Surface and Interface

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ARPES study of Bi/Ge(111) surface

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Introduction

Recently, there has been growing interest in large spin splitting of surface bands due to the Rashba-type spin-orbit interaction [1]. The large Rashba-type spin splitting has been observed on heavy metal and heavy metal adsorbed surfaces. The simplest two-dimensional free electron model is qualitatively consistent with These experimental features, but quantitatively inaccurate (predicted splitting is orders of magnitude too small). This gap between theoretical and experimental results can be explained when a large atomic spin-orbit parameter of heavy metal is taken into account.

Moreover, a semiconductor surface whose surface bands show the large spin splitting have a possibility for applications to spintronics. However, only few cases of Rashba-type spin splitting were reported on semiconductor surfaces [2].

On the Bi/Ge(111)- (√3×√3)*R*30° surface, 1 ML of Bi on bulk-truncated Ge(111) surface forms triangular trimers centered at T_4 sites [3]. We investigated the electronic structure of the Bi/Ge(111)-(√3×√3)*R*30° surface by angle-resolved photoelectron spectroscopy (ARPES).

Experimental

The ARPES measurements were performed at beam line 18A.We used a Ge(111) substrate cleaned by cycles of Ar-ion sputtering (1 keV) and annealing (<950 K) by direct current heating. Bi was deposited on the substrate from a Ta crucible, followed by annealing up to ~700 K for 5 minutes. The sample was checked by low-energy electron diffraction (LEED). The ARPES measurements were performed at room temperature and ~110 K.

Results and discussion

Figure 1 (a) shows a set of spectra along the ΓM direction of the Bi/Ge(111)-(√3×√3)*R*30° surface, taken at hν = 49 eV. Two bands labeled S1 and S2 in fig. 1 (a) are seen. These bands were observed at almost the same binding energies in the spectra taken at hν = 60 eV. Therefore, we consider these bands to be surface bands. S1 disperses from a minimum binding energy of ~1.6 eV at Γ point to a binding energy of ~0.7 eV near the M point. S2 does not display a distinct dispersion.

The S1 band is predicted to show the Rashba-type spin splitting by our first-principles calculation.

For a more thorough understanding of the splitting of surface-derived bands in any direction of surface Brillouin Zone, further analysis of the ARPES data are now in progress.

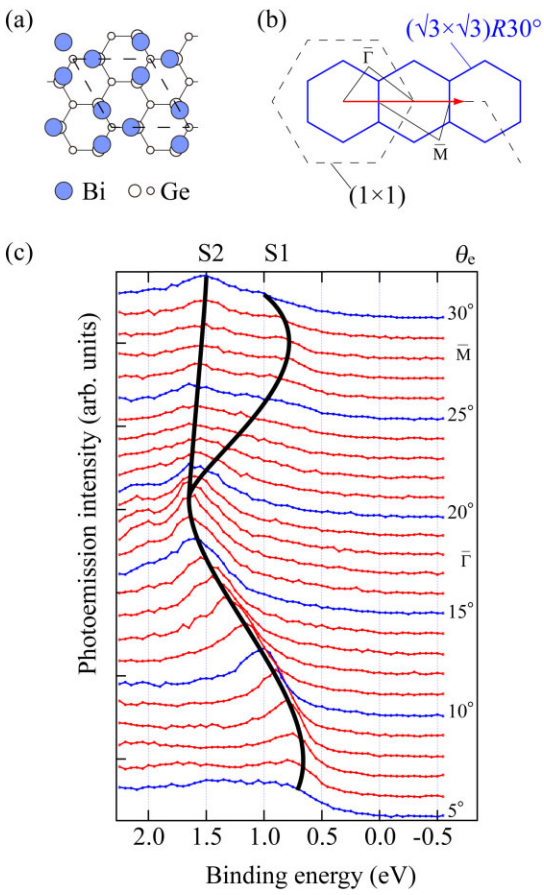

Figure 1 Surface atomic structure (a), surface BZ (b), and ARPES spectra along ΓM direction (c) of the Bi/Ge(111)-(√3×√3)*R*30° surface.

References

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