

# Temperature-dependent band modification and determining factor of the electron-phonon interaction in the topological surface states on Bi<sub>2</sub>Te<sub>3</sub>

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We examine the temperature-dependent band structure and self-energy of the topological surface state (TSS) on a prototypical 3D topological insulator Bi<sub>2</sub>Te<sub>3</sub> using a laser-based scanning angle-resolved photoemission spectroscopy (ARPES) system [1]. In the energy band along the  $\bar{\Gamma}$ - $\bar{K}$  momentum direction, we could not detect an appreciable kink structure due to the electron-phonon interaction (EPI) at 17 K [Fig. 1(a), (b)]. Then we did temperature-dependent ARPES experiments and found that the Dirac point (DP) and the bulk valence-band (VB) peak were shifting to higher energy on heating while the energy shift of the conduction band bottom was not significant as in the DP and VB peaks. Furthermore, the energy gap in the bulk and the group velocity of the TSS were reduced as temperature increased indicating the band modification was not rigid-band-like. Despite the band modification at finite temperatures, the degeneracy at the DP was robust, which is consistent with the topological protection. The value of the EPI coupling parameter was found to weakly depend on the initial-state electron energy with respect to the DP energy, varying from 0.13 (at the DP) down to 0.02 (100-150 meV above the DP) as shown in Fig. 1(c). The magnitudes and energy dependence of the EPI coupling parameter are consistent with the reported first-principles calculations [2] as well as no appreciable kink structure in the energy band dispersion at 17 K. Based on the analyses of the imaginary part of the self-energy due to the EPI, we found the magnitude of the EPI coupling was mainly determined by the number of the scattering channels. Our findings provide insight into the temperature and doping dependence of the transport properties of the TSS.

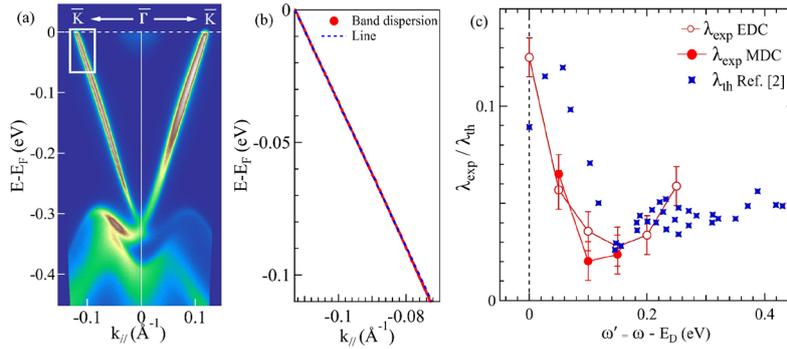


Figure 1. (a) TSS band dispersion of *n*-type Bi<sub>2</sub>Te<sub>3</sub> measured along the  $\bar{\Gamma}$ - $\bar{K}$  momentum direction at temperature of 17 K and photon energy of  $h\nu = 6.3$  eV. (b) TSS band positions determined by the MDC analyses. To see the linearity, we plotted a dotted blue line connecting a band point at the Fermi level ( $E_F$ ) and a band point at -100 meV. (c) Evaluated EPI coupling parameter as a function of initial-state electron energy ( $\omega'$ ) with respect to the DP energy ( $E_D$ ) obtained from the EDC analyses (open red circles) and MDC analyses (filled red circles). Blue stars represent the theoretical EPI coupling parameter extracted from Ref. [2].

## References

- [1] H. Iwasawa *et al.*, *Ultramicroscopy* **182**, 85 (2017).
- [2] R. Heid, I. Y. Sklyadneva, and E. V. Chulkov, *Sci. Rep.* **7**, 1095 (2017).