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Magnetotransport in Altermagnetic CrSb

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Compensated magnets with a spin-split nonrelativistic band structure have gained significant interest in spintronics research over recent years. These materials are referred to as altermagnets. In this work, the altermagnetic Chromium Antimonide (CrSb) is thoroughly investigated in both bulk form and as epitaxial thin films. Magnetometry measurements using a SQUID magnetometer confirm the vanishing net magnetization, while X-ray diffraction (XRD) and Laue diffraction analysis validates the hexagonal NiAs phase of CrSb, also ensuring high structural quality.

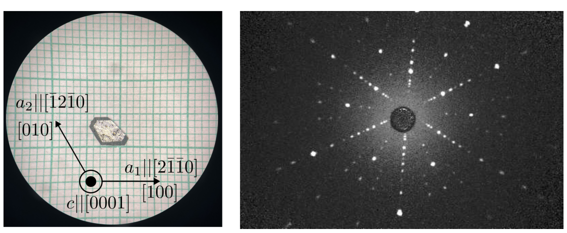

FIG. 1: Left: typical CrSb single crystal with crystal orientations. Right: Backscattered Laue diffraction pattern at room temperature.

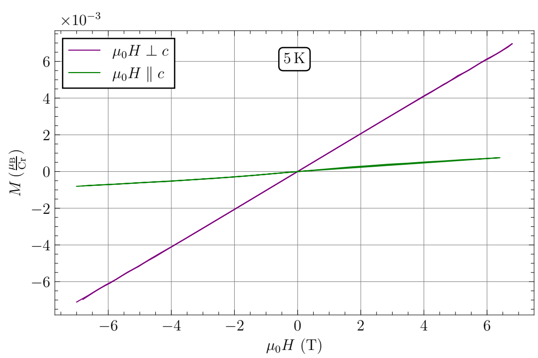

FIG. 2: Magnetic moment vs. external field in two different directions.

Detailed magnetotransport studies reveal distinct differences between the bulk and thin-film systems. The ordinary magnetoresistance (OMR) exhibits a substantial change, with bulk samples showing variations in the tens of percent range, whereas in thin films, the OMR drops significantly to sub-percent levels. Additionally, the Hall resistivity in the bulk samples shows a pronounced nonlinear slope, which is identified to arise from multi-carrier

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transport in connection with high-mobility carriers. In contrast, this nonlinear behavior is absent in the thin films, indicating distinct transport dynamics between the two material forms.

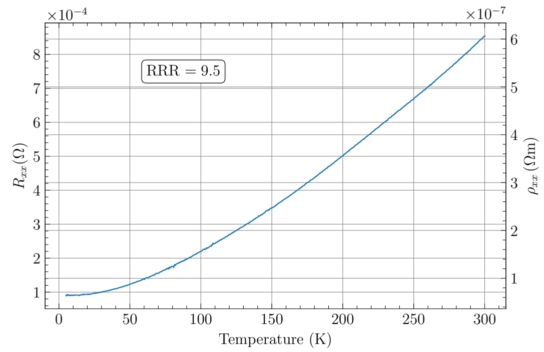

FIG. 3: ρ_{xx} vs. temperature in bulk.

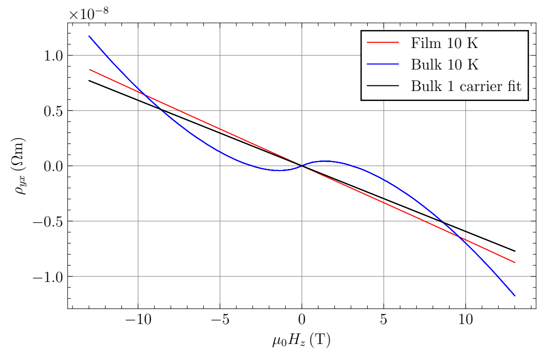

FIG. 4: ρ_{yx} vs. field in bulk and thin film.

A carrier analysis further highlights the differences in Hall resistivity in greater detail, while underscoring that the dominant hole-like transport remains consistent in both bulk and thin-film systems. The analysis reveals that while both systems share this dominant transport mechanism, the carrier densities and mobilities vary significantly. The calculated mobilities in bulk are approximately 100 times higher than in thin films, whereas the carrier density in bulk is about 20 times lower than in thin films. Magnetotransport measurements were also conducted at the high-field facility Helmholtz-Zentrum Dresden-Rossendorf (HZDR) to investigate potential high-field effects, such as spin-flop or spin-flip transitions. However, these phenomena were not observed. Additionally, none of the conducted experiments provide evidence for the occurrence of the anomalous Hall effect (AHE). This study underlines the impact of dimensionality and sample preparation on the transport properties of CrSb and its potential role in the field of altermagnetism.