

Abstract for The General Public:

(English version)

Iron-based superconductors (FBS), the second class of high-temperature superconductors besides the cuprates, gained interest for fundamental research and possible applications, e.g., as conductors in high magnetic field coil inserts. This is due to their high critical fields, low anisotropies, and high critical current densities, which let them bridge a gap in properties and application potential between the classic low-temperature superconductors and the cuprates.

Here, we plan a unique method to fabricate novel and improved species of FBS thin films by combining the conventional techniques at ambient pressure (CT-AP) (i.e., pulsed laser deposition, PLD) and high-pressure techniques by collaborating German and Polish groups. We concentrate on two important classes, so-called 1111 ($REFeAsO$; RE = rare earth, as doped family) and 1144 ($AeAFe_4As_4$; Ae = Ca, Eu; A = K, Rb as stoichiometric family). For 1111, new variants will be grown, and complete unambiguous phase diagrams will be established. For 1144, no thin film samples exist so far but are highly anticipated and important for basic and applied investigations such as electrical transport measurements. This is exploratory and high-risk/high-gain.

The materials aspect of this project is to establish high-pressure methods for thin film techniques and to synthesize new species of FBS thin films. The physics aspect is the determination of phase diagrams (regarding doping and magnetic field) and fundamental constants (penetration depth, coherence length, and their anisotropies), the engineering aspect is the evaluation of the application potential of these new FBS phases. Few studies have proven advantages of high-pressure preparation of FBS bulk and single crystals in comparison to conventional methods, such as the controlled modification of the phase diagram, enhanced reactivity, prevention of evaporation, and furthermore enhanced the superconducting properties. A systematic study of a series of samples is however needed to reach the intrinsic properties of FBS. High-pressure techniques will be used in several ways in this project: synthesis of highly dense and homogeneous bulk samples and targets, growth of thin films, annealing of films, and investigation of high-pressure properties of the grown samples. The high-pressure processed bulk samples serve as targets for PLD and HP-HTG process.

The successful execution of the project is only possible by combining the expertise of thin film deposition at KIT Karlsruhe and high-pressure methods at IHPP Warsaw by one PhD project at either institution. The expected outcomes of this project will establish new thin film growth methods, novel Fe-based superconducting phases, complete phase diagrams, a deeper understanding of fundamental and application-related properties as well as strengthened European collaboration and education of young scientists.