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Surface electronic structure of the carbon-adsorbed W(110) surface

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Introduction

Carbide-modified tungsten surfaces have been attracting much attention due to their potential applicability to catalysts in fuel cells. Recently our temperature-programmed desorption study has shown that carbon adsorption drastically changes the chemical property of a tungsten surface. In order to know the mechanism underlying the changes in the chemical property, we investigated the electronic structures of the clean and carbon-adsorbed W(110) surfaces with angle-resolved photoelectron spectroscopy (ARPES).

Experimental procedure

A W(110) single crystal was cleaned with oxygen treatment and subsequent flashing to 2200 K. After 10-Langmuir exposure of the clean surface to ethylene, the W(110)(15×3)R14°–C surface was prepared with flashing to 1500 K. ARPES measurements was performed with the vacuum ultraviolet beam line, BL-7B, of KEK-PF. The spectra were measured at the sample temperature of 300 K. The angular resolution of the spectrometer was estimated to be better than 2°.

Results and discussion

Figure 1(a) shows the normal-emission photoelectron spectrum from the clean surface measured with the photon energy ($h\nu$) of 21.6 eV. Two distinct spectral features are discernible at about 1.2 and 1.8 eV (labeled as SR and A, respectively) below the Fermi energy (E_F). Peak SR originates from the well-known surface resonance state of W(110), while feature A from the bulk band [1]. As shown in Fig. 1(b), carbon adsorption induces drastic changes in the spectrum: The adsorption diminishes intensity of the surface-resonance peak, SR, while hardly affects the bulk-band feature, A. Four new spectral features appeared at about 0.4, 3.0, 4.0, and 5.0 eV (labeled as S1, B, S2, and C, respectively).

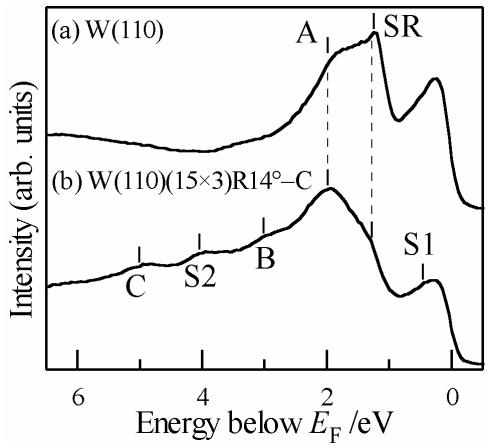

Fig. 1. Normal-emission angle-resolved photoelectron spectra of the (a) clean and (b) W(110)(15×3)R14°–C surfaces measured with the photon energy of 21.6 eV.

We investigated dispersion of the new features with the surface-normal component of electron wave vector (**k**). Fig. 2 shows the normal emission spectra of the W(110)(15×3)R14°–C surface with various photon energies. S1 and S2 do not show significant dispersion with $h\nu$, indicating that they originate from the two-dimensional surface layer. On the other hand, B and C clearly show dispersion with $h\nu$, and thus, are explained by transitions from the bulk bands; the carbon-induced change in periodicity of the surface results in the appearance of new bulk-band features via the Umklapp process. In the spectra at the photon energies of 20 and 19 eV, there are two new spectral features (labeled as D and E, see Fig. 2). Because of dispersion with $h\nu$, they are attributable to transitions from the bulk bands. Note that bulk-band features A and D are already observed on the clean surface [1] and not disturbed even after the carbon adsorption. This implies that carbon atoms are not incorporated into the deeper layers.

The present results lead us to conclude that the carbon adsorption induces at least two new electronic states on the surface layer. In order to know dispersion of these states with the surface-parallel component of **k**, further ARPES study is now in progress.

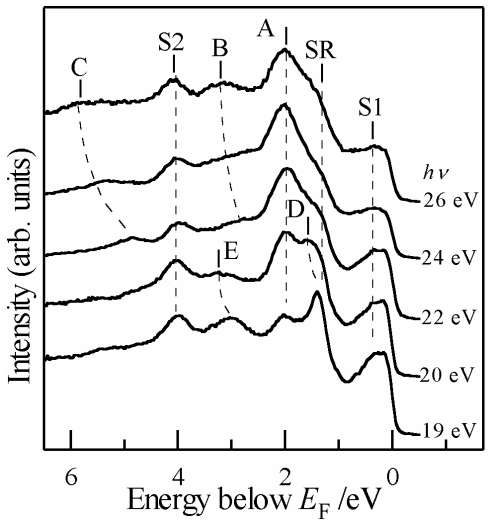

Fig. 2. Normal-emission angle-resolved photoelectron spectra of the W(110)(15×3)R14°–C surface measured with various photon energies.

Reference

[1] J. Feydt *et al*., Phys. Rev. B 58, 14007 (1998).

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