For decades now, of great interest are studies of materials with so-called strongly correlated electrons, which exhibits high electron effective mass as well as superconducting and thermoelectric properties. The term "strongly correlated electrons" hides the physics of interactions between individual electrons. In classical solids, valence electrons are either closely tied to the atoms in crystal lattice (insulators), or may flow freely through the material and can be described in a similar way than liquids (conductors), with neglecting the electron-electron interactions. However, in some compounds neither of these descriptions are sufficient for explaining their properties. Such materials exhibit a variety of exotic quantum states (ie. Kondo insulator, Kondo lattice, metal-insulator transition, superconductivity, Fermi liquids, quantum critical point), which strongly determine their electrical and thermal properties. Our research project focuses on one of the interesting topics, which are studies of the thermoelectric properties of subgroup of strongly correlated materials, namely Kondo insulators. The main feature of the Kondo insulator is metal-insulator transition at very low temperatures (<100 K).

Kondo insulators are interesting not only because of its potential applicability in thermoelectric devices (eg. In the space industry), but also due to various physical effects resulting from the electronic correlation, which are great research topics itself. The phenomenon of thermoelectricity an important role play physical quantities: thermopower, thermal conductivity (κ) and electrical resistivity (ρ). The thermoelectric performance ZT is described with following formula $ZT=S^2T/\kappa\rho$ (figure of merit). Among Kondo insulators, many are have high thermopower, which encourages to study their thermoelectric properties. In order to have a good thermoelectric material, not only high thermopower, but also low thermal conductivity and low electrical resistance (see formula for ZT) is desired. Fortunately, one can substantially control these parameters by modifying the material at nanostructural level. For example, it is to reduce the thermal conductivity by obtaining highly grained the material, where distances between the grain boundaries are of the order of nanometers. In general, such defects in material causes the disturbance of both heat transport (increase ZT) and electronic transport (decrease ZT) and does not necessarily lead to improved thermoelectric properties. However, under specific conditions modifying parameters κ and ρ through nanostructurization may result in increasing the ZT parameter.

Recent theoretical predictions suggest that in the case of Kondo insulators such treatment might work. These predictions are main motivation of the project, which assumes searching of Kondo insulators with high thermopower and examining their granulates. Granulated samples are prepared by grinding the polycrystalline material and pressing the obtained powders in a hydraulic press. Then, a series of comprehensive structural, electrical and thermal transport measurements allows for the analysis and description of structural, thermodynamic and thermoelectric properties for both solid and granulated materials.