The main aim of this project is the synthesis of new compounds at high pressure and temperature, and investigation of covalent bond formation between two sulfur atoms at these extreme conditions. Science and industry are putting more and more effort into discovering and designing new processes to eliminate the use and production of hazardous substances. High pressure seems to be promising in realizing these efforts.. The pressure on Earth's surface is unique in the Universe. Pressure around us, about 0.1 MPa, is significantly higher than pressure in the interstellar space, but also much lower compared to the pressure at the bottom of the oceans. Most of phenomena and nature-laws have been formulated for the specific conditions on Earth's surface, which lead to the conclusion, that the application of high-pressure as a variable in chemical studies may yield in discovery of new materials with unique properties.

Formation of covalent bonds is traditionally dominated by solvothermal solution-based methods requiring elevated temperature and pressure (up to 100 atmospheres). Recently a rapid increase of searching for alternative synthetic methods was observed. One of the most promising method is mechanochemistry. The significance of mechanochemical synthesis is that reactions are activated through mechanical actions, rather than thermal energy and catalytic agent what makes them ‘environmental friendly’. The mechanical treatment can break or stretch chemical bonds directly, which makes it applicable in the construction of covalently bonded molecules. In this project, the formation of covalent bonds at high-pressure will be investigated for the disulfide exchange reaction. The syntheses are planned to avoid any undesired by-products. In this adduct-formation approach reactants are mutually bound to form the final product. The preliminary research conducted so far, indicates the feasibility of the research objectives. For each reaction the substrates will be placed inside a diamond anvil cell (DAC) in equimolar concentration. The DAC modified for this project, allows not only to control the process, due to diamonds transparency to visible light, but also can result in rapid reaction between substrates, because of using the hydrostatic medium, which will be also, liquid environment of reactions. Moreover, construction of the DAC allows a high-pressure recrystallization, which can lead to single-crystalline products required for advanced-technology applications. For all successfully performed high-pressure syntheses, the attempts to transfer them into a macroscale will be taken. For this purpose a macro-scale high-pressure reactor will be constructed.

The results will identify an influence of high pressure on covalent bonds formation. Knowledge about mechanisms of their occurrence may allow to apply high-pressure techniques for designing new functional materials. Furthermore, such a fundamental research can open new paths to obtain important, from industrial point of view, materials in a ‘green way’. This can also be reflected in patents, especially for the reactions, which previously were expensive and finished with poor yields. The experience gained by the project manager in the field of complex chemical synthesis and new techniques of testing materials under extreme conditions will benefit in the future.