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ARPES study of hydrogen adsorption on the C/W(110) surface

Junichi IKEUCHI, Kensuke TONO, Hiroshi KONDOH, Toshiaki OHTA*
Department of Chemistry, Graduate School of Science, The University of Tokyo,
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan

Introduction

Carbon-induced reconstruction drastically changes the chemical property of tungsten surfaces. The carbon modification of the surfaces gives rise to significant effect on hydrogen adsorption; It has been reported that the carbon-induced reconstruction reduces sticking coefficient of hydrogen on the tungsten surfaces [1]. Actually, we have found that the (15×3)R14°–C/W(110) surface is saturated with a hydrogen exposure above 3000-L (Langmuir), while the W(110) surface is saturated with the exposure of only 3 L. In the present work, the hydrogen adsorption on the (15x3)R14°-C/W(110) surface were investigated using angle-resolved photoelectron spectroscopy (ARPES).

Experimental

ARPES measurements were performed at beamline BL-7B. A single crystal of W(110) was cleaned by heating to 1500 K in an oxygen atmosphere ($1x10^{-8}$ Torr) and subsequent flashing to 2200 K. The (15x3)R14°-C/W(110) surface was prepared by exposure to 10-L ethylene and flashing to 1500 K. The sample surface was checked by LEED and ARPES. Hydrogen exposure and ARPES measurements were performed at the sample temperature below 150 K.

Results and discussion

Figure 1 shows the dependence of the sample work function on the H_2 exposure. In the low-exposure range below 1500 L (“low-exposure phase”), the work function decreases monotonically from 5.1 ± 0.1 eV to 4.3 ± 0.1 eV with increasing hydrogen exposure. In the high-exposure range above 1500 L (“high-exposure phase”), the work function decreases gradually to a constant value of 4.1 ± 0.1 eV.

Figure 2 shows the normal-emission photoelectron spectra measured at various hydrogen exposures. In the low-exposure phase, there are three spectral features that originate from the surface layer (labeled as S1, SR, and S2) and three bulk-band features (A, B, and C) [2]. The S1 feature shifts towards the lower-energy side with increasing exposure, while the other features do not change significantly; the electronic state of hydrogen hybridizes exclusively with the S1 state. Due to this hybridization, electronic charge of adsorbed hydrogen is polarized towards the C/W(110) surface. This polarization leads to lowering of the original potential barrier of the substrate surface, and thus, the work function decreases as shown in Fig. 1. Between the low- and high-exposure phases, the spectrum changes drastically (see the spectra at 1000 and 2000 L): The six spectral features lose their intensity, and a new feature appears at about –6.7 eV (labeled as H). In the high-exposure phase, hydrogen induces a gradual change in the spectrum.

We also measured the work function of the clean and hydrogen-saturated W(110) surfaces: 5.2 ± 0.1 eV and 4.8 ± 0.1 eV, respectively. The work function of W(110) also decreases with H_2 adsorption, but the decrement of 0.4 eV is much smaller than that for C/W(110) (1 eV). These results imply that the electronic charge of hydrogen is polarized on the C/W(110) surface more strongly than on the clean W(110) surface.

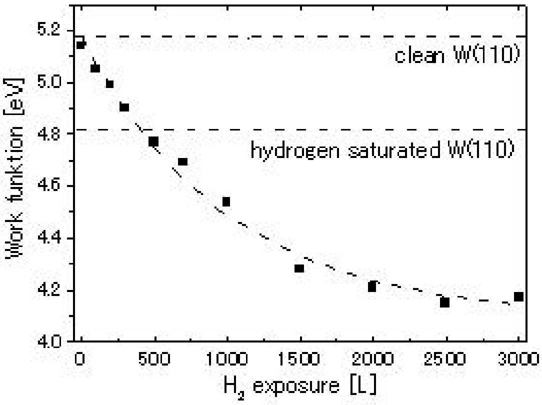

Fig. 1. Dependence of the work function of the (15x3)R14°-C/W(110) surface on the H_2 exposure

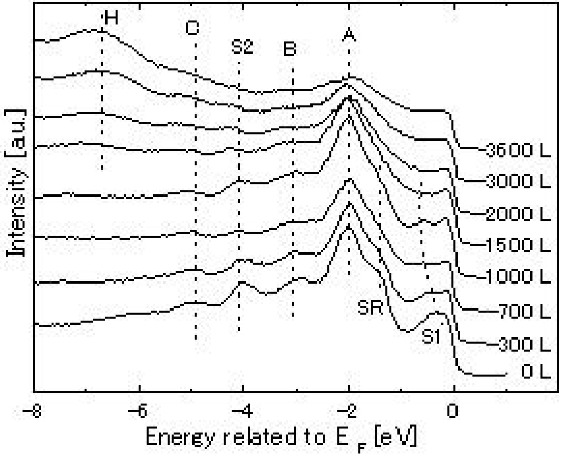

Fig. 2. Normal-emission photoelectron spectra of the (15x3)R14°-C/W(110) surface at various hydrogen exposures measured with the photon energy of 21.6 eV.

References

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* ohta@chem.s.u-tokyo.ac.jp