The topologies of the surfaces shown in Fig. 1, the sphere and the doughnut, are different since no continuous transformation of the sphere exists that would lead to a doughnut without punching the hole in the surface. However, a sphere can be continuously buckled into a bowl and a doughnut into a coffee mug: sphere and bowl on one side, and the doughnut and coffee mug on the other, are topologically identical. Our Universe also has some topology and as long as this topology is stable, i.e. as long as a certain "hole" is created, nothing strange occurs locally. However, we can calculate the genus, the number distinguishing different topologies, so we can discover what topology our world belongs to.

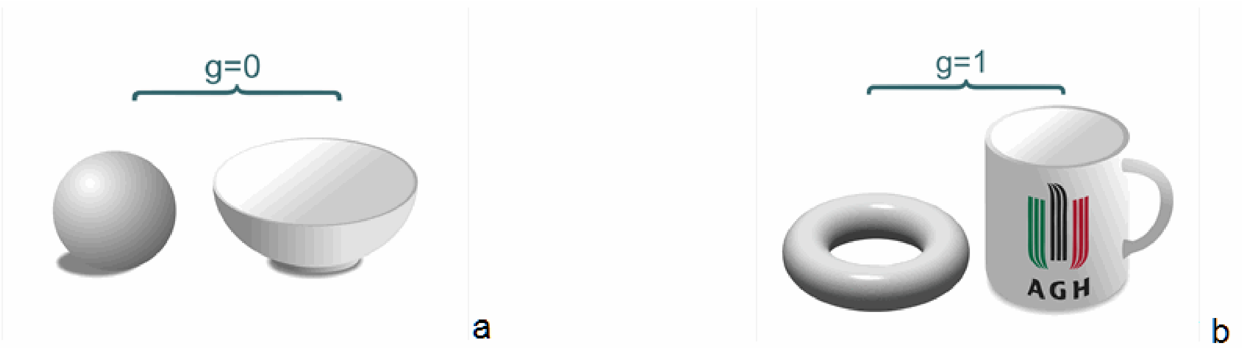

Fig. 1; a): Surfaces with g=0 that cannot be continuously transferred to the surfaces with g=1 (b)

Space of electronic states can also have different topologies. And, in equivalence to the normal space, we see nothing strange in their electron local behaviour as long as a break in topology does not occur. But once the topology changes, e.g. when electronic states belonging to two different topologies meet, some strange situation may be found. For example, if the insulator of nontrivial topology, i.e. with the non-zero Chern number - the equivalent of the genus in normal space - is terminated, electronic states of different topologies meet since the vacuum topology is trivial. Such a situation leads to some strange electron behavior on the surface: surface, 2D, electronic states are metallic with linear dispersion relation, like in the relativistic case, i.e. in the form of the Dirac cone, see Fig. 2a. Since this surface links two spaces of different topologies, the surface metallicity is protected: no action, despite some symmetry breaking (e.g. time reversal symmetry), can ruin metallic Dirac properties.

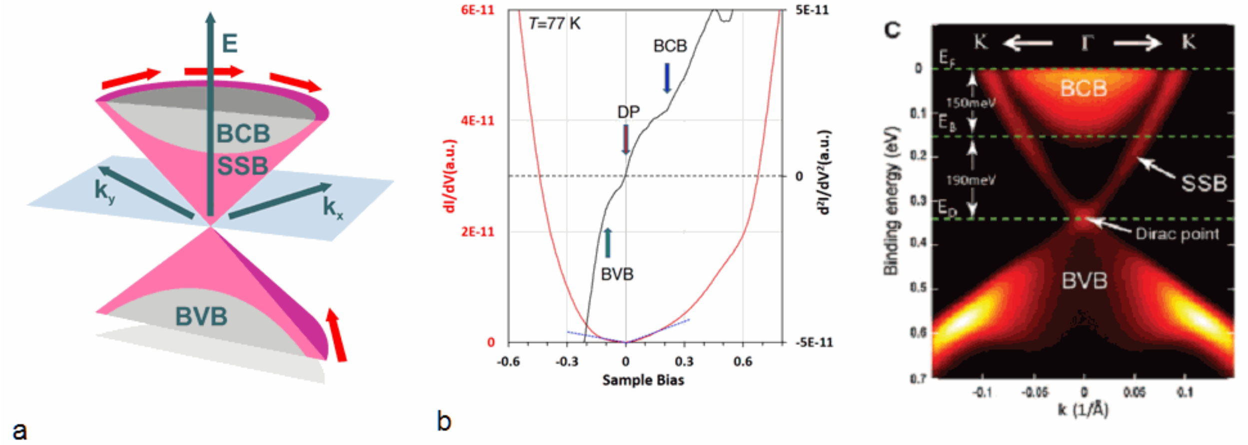

Fig. 2 a): Dirac cone of surface states (SSB) on top of bulk valence (BVB) and conduction (BCB) bends, with spin-momentum locking indicated by red arrows and these electronic states experimental images from STS (b; Xu et. Al., Nature Physics, 10, (2014) 956) and ARPES (c; Y. L. Chen et. al., SCIENCE 329 (2010) 659).

At the end of the first decade of 21st century the materials with those properties, topological insulators, TI, were discovered, with the obvious realization of sample-vacuum boundary. The 3D canonical topological insulators are, e.g. tetradymites as $Bi_{1-x}Sb_x$, Bi_2Se_3, Bi_2Te_3 and Sb_2Te_3. Apart from metallic surface states, their most conspicuous feature is their surface protection: no backscattering of surface electrons on nonmagnetic dopands is possible. This fact may have a tremendous effect on the stability of spintronic devices and quantum computers. It is thus natural to ask to what extent such a material may be altered, i.e. by introducing electrodes, or changing its shape and size, to make microelectronic devices, before its unique properties are lost. Our project is aimed at answering this question.

In particular, we would like to prepare nonostructures made from single crystals of canonical Topological Insulators and to experimentally check their topology stability under their size and geometry change. We are confident that preparing a good single crystal first and then forming this crystal with an electron or ion beam, FEB/FIB, i.e. performing top-down material preparation, is more promising than the usually used bottom-up approach, i.e. thin films preparation in the proper size to mictroelectronic needs, and will allow for a better control of the TI properties disappearance.

Electronic properties of our nanostructures will be continuously controlled by the observation of their electric conductance, also in the magnetic field, static and impulse of up to 60T, and in a wide temperature range down to 50mK. Surface electronic properties will be checked with the well developed and dedicated to these materials techniques: angle resolved photoemission, ARPRES, (Fig. 2c), scanning tunneling spectroscopy STS (Fig. 2b) and the Hall effect. We think that such a comparative analysis will allow to identify those phenomena linked to magnetotransport properties that are relevant not only to their nontrivial topology, but also to their size effects as well as those caused by the nanofabrication process. We are thus sure that we will pose the ground for the coming application of these materials in nanoelectronics and spintronics.