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Carbon-induced changes in the chemical property of a W(110) surface

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Introduction

Carbide-layer formation on tungsten surfaces induces drastic changes in the chemical properties of the surfaces. Our recent study has shown that a W(110)(15×3)R14°–C surface adsorbs hydrogen molecules much more slowly than a clean W(110) surface [1]. The present study extends the investigation of chemical reactions between the carbide-modified W(110) surface and gas molecules such as carbon monoxide (CO) and oxygen (O_2) by means of angle-resolved photoelectron spectroscopy (ARPES).

Experimental procedure

ARPES experiments were performed with the vacuum ultraviolet beam line, BL-7B, of KEK-PF. The W(110) surface was cleaned by oxygen treatment and subsequent flashing to 2200 K. The W(110)(15×3)R14°–C surface was prepared by 10-Langmuir (L) exposure of the clean surface to ethylene and subsequent flashing to 1500 K. Photoelectron spectra were measured at an electron-emission angle of 90° from the surface (normal emission). The energy and angular resolutions are estimated to be 0.2 eV and 2°, respectively, in the present experimental condition.

Results and discussion

Figure 1(a) shows a normal-emission photoelectron spectrum of the W(110)(15×3)R14°–C surface measured with the photon energy of 21 eV. The origins of the spectral features observed have been discussed in our previous report [2]. The spectrum did nod change after 20-L exposure of the surface to CO at the temperature of 295 K [see Fig. 1(b)]. Therefore, it is found that the W(110)(15×3)R14°–C surface does not adsorb CO molecules at 295 K. However, this surface adsorbs the CO molecules at the lower temperature of 100 K. Figure 1(c) shows the spectrum measured after 5-L exposure to CO at 100 K. This spectrum is completely different from that of the intact W(110)(15×3)R14°–C surface. The spectral features at about 7.5 and 11.5 eV are ascribed to the molecular orbitals of CO ($5\sigma+1\pi$ and 4σ, respectively), and thus, indicate molecular adsorption of CO.

On the other hand, the W(110) surface adsorbs the CO molecules even at 295 K; a photoelectron spectrum of this surface significantly changed after 5-L exposure to CO at 295 K as shown in Figs. 1(e) and (f). In the spectrum measured after the CO exposure [Fig. 1(f)], there are no spectral features that originate from the molecular orbitals of CO, that is, the CO molecules on the surface are readily dissociated at 295 K. These results indicate that the W(110) surface is more reactive with CO than the W(110)(15×3)R14°–C surface.

Figures 1(d) and (g) show normal-emission photoelectron spectra of the W(110)(15×3)R14°–C and W(110) surfaces measured after 10-L exposure to O_2 at 295 K. The O_2 exposure induces only slight change in the spectrum of the former surface [see Figs. 1(a) and (d)], while considerable change in the spectrum of the latter surface [see Figs. 1(e) and (g)]. Therefore, it is suggested that the W(110) surface is oxidized much more easily than the W(110)(15×3)R14°–C surface.

The present results lead us to conclude that the carbide layer on the W(110) surface is less reactive than the bare W(110) surface.

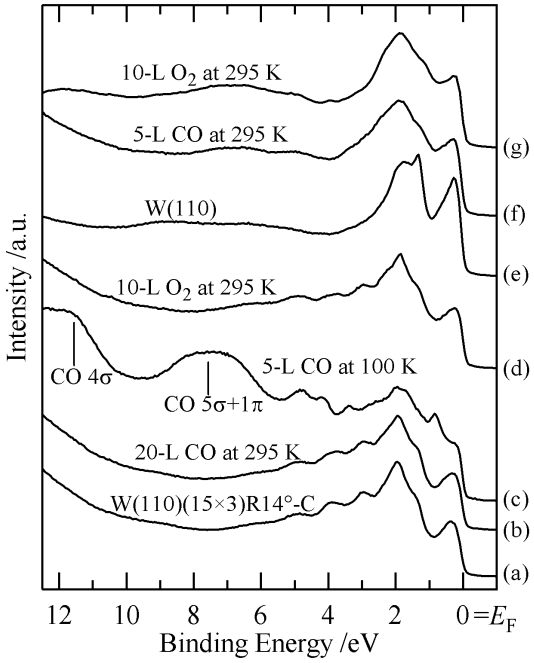

Fig. 1. Normal-emission photoelectron spectra of the W(110)(15×3)R14°–C and W(110) surfaces measured with the photon energy of 21 eV: (a)–(d) W(110)(15×3)R14°–C surface. (e)–(g) W(110) surface.

References

[1] J. Ikeuchi et al., PF Activity Report 2003 part B, 86 (2004).
[2] K. Tono et al., PF Activity Report 2003 part B, 87 (2004).

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