Topological insulators (TIs) represent an interesting group of materials that exhibit a quantum phenomena even at room temperature. **In 2016 Nobel Prize in physics was awarded for theoretical discoveries of topological phase transitions and topological phases of matter**. As stated in the press release of the Nobel Committee laureates: *opened the door on an unknown world where matter can assume strange states. They have used advanced mathematical methods to study unusual phases, or states, of matter, such as superconductors, superfluids or thin magnetic films. Thanks to their pioneering work, the hunt is now on for new and exotic phases of matter. Many people are hopeful of future applications in both materials science and electronics.* Over the last decade, topology research has been leading in the field of condensed matter physics - mainly due to the discovery of new topological phases matter and exotic effects not observed in classic materials, giving hope for wide use in a variety of devices. By entering into current trends, we propose an experimental approach to the subject including the creation of TI-based structures and the study and modification of their properties. TI are poorly conducting electricity in the bulk (centre) of the crystal, but the surface electrons are able to move around freely in a manner that is protected from defect scattering. Moreover all electrons moving in a given direction must have their spins, pointing the same way (spin locking), or to put it another way, all electrons with the same spin component must travel in the same direction. This spin or internal angular momentum can be imagined as a property associated with particle motion around its own axis.

The result possibility to control of moving spin polarized electrons around the material by passing current has generated considerable interest in potential electronic applications. Like for example spin valves or sources (injectors) of spin-polarized carriers, Schottky diodes or even spin-to-charge converters. In our project we will try to directly interact with those phenomena and change them by utilising the effects appearing near TI and metal junctions. In case the case of planned studies of the structure that would be characterized and modified consist of TI layer and metal (Cr, Cu, Ag, Pt oraz Ag). The impact of the presence of the metal layer on TI properties as well as the accompanying effects appering near the TI-metal interface on the crystalline and electron structure and the dynamics of the electrons would be a major interest.

Such phenomena as surface states and the electron spin polarization is still hard to observe without a highly sophisticated equipment such as angle resolved photo emission spectroscopy (ARPES). Unfortunately such measurements require extremely fresh surface layer because of low penetration depth of measurements as well as overlapping of the band structure coming from oxidation of the layers. Because of that it is impossible to work on a sample outside of the ultra high vacuum, and even then it is possible to keep complete freshness of the surface only for couple of hours. Fortunately it is possible to still tap into this phenomena in real working conditions. In order to do so it is necessary to utilise the very short penetration depth of the visible light in materials such as Bi_2Te_3. Due to thorough analysis of the existing oxidated layer it is known that it is a mixture of tellurium and bismuth oxide, which are transparent in visible spectra, that does not disturb the measurement. Because of their similar properties to the passivation layer of aluminium oxide they create stable 2nm thick layer that protects the material from further damage and moisture.

The technique that can utilise all those properties to its fullest potential is so called pump-probe femtosecond laser spectroscopy. The basic concept of this method is quite simple. Femtosecond laser creates short pulses 200fs ($200*10^{-15}$s) that are divided into a pumping beam, that excites the electrons and vibration with the thin layer, and probe which detects the change of reflection in time domain. This experiment is very similar to creation of stop-motion film one photo at the time, due to a moving mirror (delay line) we are able to "photograph" effect of the pump after a slightly different time. This technique has very subtle interact with the matter is able to detect even the slight changes within analyzed structure without damaging the structure. That is why pump-probe spectroscopy is widely used in electronic devices development and control. The signal registered with this technique consists of different phenomena such as relaxation of the electron carriers, phonon vibrations and even mechanical vibration of different structures in the sample. Due to the ability of direct interaction with the electrons it is possible to observe such subtle changes like modification of electron dynamic even after exposure to air and ageing of the thin film, or to directly register the crystal lattice (phonon) vibration in time domain.

In this project we will utilize this techniques for creation and thorough investigation of the effects occurring at the close proximity to TI-metal junctions. We consider that those techniques along with careful structural, chemical and electronic analysis will provide great insight into realization of working spintronic and optospintronic systems. This data will subsequently move forward our understanding of phenomena governing this highly interesting phase of matter.