Size-Dependent Effects in Thin Films of Transition Metal Chalcogenides

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In recent years, the search for novel two-dimensional (2D) materials has led to the discovery of a lot of different materials. Here, the transition metal chalcogenides include several groups with a wide range of band gaps and unique properties.

Two of the so far lesser researched groups of 2D materials are the transistion metal trichalcogenides of the form MX_3 and the transition metal pentachalcogenides of the form MX_5, where M is a transition metal and X is a chalcogen. The materials from these group show strong in-plane anisotropy in the form of quasi one-dimensional chains. This leads to special properties with the potential for new applications [1-4].

We took a closer look at the layered materials $ZrSe_3$ [1] and $HfTe_5$ [2] particularly concerning size dependent effects in thin transistor structures.

For $ZrSe_3$ we were able to determine a mean free path for the material by looking at the thickness dependence of the resistivity in the samples. By comparing the width of several samples of otherwise similar geometries it was also possible to determine that the conductivity between the chains is more dominating than the conductivity along the chains. This can be attributed to the fact that the main electron localization appears in the Se-atoms [5]. Additionally, we see a thickness dependence of the band gap energy.

Similarly, we also see a thickness dependence of the band gap energies in $HfTe_5$. In both cases the energy increases for thinner samples indicating large band gaps for monolayers, which is a prerequisite for the observation of the predicted quantum spin Hall effect.

References

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