIAD in wide solid angle at one time, without rotating a sample or an analyzer. Thus, by acquiring a PIAD excited by linearly polarized light at one time, we can deduce atomic orbitals composing band dispersions from PIAD.

Previously we have installed a display-type analyzer with an energy resolution of 1% at BL-7 and succeeded in measuring three dimensional band dispersions and Fermi surfaces [1,2]. In order to extend our research to more complicated materials, we have constructed a New-DIANA with the total energy resolution improved more than two times compared to that of the old one [3,4]. Moreover, we also installed the mini-electron gun for Auger electron spectroscopy (AES). The measurement of the valence band electronic structure together with the analysis of element composition and distribution *in situ* became possible. Here we report measurement of band dispersions and Auger electron spectrum of single crystal graphite (kish graphite).

2. Experiments

Measurements of the band dispersions and Auger electron spectrum of kish graphite were performed. The clean graphite surface was obtained by degassing at 1000℃ in ultrahigh vacuum condition for more than one day. The photon energy is fixed to 42 eV. PIAD's were measured with the intervals of 0.1 eV. Typical acquisition time for one PIAD is five minute. Electron energy for AES measurements was fixed to 1000 eV. The energy step was 10 eV. Acquisition time for one point was 0.1 seconds.

3. Results and Discussion

Figure 1 shows the schematic diagram of New-DIANA. The electron gun developed for scanning electron microscopy is equipped. The direction of the electron beam is 45° off from the sample normal direction. The energy range of the electron gun is from 200 eV to 1200 eV. LEED and AES measurement from the focused region became possible. Figure 2 is the photograph of the electron gun. Figure 3 shows DIANA equipped with the electron gun. The electron gun is shielded by μ-metal to prevent the leakage of electric and magnetic field which disturb the photoelectron orbit.

Figure 4 shows the Auger electron spectrum of kish graphite surface. The peak at 270 eV is attributed to C KLL Auger electron. The position of the light source coincides with the electron beam on the sample. Therefore we can measure spectra and patterns of Auger electrons and photoelectrons at the same position on the sample without changing the analyzer. This enables the two-dimensional mapping of element distributions prior to the valence band dispersion measurement.

Figure 5 shows the PIAD of kish graphite at the binding energy of 0.3 eV. The white arrow indicates the of the polarization direction of incident light. Four bright and two dark photoelectron spots correspond to the six-fold symmetric K points at the apices of graphite Brillioun zone. However the intensity around the top and bottom K points is suppressed. This is due to the matrix element of the C 2p_z atomic orbital composing the π band excited by linearly polarized light [1].

4. Conclusion

The development and installation of New-DIANA at BL-7 have been completed. The Auger electron spectra and PIAD were successfully obtained. As for the future plan, we will measure the electronic state of thin films and surface superstructures.

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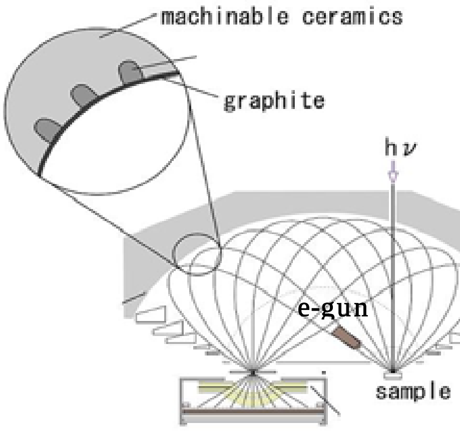

Fig. 1. Schematic diagram of DIANA with new electron gun. Incidence angle of electron beam is 45° off from the sample normal direction.

Fig. 2. Close-up of the electron gun designed for scanning electron microscopy.

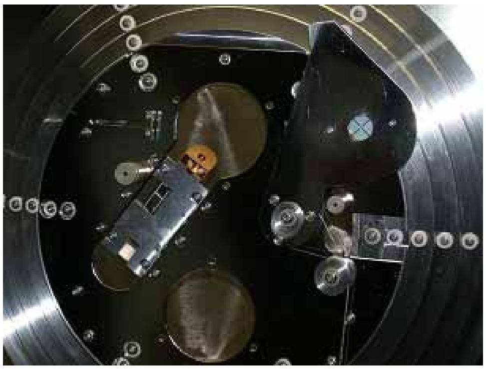

Fig. 3. The photograph of the electron gun equipped with New-DIANA.

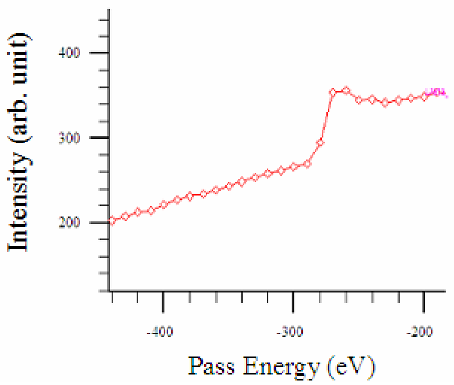

Fig. 4. Auger electron spectrum of kish graphite. The peak at 270 eV is C KLL Auger electron.

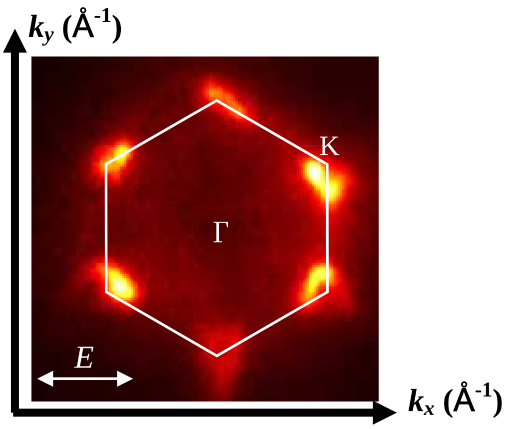

Fig. 5 The PIAD (E_B = 0.3 eV) of kish graphite.