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Angle resoloved photoemission study of Gd induced one-dimensional chain structure on Si(111) surface

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Introduction

Nanostructures on a semiconductor surface have been getting much attention because of their potential to the application of nano-electric devices. Among the nanostructures, one-dimensional system is predicted to have interesting physical properties such as the charge density of states or spin-charge separation due to their one-dimensional electronic behavior. Recently, the Gd induced one-dimensional chain structure on Si(111) substrate has been observed by scanning tunneling microscope[1]. In this system the large magnetic moment of the Gd 4*f* electrons is expected to create atomic chains with a magnetic coupling. In the present study, we have investigated the electronic structure of the Gd chain on Si(111) surface by means of angle-resolved photoelectron spectroscopy(ARPES) and determined the surface states.

Experimental

All the ARPES measurement was done at the beamline 18A. The single domain one-dimensional chain structure with a 5x2 periodicity was obtained by Gd adsorption on the Si(111)7x7 vicinal surface at the substrate temperature of about 970 K, which was checked by a sharp low energy electron diffraction (LEED) pattern (Fig.1). The ARPES spectra were recorded by VG-ADES 500 system at R.T. with the photon energy of 12.5 and 21.2 eV. The photon incident angle was 45 degree from a sample normal. To obtain the information of the surface states symmetries we have also applied the different measurement geometries between polarized synchrotron radiation light and the electron analyzer.

Results and Discussion

Figure 2 (a) shows the ARPES spectra measured at hν=21.2 eV along the direction parallel to Gd chain structure. Dispersion maps along Γ-K and Γ-M are also presented in Fig. 2(b). As shown in the figures, at least two surface states (S1 and S2) exist at the binding energies of around 1 to 2 eV from the Fermi level. We have also observed very week states (S*) near the Fermi edge. The faint states, however, do not show clear band dispersion and it is still questionable whether the states are the real one-dimensional metallic states in which the density of states are suppressed at the Fermi level because of the one-dimensional property of the system or just the defect states. Further detail experiments will be performed in the future.

Fig.1 LEED pattern of Si(111)5x2-Gd surface. The pattern indicates clearly that the obtained surface consists of single domain. The faint streaks suggest that the surface has actually x2 periodicity.

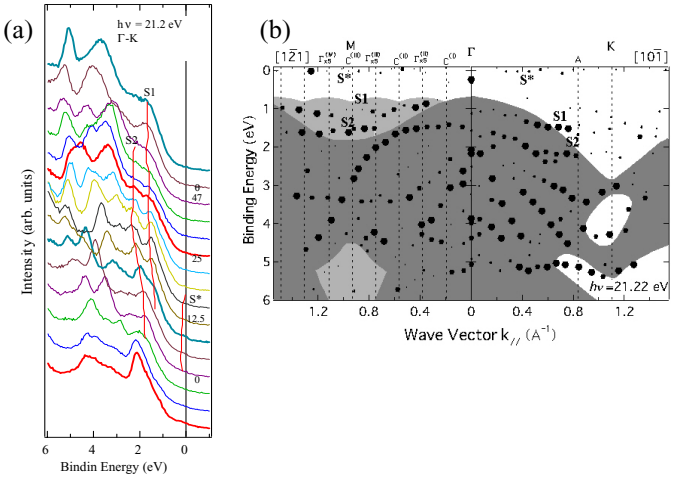

Fig.2 (a)ARPES spectra of Si(111)5x2-Gd surface along Γ-K(parallel to chain) . (b)Map of dispersion of 5x2-Gd along Γ-K and Γ-M(perpendiculat to chain).

References

[1] A. Kirakosian *et al.* , Surf. Sci. **498** L109 (2002).

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