Shear-resistant topology and electrical anisotropy quasi-one-dimensional van der Waals material α-Bi_4Br_4

Jonathan K. Hofmann[1,2], Serhii Kovalchuk[1,3], Mingqian Zheng[4], Yuqi Zhang[4], Vasily Cherepanov[1], Timofey Balashov[1], Jin-Jian Zhou[4], Zhiwei Wang[4], Yugui Yao[4], Irek Morawski[3], F. Stefan Tautz[1,2], Felix Lüpke[1,5], and Bert Voigtländer[1,2]

[1] Peter Grünberg Institut (PGI-3), Forschungszentrum Jülich, Germany
[2] Experimentalphysik IV A, RWTH Aachen University, Germany
[3] Institute of Experimental Physics, University of Wrocław, Poland
[4] Key Laboratory of Advanced Optoelectronic Quantum Architecture and Measurement, Beijing Institute of Technology, China
[5] II. Physikalisches Institut, Universität zu Köln, Germany

α-Bi_4Br_4 is a quasi-one-dimensional material [see Fig. 1(a)]: covalently bonded Bi_4Br_4 chains are arranged in parallel, side-by-side and layer-by-layer, with van der Waals gaps in between [1,2,3]. Bulk α-Bi_4Br_4 is higher-order topological insulator [1]. At step edges on the (001) surface, quantum spin Hall (QSH) edge states are present [2], that can be observed up to room temperature [1].
Using a scanning tunneling microscope (STM), we analyzed a cleaved bulk crystal [3]. Fig. 1(b) shows STM topography of the (001) surface, showing a significant shift of the chains, relative to each other in crystallographic *b* direction [3]. We attribute this shift to shear stress arising from cleaving or gluing the crystal or from domain boundaries. Scanning tunneling spectroscopy [Fig. 1(c)] shows the bulk band gap on the terraces and a metallic density of states at step edges, which we attribute to the QSH edge states. Density functional theory (DFT) confirms that a strained monolayer of Bi_4Br_4 is a QSH insulator with $\mathbb{Z}_2 = 1$ [3].
Furthermore, we used a four-tip STM to disentangle the elements of the resistivity tensor of α-Bi_4Br_4 *in situ*. For this measurement, we prepared a bulk sample of α-Bi_4Br_4 to measure the anisotropy in the *ab*-plane [Fig. 1(d)] and a flake sample to measure the resistivity component ρ_b. Due to its crystal structure [Fig. 1(a)], α-Bi_4Br_4 tends to form long rectangular flakes. At room temperature, we find $\rho_b = 10(3)\ \mathrm{m\Omega cm}$ and an in-plane anisotropy of $A = 6.4(5)$. The out-of-plane component is much larger: $\rho_z = 11(3)\ \Omega\mathrm{cm}$. While the low resistivity along the chains (*b* direction) is expected from the crystal structure, the large difference between ρ_a and ρ_z is noteworthy. We attribute this marked difference in resistivity to the weak inter-layer coupling found by DFT [2].

References:
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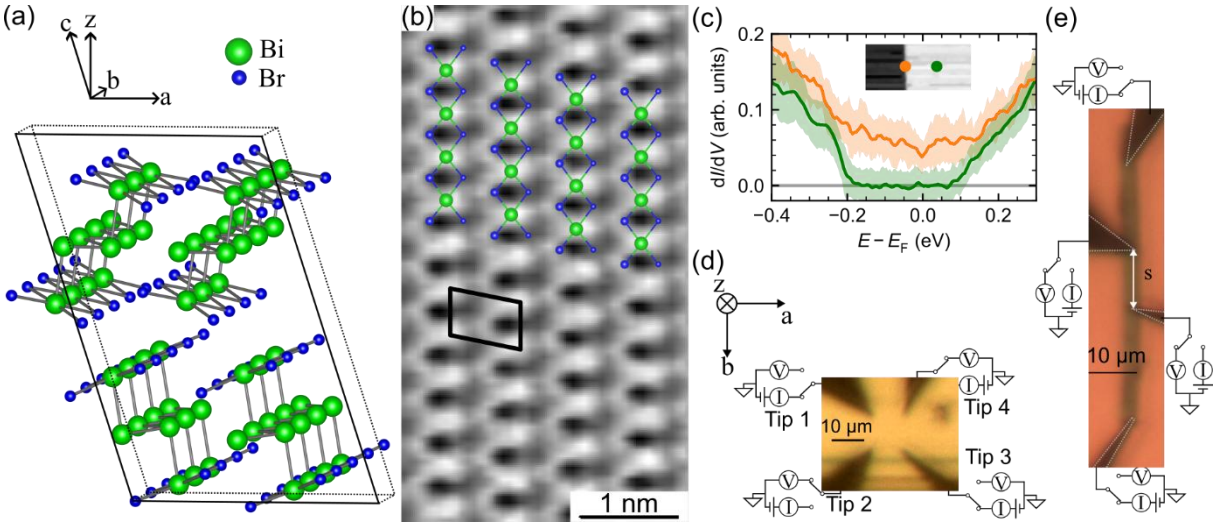

FIG. 1: (a) Model of the crystal structure of α-Bi_4Br_4. (b) STM topography of the α-Bi_4Br_4(001) surface showing the $^b/_3$ structure. A modified crystal model has been overlayed. (c) STS showing the bulk band gap visible on the (001) surface and metallic DOS present at a step edge. (d) Transport measurements in a square geometry on a bulk sample. (e) Linear transport measurements on an exfoliated flake.