Scientific studies are often conducted based on the curiosity of the researcher with the aim to understand the fundamental phenomena that govern our world. Often, their impact or practical applications are not immediately obvious, but time reveals their significance. For example, the studies of the magnetic coupling between the thin layers of magnetic iron separated by a thin chromium layer lead to the discovery of the giant magnetoresistance, an effect which formed the basis for the field of spintronics, that gave us e.g. hard disk drives of large capacities.

Understanding of the properties or functions that an atomically ordered (crystalline) layer of a chosen material can have, is often based on the knowledge of its electronic band structure. The electronic band structure introduces us to the "secret life" of electrons that live in a certain material. Because of the constrains imposed by the atomic composition (each element has specific number of electrons that can have only well defined energies, as the quantum physics teaches us) and arrangement of atoms in the crystal lattice (number of nearest neighbors, angle between the atoms etc.), the electrons that reside in a particular material move around having only specific energies and also well-defined momenta. These relations of energy and momentum are called dispersion relations, and when determined for various directions within the crystal, form the electronic band structure. It turns out, that electronic bands often have very peculiar properties, and especially interesting are the crossing points between particular bands. For example, in graphene, the linear crossings of bands are found that are referred to as Dirac cones. Electrons that "live" on the Dirac cone have no mass, therefore they can move with ultrahigh speeds leading to very high electrical conduction of the materials that have this feature.

Within the project TopoTin, we will study the electronic band structure of the thin film materials that are composed of tin and iron, Fe_xSn_y. Such compounds are magnetic, and in the same time, exhibit interesting electronic structures that host Dirac cones. Following some theoretical predictions and first results obtained using scanning tunneling spectroscopy, we will investigate modifications of the electronic band structure of Fe_xSn_y which can be caused by the change of the magnetic state of the sample. If such dependence is observed, it will mean that it should be possible to change the electronic band structure (e.g. open the energy gap at the Dirac point), and thus the electronic transport characteristics by changing the direction of magnetization, which is an easily controllable "turning knob". Such effects could be potentially used in the future in the new generation of spintronic devices.

In the project, we will prepare the thin film Fe_xSn_y samples by the method of molecular beam epitaxy, which allows depositing of ultrathin layers of crystalline materials, with well-controllable thicknesses, down to single atomic layers. We will characterize the magnetic properties of such prepared films and visualize their electronic band structure using the experimental method of angle-resolved photoemission spectroscopy. The theoretical calculations of the electronic structure will accompany the experimental investigations.

Fe_xSn_y samples are layered materials, composed of single layers of tin atoms (stannene, which is the analogue of graphene), and a layer composed of iron and tin atoms placed on the so-called Kagome lattice, which is the arrangement of the hexagons surrounded by equilateral triangles. In the course of the project realization, we want to turn to the creation of an artificial, "man-made" crystal, by sequential deposition of stannene, and Kagome layers in a specific, chosen, order. This way, we will be able to create thin films of new, unexpected, and potentially useful magnetic and electronic properties.