A topological metal at the surface of an ultrathin BiSb alloy film

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Recently there has been growing interest in *topological insulators* or the *quantum spin Hall (QSH) phase*, which are insulating materials with bulk band gaps but have metallic edge states that are formed topologically and robust against any non-magnetic impurity [1]. In a three-dimensional material, the two-dimensional surface states correspond to the edge states (topological metal) and their intriguing nature in terms of electronic and spin structures have been experimentally observed in bulk $Bi_{1-x}Sb_x$ single crystals [2,3,4]. However, if we want to know the transport properties of these topological metals, high purity samples as well as very low temperature will be needed because of the contribution from bulk states or impurity effects. In a recent report, it was also shown that an intriguing coupling between the surface and bulk states will occur [5]. A simple solution to this bothersome problem is to prepare a topological metal on an ultrathin film, in which the surface-to-bulk ratio is drastically increased.

Therefore in the present study, we have investigated if there is a method to make an ultrathin $Bi_{1-x}Sb_x$ film on a semiconductor substrate. From reflection high-energy electron diffraction observation, it was found that single crystal $Bi_{1-x}Sb_x$ films (0<x<0.25) as thin as ~30 Å can be prepared on Si(111)-7x7. The transport properties of such films were characterized by *in situ* monolithic micro four-point probes [6]. The temperature dependence of the resistivity for the x=0.1 samples was insulating when the film thickness was 240 Å. However, it became metallic as the thickness was reduced down to 30 Å, indicating surface-state dominant electrical conduction. Figure 1 shows the Fermi surface of 40 Å thick $Bi_{0.92}Sb_{0.08}$ (a) and $Bi_{0.84}Sb_{0.16}$ (b) films mapped by angle-resolved photoemission spectroscopy. The basic features of the electronic structure of these surface states were shown to be the same as those found on bulk surfaces, meaning that topological metals can be prepared at the surface of an ultrathin film. The details will be given in the presentation.

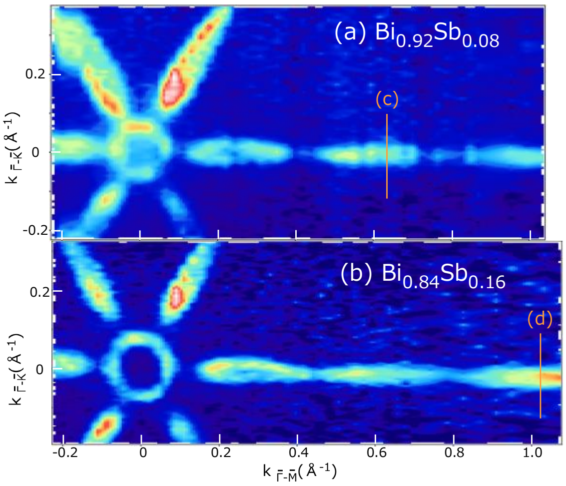

Fig. 1. The Fermi surface mapped by ARPES at 10 K for 40 Å thick $Bi_{0.92}Sb_{0.08}$ (a) and $Bi_{0.84}Sb_{0.16}$ (b) films, respectively. A circularly polarized light was used at the photon energy of 28 eV.

References:

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