Mapping the band structure of three-dimensional topological insulator Bi$_2$Se$_3$ in two-dimensional limit KE HE, YI ZHANG, CUI-ZU CHANG, CAN-LI SONG, LI-LI WANG, XU-CUN MA, ZHONG FANG, XI DAI, Institute of Physics, Chinese Academy of Sciences, WEN-YU SHAN, SHUN-QING SHEN, The University of Hong Kong, QIAN NIU, The University of Texas, Austin, XIAO-LIANG QI, SHOU-CHENG ZHANG, Stanford University, XI CHEN, JIN-FENG JIA, QI-KUN XUE, Tsinghua University — In this work, with in situ angle-resolved photoemission spectroscopy, we have investigated the thickness dependent band structure of molecular beam epitaxy grown Bi$_2$Se$_3$, a typical three-dimensional insulator, from 1 quintuple layer (QL) up to 200QL. An energy gap is observed in the topologically protected metallic surface states of bulk Bi$_2$Se$_3$ below the thickness of 6QL, due to the coupling between the surface states from two opposite surfaces of the Bi$_2$Se$_3$ film. The gapped surface states exhibit sizable Rashba-type spin-orbit splitting, resulting from breaking of structural inversion symmetry induced by 6H-SiC substrate. The spin-splitting can be controlled by tuning the potential difference between the two surfaces, which can be utilized into electrical spin manipulation.

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