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Novel electronic states of topological insulators studied by ARPES

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The surface state of a three-dimensional topological insulator is characterized by a Dirac-cone dispersion protected by the time-reversal symmetry. Breaking the TRS by a magnetic order leads to the opening of a gap in the surface state and consequently the Dirac fermions become massive. It has been proposed theoretically that such a mass acquisition is necessary for realizing novel topological phenomena, but achieving a sufficiently large mass is an experimental challenge.
We report an unexpected discovery [1] that the surface Dirac fermions in TlBi(S1-xSex)2 acquires a mass without explicitly breaking the TRS. ARPES data around the Brillouin-zone center measured for various sulfur concentrations x revealed a finite energy gap at the Dirac point in $0.6 \leq x \leq 0.9$, while such an energy gap is absent in $x = 1.0$. This indicates that the masless Dirac fermions transforms into a massive state by simply replacing Se with S in the crystal. Present result provides a new route to achieving the massive Dirac state required for realizing the exotic topological phenomena. We will also present our recent ARPES results on tunable Dirac carriers in topological insulator Bi2-xSbxTe3-ySey [2].
This study has been performed in collaboration with S. Souma, T. Arakane, K. Nakayama, K. Kosaka, T. Takahashi (Tohoku Univ.), Kouji Segawa, K. Eto, T. Minami, Z. Ren, and Yoichi Ando (Osaka Univ.).

[1] T. Sato et al., Nat. Phys. 7, 840 (2011).
[2] T. Arakane et al., Nat. Commun. 3:636, ncomms1639 (2012).

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