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Two-dimensional boron network and its electronic structure on YbB_{12}(001)

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1 Introduction

Two-dimensional materials made with light elements, as typified by graphene, exhibit various unconventional electronic phenomena such as the massless dispersion of the 2D Dirac fermion and out-of-plane orbital angular momentum polarization derived from the lack of two-fold rotational symmetry, namely valley polarization [1]. Borophene is a member of two-dimensional materials composed of boron and is known as a fertile research playground for low-dimensional Dirac fermions, due to its atomic structure spanning a wide range from 1D to quasi-3D, compared to the ideal 2D case of graphene [2, 3].

In this work, we discovered the new 2D electronic states derived from surface superstructure on YbB_{12}(001), a long-known Kondo insulator [4]. Here, we report its dispersion measured by angle-resolved photoelectron spectroscopy (ARPES).

2 Experiments

ARPES measurements were performed at BL-28A of Photon Factory. A YbB_{12} single crystal was grown via the floating-zone method using an image furnace. The crystal was cut along the (001) plane and polished in air. The polished crystal was heated up to ~1350 K for an hour in the ultra-high vacuum preparation chamber at the beamline and then transferred to the ARPES measurement chamber without breaking the vacuum. Linearly polarized photons with energies from 30 to 250 eV were used. The sample temperature was maintained at around 10 K, and the ARPES energy resolution ranged from 20 to 40 meV, calibrated using the Mo foil attached to the sample.

3 Results and Discussion

Figure 1 shows the band dispersion of the YbB_{12} surface along the $\bar{\Gamma} - \bar{M}$ direction in the surface Brillouin zone. A band dispersion with the apex at ±0.6 Å^{-1} was clearly observed here. This band dispersion was identical from 30 to 70 eV, implying its two-dimensional nature.

We have also performed a density-functional-theory calculation, and it suggested that the observed two-dimensional electronic states are derived from surface borons [5].

To unveil the characteristics of the new two-dimensional boron states discovered here, we plan further ARPES measurements, including circular dichroism, to observe the valley polarization of this state.

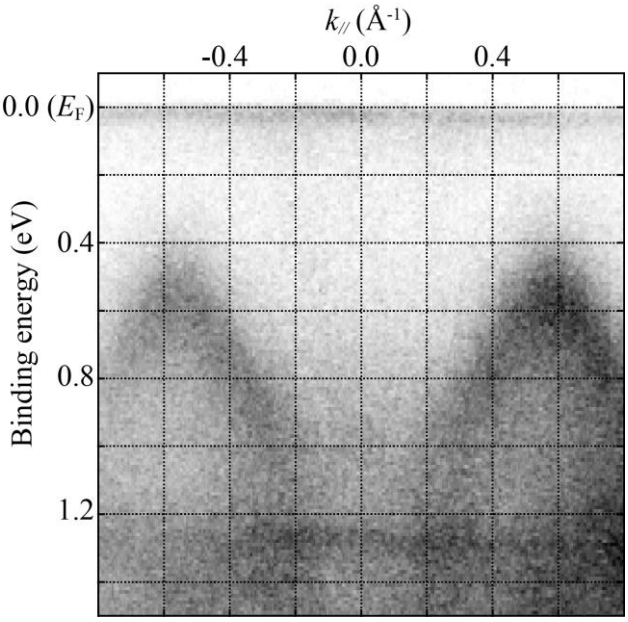

Figure 1: ARPES intensity plot taken with linearly polarized photons ($h\nu$ = 60 eV) at 10 K, along the $\bar{\Gamma} - \bar{M}$ direction in the surface Brillouin zone.

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References

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