Current-induced second-order nonlinear Hall effect in bulk WTe_2

Hui Li,[1] Rui-Chun Xiao,[2] Wenhui Liu,[2] Lin Wu,[1,2] Minxin Li,[2] Wei Gan,[2] Hui Han,[2] Xi Tang,[2] Takashi Taniguchi,[3] Kenji Watanabe,[3] Changjin Zhang,[2,4] Jiannong Wang[1]*

[1]*Physics Department, the Hong Kong University of Science and Technology, Hong Kong, China*

[2]*Institute of Physical Science and Information Technology and Information Materials and Intelligent Sensing Laboratory of Anhui Province, Anhui University, Hefei 230601, China*

[3]*National Institute for Materials Science, Namiki 1-1, Tsukuba, Ibaraki 305-0044, Japan*

[4]*High Magnetic Field Laboratory of Anhui Province, Chinese Academy of Sciences, Hefei 230031, China*

Second-order nonlinear Hall effect has opened up access to a deep understanding of the connection between symmetry and topological states of materials. For example, second-order nonlinear Hall effect has been demonstrated in bilayer and few-layer T_d-WTe_2 experimentally originating from Berry curvature dipole [13]. More importantly, the emergence of the second-order Hall effect generally requires broken inversion symmetry and other spatial symmetries (such as in-plane C2 symmetry) rather than broken time-reversal symmetry, which brings new avenue to nonlinear physics research and innovative concepts for devices applications [4,5]. However, this intriguing nonlinear phenomenon is smeared out in bulk counterpart of T_d-WTe_2 due to the preservation of C2 symmetry.

Here, we investigate the induced second-order Hall effect in bulk T_d-WTe_2 by applying direct current along the longitudinal direction (Fig. 1a,b). The observed second-order Hall effect is strongly dependent on the external direct current with its magnitude increasing with direct current (Fig. 1c,d). Furthermore, the direct current induced second-order Hall effect in bulk T_d-WTe_2 exhibits two-fold angular dependent features, which is different from that in bilayer and few-layer T_d-WTe_2, but similar to third-order Hall effect observed in bulk T_d-WTe_2 (Fig. 1e,f). The occurrence of the second-order Hall effect in bulk T_d-WTe_2 is believed to be originated from several possible origins, including Berry connection polarization tensor, Drude transport, disorder scatterings. Our work outlines a potential roadmap to control the second-order Hall effect in materials where crystal symmetry forbids with both fundamental interests and technological applications.

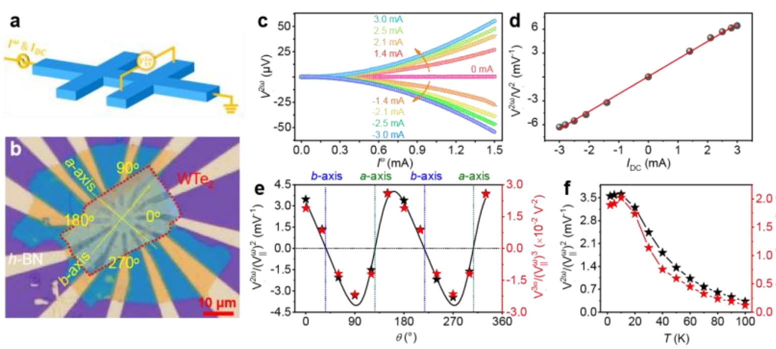

FIG. 1. DC induced nonlinear Hall effect in bulk T_d-WTe_2. (a) Measurement schematic of second-order nonlinear Hall effect. (b) Optical image of the bulk T_d-WTe_2 device. (c) Second-order Hall voltage in bulk T_d-WTe_2 measured under different DC. (d) The slope of versus square of the longitudinal first-harmonic voltage as a function of applied DC. (e) Angular and (f) temperature dependence of third- (red pentagram) and DC induced second-order (black pentagram, I_{DC} = 1.5 mA) nonlinear Hall effect in bulk T_d-WTe_2. The vertical dashed lines in (e) indicate the crystalline a-axis and b-axis.

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