Thesis Summary

Angle-resolved Photoemission Spectroscopy Study of Many-body Effects on 3D Topological Insulator Bi_2Te_3
（角度分解光電子分光法による 3 次元トポロジカル絶縁体 Bi_2Te_3 の多体効果の研究）

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Topological Insulators are a fascinating class of materials, which sparked renewed interest in the topological aspects of condense matter physics. Like conventional insulators, Topological insulators feature a gap that separates valance and conduction bands but conducting at edges or surface, so-called topological edge states or surface states. These states are protected by time-reversal symmetry, which makes them robust to nonmagnetic disorders and crystal defects. These metallic topological surface or edge states inside the bulk bandgap of TIs degenerate at the time-reversal invariant momentum (TRIM) and exhibit a Dirac-fermion-like linear dispersion away from the TRIM. The electron spin and momentum directions of the Topological surface states are locked due to the strong Spin-orbit coupling, which is so-called spin momentum locking. Although Dirac electrons are robust to non-magnetic impurity or lattice imperfections and elastic electron back scattering is suppressed due to spin momentum locking in the Topological insulators, but there is always possible to have electron-phonon scattering at elevated temperature. Which is very indispensable to clarifying the electron-phonon interaction in the topological insulators at elevated temperatures. For this study, We have chosen the promising candidate Bi_2Te_3, which is the second most studied topological insulator and belongs to the strong 3D topological insulators family.

In this study, we have grown Bi_2Te_3 single crystal using the modified Bridgeman method and systematically investigated the electron-phonon interaction using High-resolution laser μ-angle-resolved photoemission spectroscopy. We did not observe band renormalization so-called kink structure within the Debye characteristic energy range at low temperature, indicating weak electron-phonon coupling. As we did not find kink structure at low temperature, therefore we ran the detailed temperature-dependent angle-resolved photoemission spectroscopy measurement. We found that the Dirac point is shifting upward on heating, however, the Dirac point position is fully recovered in the temperature cycle, which confirms the reproducibility. By analyzing the temperature-dependent Energy distribution curves, we confirmed for the first time that bulk and the topological surface bands are non-rigid-like bands. By considering the temperature-induced shift, we assume that scattering states are changing with temperature. Therefore, we evaluated the electron-phonon coupling parameter at fixed energy with respect to the Dirac point. We revealed that the magnitude of the electron-phonon coupling weakly depends on the chosen initial energy state and nice matched with the first-principle calculation. Our study provides a deep incite about electron-phonon interaction in the Topological surface states of Bi_2Te_3, suggesting weak coupling electron-phonon interaction. Our analysis method can also be apply further to other Topological insulators or Topological superconductors. The most important benefit of this analysis is, instead of growing many samples with differently tuned chemical potential, one can extract electron-phonon coupling information by choosing the initial energy states in only one sample.