Over 100 years have passed since the discovery of superconductivity by Kamerlingh Onnes. He observed, that resistivity of Mercury vanishes in a temperatures close to the absolute zero, at 4.1 K, that is -269 ^{o}C. A great significance of this discovery comes from the fact, that one can losslessly transmit energy through such material and create a high magnetic field. The following investigations in this field revealed many other superconducting materials, of which the most important are Nb_3Sn and NbTi. Both were discovered in 50's-60's and are, up to day, the most used superconductors. Their main applications are scientific devices, like LHC, and medical MRI systems. However, due to high production and maintaining costs, those superconductors still are not commonly available. The effectiveness of superconductors discovered in following years has not met the expectations of replacing the conventional Nb_3Sn and NbTi. Now is the chance for a new superconductor – MgB_2, even though it lacks a revolutionary performance. Its main advantages are a simple and cheap production technology, and a feasibility to operate in 20 K. This temperature, though only a bit higher than for conventional superconductors, allows for a replacement of liquid helium cooling with liquid hydrogen or cryocooler cooling. As a result, maintenance costs drop dramatically.

Currently, all around the world there are efforts both to produce prototype devices using MgB_2 as well as to increase the maximum current achievable in this material. For this purpose, scientific investigations are mostly focused on optimization of synthesis process, which unfortunately is not an easy task. MgB_2 is polycrystalline and porous in structure, somewhat like pumice. We would like to densify it as much as possible and remove the pores, but we have to keep the grains small enough to maintain superconducting state. We would like to add carbon compounds so that they penetrate into the crystals and improve superconducting properties, but we have to restrain addictions of such compounds, because they form insulting layers between crystals that stop current flow. Situation is further complicated by the diversity of boron forms, which vary by purity, morphology and price.

Iron based superconductors (FeSC) were discovered later, and became the object of interest on a greater scale only in 2008. That is why experiments on them are not equally advanced as compared to MgB_2. Yet, in laboratories there are constructed first superconductive wires of this material based on a technology similar to MgB_2 wires.

The critical temperature for MgB_2 (39 K) and iron-based superconductors (mostly 15-60 K) is significantly higher than of the conventional superconductors NbTi and Nb_3Sn. It allows replacing expensive liquid helium cooling with cryocoolers or liquid hydrogen. This in turn creates a possibility of a wider usage of such devices as MRIs, superconductive induction heaters, magnetic bearings for wind turbines and DC current lines. However, the improvement of transport properties (that is the critical current density j_c) is still needed. Such improvement can be achieved by means of high pressure synthesis, which was already proven, however the full understanding of this process in necessary for repeatability and control. As a result of proposed investigation, we should learn what type of synthesis could be applied for a given morphology of a superconductor, considering type of initial powders, dopants and the area application.

The aim of this project is to conduct analyses that allow a precise identification of phenomenon occurring during the high pressure synthesis, e.g. the mechanisms that lead to an increase in superconductivity parameter due to the Hot Isostatic Pressing HIP.