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S E M I N A R
aus
Halbleiterphysik und Nanotechnologie

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"Manganese doped topological insulators: Magnetic band gap and formation of natural heterostructures"

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Magnetically doped topological insulators enable the quantum anomalous Hall effect which provides quantized edge states for lossless charge transport applications [1-3]. The edge states are hosted by a *magnetic energy gap* at the Dirac point [1] but attempts to observe it directly have remained unconclusive. Here, we focus on Mn-doped topological insulator films grown by molecular beam epitaxy. Using low temperature and spin-resolved photoelectron spectroscopy, we reveal the presence of a magnetic gap in Mn-doped Bi_2Te_3 that opens only below the ferromagnetic Curie tem¬pe¬ra¬ture and displays a ferromagnetic out-of-plane spin texture [4]. Our analysis reveals surprisingly large gap sizes of up to 90 meV at 1 K, which is five times larger than predicted by density functional theory. By extensive multiscale structure analysis [4], we show that this enhance¬ment is due to a remarkable *structural* modification induced by Mn doping. Instead of a disordered impurity system, an sequence of septuple Bi_2MnTe_4 layers alternating with quintuple Bi_2Te_3 layers is formed, where Mn is predominantly incorporated in the center of the septuple layers. This self-organized heterostructure enhances the wave-function overlap and the size of the magnetic gap at the Dirac point, as recently predicted [5]. Mn-doped Bi_2Se_3 forms similar heterostructures [4], however, a nonmagnetic gap is formed [6]. This striking difference is explained by the higher spin-orbit interaction in Bi_2Te_3, resulting in a magnetic anisotropy perpendicular to the films, whereas for Bi_2Se_3 the spin-orbit inter¬ac¬tion it is too weak to overcome the dipole-dipole interaction. The formation of natural heterostructures is not unique for Mn, but also occurs for various other dopants such as Ge, Sn, Pb and Bi. The resulting structures can be described in terms of a paracrystal model with random stacking sequences. This opens up interesting perspectives for tuning and control of the topology in theses systems.

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[4] E. Rienks et al., Nature 576, 423 (2019).
[5] M. M. Otrokov, et al., 2D Mater. 4, 025082 (2017).
[6] J. Sanchez-Barriga, et al., Nat. Commun. 7, 10559 (2016).