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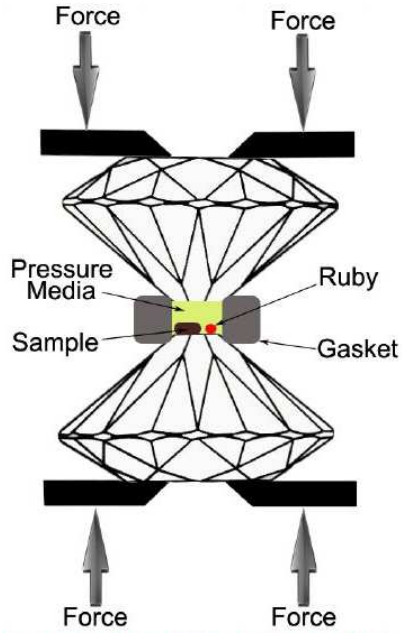
High-pressure synthesis and characterization of the chemical compounds based on boron, hydrogen, and selected main-group elements

Description for the general public

Extremely high pressures, over million atmospheres, dramatically influence matter: under such pressures some of the non-metallic elements may conduct electricity, while some of the metals become insulators. Nitrogen – the main ingredient of the Earth's atmosphere – polymerizes, while hydrogen sulfide becomes a superconductor, showing lossless electrical conductivity even at the temperatures recorded in Earth (-70^{o}C), which is currently the highest temperature at which superconductivity has been observed.

Such pressures are achieved in diamond anvil cells, in which the sample is squeezed in the cave between two diamonds and a gasket in a hydrostatic pressure medium, like compressed helium. The pressure is measured here with the use of a small piece of ruby. Such system is presented in the picture below. While the typical size of a sample is one tenth of a millimeter, this device still allows detection of above-mentioned extraordinary phenomena occurring under the pressures close to those in the Earth's interior.



The main goal of this project is to investigate how the extremely high pressures will influence the selected compounds containing hydrogen, boron, phosphorus and silicon. During the course of this project new chemical compounds containing these elements will be synthesized, we will establish their structures and characterize their properties. We will check how the pressure influences the investigated systems, if it deforms the molecules and triggers chemical reactions. We will verify whether, under sufficiently high pressures, some of these systems could become metals or show superconducting properties, as hydrogen sulfide mentioned above. Moreover, the selected chemical compounds prepared in this project will be tested as potential hydrogen stores, which could be applied in hydrogen tanks for supplying electric motors in vehicles.