FAKULTA STROJNÍHO INŽENÝRSTVÍ ústav materiálových věd a inženýrství

Dissertation topics

D-MAT-A Materials Sciences

2026/27

Self-Assembling Multicomponent Metal Nanocomposites

Supervisor: prof. Ing. Ivo Dlouhý, CSc.
Specialist supervisor: doc. Ing. Vít Jan, Ph.D.

Institution: IMSE

The doctoral thesis project aims to utilise and investigate self-assembling processes in the solid state of selected binary or multicomponent systems to influence the nanostructure and resulting properties. Preliminary experiments have shown that these processes enable the formation of nanocomposites, in some cases even hierarchical ones, with particle sizes up to 100 nm and various morphologies in the immiscible binary system Cu-Fe and other systems with similar performance. The key parameters for these self-assembling processes, such as pre-processing, heat and thermomechanical treatment, as well as the influence of microalloying, will be investigated step by step in the systems mentioned. Based on these findings, other metallic binary and/or multicomponent systems will be continuously identified and studied, with an emphasis on influencing nanostructure parameters and further improving properties such as strength, ductility, fracture resistance, and others.

The doctoral student is expected to master and actively use software for thermodynamic modelling of equations, descriptions of thermodynamic conditions, and kinetics of phase transformations, including spinodal decomposition, structural analysis, and powder metallurgy procedures. Familiarity with mechanisms of plastic deformation and basic mechanical properties is also beneficial.

Machine-learned interatomic potentials for study of crystal lattice defects

Supervisor: Ing. Martin Zelený, Ph.D. **Institution:** IMSE

Machine learning algorithms are currently under great development and their applications can be found also in computational material science. Using such approaches, it is possible to obtain information about interatomic interactions, which can be used subsequently for computer simulations of large-scale systems and predict material properties at real operation temperatures without the need for their experimental preparation.

Material properties are strongly influenced by defects of crystal lattice such as impurity atoms, grain boundaries and twin boundaries. Therefore, it is necessary to develop procedures for training machine-learned potentials that will be able to cover the influence of mentioned defects.

Creep of ferritic alloys strengthened by oxide dispersion at very low strain rates

Supervisor: Ing. Petr Dymáček, Ph.D.
Specialist supervisor: prof. Ing. Ivo Dlouhý, CSc.

Institution: IPM, IMSE

Oxide-dispersion-strengthened (ODS) alloys exhibit high creep resistance because dislocations are blocked by the dispersion of nanooxides at sub-threshold stresses.

The aim of this work is to confirm or refute the hypothesis that creep at very low strain rates is governed by the dragging of nanooxides by dislocations attached to their surfaces and, possibly, by thermally activated dislocation detachment from the particles. For this hypothesis, a thermodynamic model developed by Dr. Jiří Svoboda will be applied, which will provide a prediction of the basic parameters of the ODS alloy's creep behavior. A new FeAlOY alloy (nanocomposite) with a high volume fraction of Y_2O_3 nanodispersion, developed at the Institute of Materials Science, will be investigated in the temperature range of 800 to 1100 °C using conventional tensile creep tests and torsion tests. Since the experiments are time-consuming, the method of gradual loading/unloading will also be used to accelerate the acquisition of results. Creep test parameters such as the stress exponent and activation energy of creep, or the dependence of the creep rate on the size of the nanodispersion and dislocation density, will allow the hypothesis to be confirmed or refuted. If available within the framework of long-term cooperation with partners from MCL Leoben in Austria, a laser-printed (SLM) version of the FeAlOY alloy will also be investigated in terms of microstructure and creep behavior.

Work on this topic will primarily involve electron microscopy, conducting and evaluating experiments, and will take place mainly at the Institute of Materials Physics of the Czech Academy of Sciences, where all necessary equipment is available. Internships at MCL Leoben can also be arranged.