Large perpendicular magnetic anisotropy of the new ferromagnetic semiconductor (Ba,K)(Zn,Mn)$_2$As$_2$ single crystal

The Univ. of Tokyo[1], Chinese Academy of Sciences[2], KEK[3], JAEA[4], Columbia Univ.[5]

°(D)Shoya Sakamoto[1], Guoqiang Zhao[2], Goro Shibata[1], Zhen Deng[2], Kan Zhao[2], Bijuan Chen[2], Yosuke Nonaka[1], Keisuke Ikeda[1], Zhendong Chi[1], Yuxuan Wan[1], Masahiro Suzuki[1], Tsuneharu Koide[3], Sadamichi Maekawa[4], Yasutomo Uemura[5], Changqing Jin[2], and Atsushi Fujimori[1]

E-mail: shoya@wyvern.phys.s.u-tokyo.ac.jp

Ferromagnetic semiconductors (FMSs) have attracted much attention in the field of spintronics. Recently, a new FMS Ba$_{1-x}$K$_x$(Zn$_{1-y}$Mn$_y$)$_2$As$_2$ was synthesized in bulk form [1], which crystalizes in the tetragonal ThCr$_2$Si$_2$ structure (I4/mmm) as shown in Fig. 1. The host compound BaZn$_2$As$_2$ is a semiconductor with a narrow band gap of 0.2 eV. When holes and spins are introduced by K and Mn substitution for Ba and Zn, respectively, a ferromagnetic ground state is realized. With 30% of K and 15% of Mn substitution, the Curie temperature (T_C) reaches 230 K for polycrystalline samples (60 K for single crystals) and the carrier concentration 8 × 10^{20} cm^{-3}. Because the crystal structure is inherently anisotropic, sizable magnetic anisotropy would be expected. In fact, large perpendicular magnetic anisotropy was observed by SQUID measurements. In the present study, we have investigated the magnetic anisotropy of this material by means of angle-dependent x-ray magnetic circular dichroism (AD-XMCD) measurements [2]. Ba$_{0.904}$K$_{0.096}$(Zn$_{0.805}$Mn$_{0.195}$)$_2$As$_2$ single crystals were grown by the arc-melting solid-state reaction method. AD-XMCD measurements were performed at BL-16A2 of Photon Factory. Measurement geometry is shown at the top right of Fig.2, where Mn $L_{2,3}$-edge x-ray absorption (XAS) and XMCD spectra are also shown. The spectra look similar to those of (Ga,Mn)As and exhibit multiplet features. This suggests the localized nature of the Mn 3*d* electrons supporting the idea of carrier-induced ferromagnetism, where itinerant holes mediate ferromagnetic interaction between the localized spins. The angle-dependent measurements yielded very large perpendicular magnetic anisotropy with anisotropy field H_K of 0.8 T, which is promising for future applications such as magnetic memories.

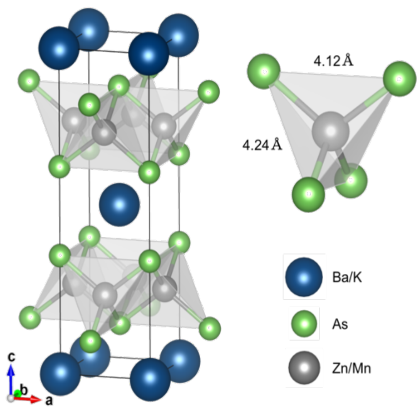

Fig. 1 Crystal structure.

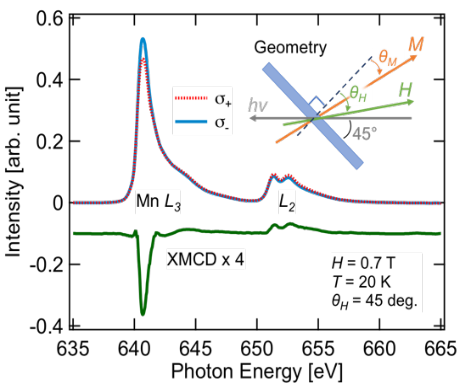

Fig. 2 XAS and XMCD spectra of Ba$_{0.904}$K$_{0.096}$(Zn$_{0.805}$Mn$_{0.195}$)$_2$As$_2$.

Reference

[1] K. Zhao et al., Nat. Commun. **4**, 1442 (2013)
[2] G. Shibata *et al.*, *arXiv*:1706.05183