DESIGNING SPIN PROPERTIES IN TOPOLOGICAL, POLAR, AND MULTIFERROIC THIN FILMS

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The growth of high quality thin films has since long been known to be an effective method to control or enhance the electronic structure of materials. Here it will be shown that similar considerations can be applied to the spin texture of special classes of materials. For example, in topological insulator thin films the energy position and spatial localization of the spin polarized interface states can be controlled by the adequate choice of substrate and thickness [1].

Furthermore it will be shown that the highly polar surface of the transition metal oxide $SrTiO_3(001)$ hosts a 2D electron gas that exhibits the spin signature of a Rashba-type spin splitting [2]. The properties of this state can be tuned by doping of thin films and transforms into a 2D hole gas for ferroelectric $BaTiO_3$ films.

The previous examples take place at the surface or interface, but the spin degeneracy can also be lifted in the bulk of a thin film if the crystal structure lacks inversion symmetry. In this respect ferroelectric materials bear large promise as in this case the inversion symmetry breaking can be controlled by an external electric field. In the polarized state of ferroelectric GeTe films the electronic structure consists of a plethora of spin-polarized bulk and surface states, whereby the latter can be suppressed by a capping layer [3].

In this work we will take this concept one step further and induce ferromagnetic order in ferroelectric GeTe by Mn-doping. By using a combination of spectroscopic techniques it will be shown that the films are both ferroelectric and ferromagnetic at temperatures below 130K and that the chiral spin texture remains even for Mn concentrations around 20%. Furthermore, our spin-resolved ARPES and soft X-ray ARPES measurements show that the ferromagnetic order induces a Zeeman gap and out-of-plane spin texture around the Dirac point [4]. By switching the magnetization it could be determined that the ferroelectric and ferromagnetic order are directly entangled. This opens up new pathways for the use of non-volatile spintronics applications and electronically switchable magnetic substrates.

References

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