In-plane band banding effect around Au islands grown on a Bi_2Te_3 topological insulator

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Bi_2Te_3 belongs to the topological insulators (TI) class of materials. They are characterized by the presence of topologically protected conductive surface states (TSS). An important feature of TSS is that, due to spin-momentum locking, the charge current induces spin polarization whose sign can be controlled by the direction of the charge flow. These properties make TI a promising candidate for spintronic devices [1].

When speaking about TI devices, it is important to keep in mind that the surface of a TI is vulnerable to processing procedures. Thus, it is difficult to avoid modifications of the TSS during device fabrication. For example, the question is how TSS are influenced by Au, which is the material most commonly used for contacts. However, there is a lack of unambiguous reports in the literature on what changes occur at the Au-Bi_2Te_3 interface, except for studies at elevated temperatures [2-3].

The aim of this work is to test locally the influence of Au island on the TSS in Bi_2Te_3 TI. The first question is whether Au mixes with Bi_2Te_3 at room temperature. For that, we utilized the x-ray linear dichroism (XLD) technique at Tellurium M5,4-edge, employing linearly polarized synchrotron light in NCSR SOLARIS (Krakow). The FFT-transformed XLD spectra, measured after Au deposition, were compared with the DFT simulations for different atom configurations near the interface (AuTe, $AuTe_2$, Au_2Te_3, Au/Bi_2Te_3). We conclude that Au does not mix with the Bi_2Te_3 substrate and forms a rather sharp Au/Bi_2Te_3 interface, which makes it possible to suppose that TSS are not destroyed.

The changes in TSS can be probed in the vicinity of Au islands by scanning tunneling spectroscopy (STS) [4]. Since the TSS form the so-called Dirac cone in the volume band gap of Bi_2Te3, they are visible in the STS spectra as a signal linearly dependent on energy, i.e., on the bias voltage. The TSS-related contribution to the spectra is observed both at a distance and in the near proximity to the Au islands, indicating that the TSS are preserved. Furthermore, at distances of less than 10 nm from the islands, an increasing shift of the STS spectra towards negative energies is observed with decreasing distance from the islands. Since we exclude Au-Bi_2Te_3 mixing, we attribute this effect to the presence of an in-plane downward band bending near the Au islands.

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