Study of the topological transition in $Bi_{1-x}Sb_x$ as a function of Sb-doping

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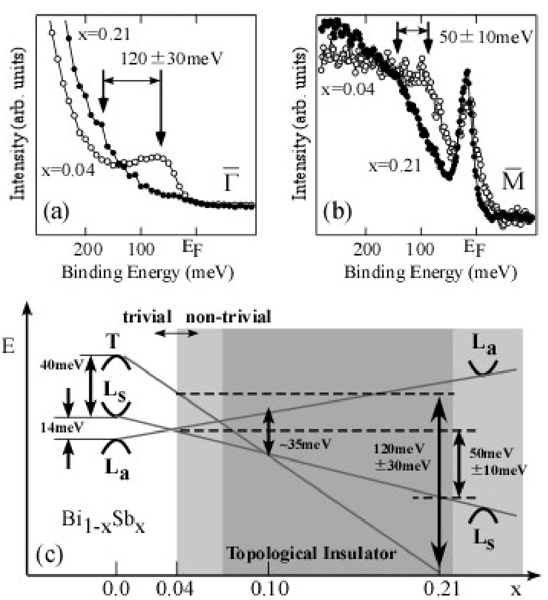
Bismuth antimony alloy has long been studied for its thermoelectronic properties and, nowadays, it has been vigorously investigated as one of the topological insulators [1,2]. The topological insulator is a material realizing the quantum spin-Hall effect. While the gap of bulk bands are energetically opened, the edge-state is gapless and carries spin current which is topologically protected from scattering by a non-magnetic impurity. A topological $Bi_{1-x}Sb_x$ insulator is synthesized by Sb doping (x~0.1) to a Bi crystal, which is topologically trivial semimetal.

In the present research, we systematically measured an evolution of the electronic structure of $Bi_{1-x}Sb_x$ at different Sb concentration (x=0.04, 0.07, 0.21) by momentum- and spin-resolved photoemission spectroscopy to trace the topological transition from the Rashba-split trivial surface states to the topological surface states. The experiments are performed at Photon Factory BL-19A, UVSOR BL-5U, and SOLEIL CASSIOPEE beamlines. Shifts of the bulk bands with x are quantitatively evaluated as shown in Fig.1. Changes of the surface-state band structure are experimentally determined (Fig.2). The surface-state (edge-state) band becomes topologically non-trivial, connecting the bulk T valence band and the bulk L_a conduction band around x=0.04. The additional surface-state band additionally appears in the L gap above x=0.04. Surface band structure of the topological $Bi_{1-x}Sb_x$ insulator is likely a result of hybridizations between the non-trivial edge-states and the trivial surface-states, as proposed in the previous theoretical research [3].



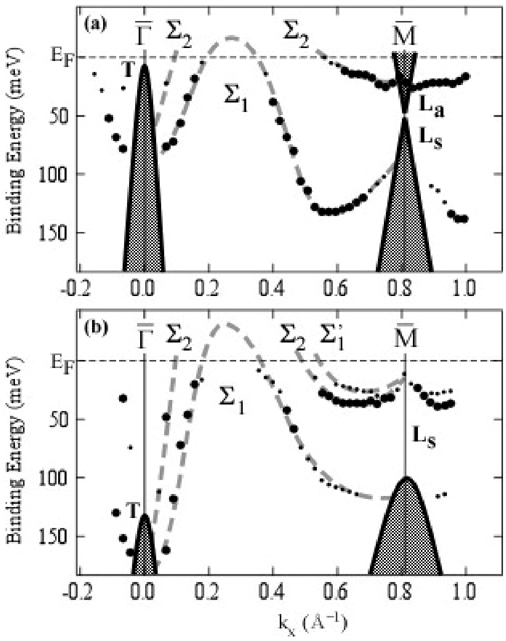


Fig.1 (a) Photoemission spectra of $Bi_{1-x}Sb_x$ at the Γ for the x= 0.04 and x=0.21 samples, measured at *hv* = 23eV. (b) Photoemission spectra of $Bi_{1-x}Sb_x$ at the M point for the x= 0.04 and x=0.21 samples, measured at *hv* =29eV. (c) Schematic representation of the bulk band energy evolution as a function of x.

Fig.2 Photoemission band diagram of $Bi_{1-x}Sb_x$ crystals at (a) x=0.04 and (b) x=0.21. The small and large symbols represent the rather distinctive and the weak spectral features, respectively. The shaded region is the bulk band structure projected onto the SBZ.

Reference

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