BL-28A, BL-2A/2018S2-001, 2016G555

Nodal-line fermions protected by nonsymmorphic symmetry in Ta_3SiTe_6

Takafumi Sato,[1,2,3,*] Zhiwei Wang,[4] Kosuke Nakayama,[2] Seigo Souma,[1,3] Daichi Takane,[2] Yuki Nakata,[2] Takashi Takahashi,[1,2,3] Koji Horiba,[5] Hiroshi Kumigashira,[5,6] and Yoichi Ando[4]
[1] WPI-AIMR, Tohoku University, Sendai 980-8577, Japan
[2] Department of Physics, Tohoku University, Sendai 980-8578, Japan
[3] Center for Spintronics Research Network, Tohoku University, Sendai 980-8577, Japan
[4] Institute of Physics II, University of Cologne, Köln 50937, Germany
[5] Photon Factory, Institute of Materials Structure Science, High Energy Research Organization,
1-1 Oho, Tsukuba, 305-0801, Japan
[6] IMRAM, Tohoku University, Sendai 980-8577, Japan

1 Introduction

The search for new types of topological materials hosting nodal fermions is currently one of emergent topics in condensed-matter physics. Recently, it was theoretically proposed that layered ternary telluride Ta_3SiTe_6 hosts the nodal fermions protected by the nonsymmorphic glide mirror symmetry [1]. This material crystalizes in the orthorhombic structure [Fig. 1(a)] with the space group No. 62 (*Pnma*). First-principles band-structure calculations show that, when the spin-orbit coupling (SOC) is neglected, Ta_3SiTe_6 displays a four-fold-degenerate (eight-fold-degenerate if counting spin) nodal line on the SR line in the bulk Brillouin zone (BZ) shown in Fig. 1(b) due to the band crossing protected by the glide mirror symmetry. It is also suggested that when the SOC is included, the four-fold degeneracy on the SR line is slightly lifted and as a result the hourglass-like dispersions appear in the close vicinity of E_F. To examine such intriguing predictions, it is highly desirable to experimentally establish the electronic band structure of Ta_3SiTe_6.

2 Experiment

High-quality single crystals of Ta_3SiTe_6 were grown by the chemical vapor transport method by using I_2 as transport agent. Angle-resolved photoemission spectroscopy (ARPES) measurements were performed with a DA30 electron analyzer at BL28. To excite photoelectrons, we used linearly polarized VUV light of 40-100 eV. The energy and angular resolutions were set to be 6-20 meV and 0.2°, respectively. We also measured the core-level spectrum with 600-eV photons at BL2. Crystals were cleaved *in-situ* along the (001) plane in an ultrahigh vacuum of 1×10^{-10} Torr and showed a shiny mirror-like surface indicative of high quality of the crystal. Sample temperature during measurements was kept at $T = 30$ K.

3 Results and Discussion

We show in Fig. 1(c) the ARPES-intensity mapping at E_F as a function of in-plane wave vectors (k_x and k_y) [2]. We observe two types of Fermi surfaces, one is an open Fermi surface with a holelike character, surrounding the $\bar{\Gamma}$ and $\bar{Y}$ points with strong wiggling along the k_x direction. Another Fermi surface encloses the $\bar{M}$ and $\bar{X}$ points, forming an open Fermi surface with an electronlike character. By utilizing the energy-tunable photons from synchrotron radiation, as shown in the normal-emission spectra in Fig. 1(d), we have determined the band structure in the 3D BZ, and found that the energy bands in the valence-band show Dirac-like dispersions which present a band degeneracy at the R point of the bulk orthorhombic Brillouin zone (not shown). This band degeneracy extends one-dimensionally along the whole SR high-symmetry line, forming the nodal lines protected by the glide mirror symmetry of the crystal. Our result thus suggests that the glide symmetry is highly useful to search for new platform of topological semimetals hosting nodal lines.

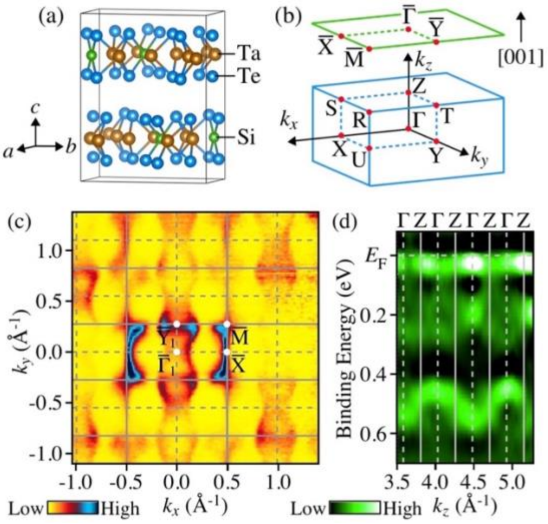

Fig. 1: (a) Crystal structure and (b) BZ of Ta_3SiTe_6. (c) ARPES intensity at E_F plotted as a function of k_x and k_y. (d) Plot of normal-emission ARPES intensity as a function of k_z [2].

References

[1] S. Li *et al.*, *Phys. Rev. B* **97**, 045131 (2018).
[2] T. Sato *et al.*, *Phys. Rev. B* **98**, 121111(R) (2018).

* t-sato@arpes.phys.tohoku.ac.jp