Fermi surface analysis of Ni(111) by two-dimensional photoelectron spectroscopy

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1. Introduction

The Ni(111) surface has attracted much attention because of its interesting electronic, magnetic, and chemisorption properties. The existence of surface state has been elucidated by utilizing an angle-resolved photoelectron spectroscopy (ARPES) [1]. ARPES is very powerful to study the electronic structure of solids. Especially, a Fermi surface map obtained by ARPES has useful information because of its close relationship to the physical properties. A stereo profile of the Fermi surface is efficiently obtained by two-dimensional photoelectron intensity angular distribution (PIAD) patterns which are observed by a display-type spherical mirror energy analyzer (DIANA) in two-dimensional photoelectron spectroscopy (2D-PES) [2,3]. In this work, we have performed 2D-PES measurements on Ni(111) surfaces in order to study the electronic structure near the Fermi surface.

2. Experimental

2D-PES measurements were performed at the BL-7 of SR center, Ritsumeikan University [4]. A Ni(111) single crystal sample was cleaned by repeated cycles of Ar^+ bombardment and annealing to 800 ^{o}C. The surface quality was checked by low energy electron diffraction and Auger electron spectroscopy. The 2D-PES measurements were performed at room temperature under ultrahigh vacuum of ~1×10^{-8} Pa using DIANA. The PIAD of this experiment was collected by energy window of 100 meV. Typical acquisition time for one PIAD was 30 sec. The total energy resolution was about 400 meV. The angular resolution was about 1°.

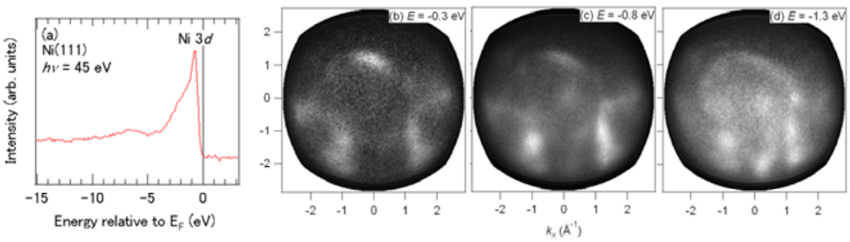

Fig. 1 2D-PES results of Ni(111) taken with $h\nu$ = 45 eV. (a) Angle-integrated PES spectrum. The PIADs at E = -0.3 eV (b), -0.8 eV (c), and -1.3 eV (d). The electric vector of the incident light is in the horizontal direction.

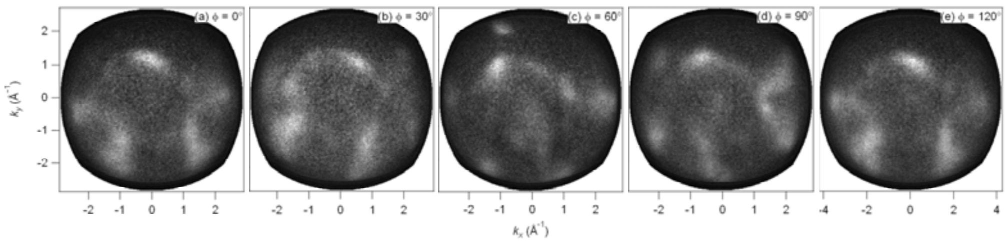

Fig. 2 Angle-dependent PIADs near Fermi level (E = -0.3 eV) taken with $h\nu$ = 45 eV. The PIAD of ϕ = 0° (a), 30° (b), 60° (c), 90° (d), and 120° (e).

3. Results and Discussion

Figure 1(a) shows the angle-integrated spectrum of Ni(111) taken with $h\nu$ = 45 eV. The peak near the Fermi level is mainly composed of Ni 3*d* states. As shown in Fig. 1(b-d), the PIAD pattern changes with the energy, that is, the dispersion of the Ni 3*d* states was successfully observed. On the other hand, the symmetry of the PIAD pattern was different from the expected one with the three-fold symmetric characteristics of Ni(111). By rotating the sample around the surface normal (Fig. 2), the PIAD of the Fermi surface at the azimuth angle ϕ = 0 coincides with that rotated by 120° [Fig. 2(a) and (e)]. This indicates that the measured Fermi surface indeed has a three-fold symmetry and that the lack of the symmetry at the upper part of PIAD can be due to the polarization dependence of the constituent atomic orbitals on the electric vector of the linearly polarized SR light.

4. Conclusions

We have performed 2D-PES measurements on Ni(111). We have successfully observed Ni Fermi surface, which has a three-fold symmetry due to the fcc-crystal structure of Ni.

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