



FAKULTA ústav
STROJNÍHO materiálových věd
INŽENÝRSTVÍ a inženýrství



Dissertation topics

D-MAT-P

2026/27



Modification of Al alloys susceptible to hot cracking

Supervisor: prof. Ing. Libor Pantělejev, Ph.D.

Specialist supervisor: Ing. Josef Zapletal, Ph.D., Ing. Jakub Judas, Ph.D.

Institution: IMSE

The use of 3D printing, more commonly referred to as additive manufacturing (AM), represents a fundamentally different manufacturing approach compared to conventional technologies. It enables a reduction in the number of required production steps and typically leads to minimized material waste. To produce a component with the desired structural design, it is essential to consider the multidisciplinary nature of additive manufacturing. This requires integrating knowledge from various fields, including materials engineering, to ensure that the fabricated structure achieves the required material properties necessary for its intended function. One of the most widely processed material groups using Laser Powder Bed Fusion (LPBF) technology is aluminum alloys.

The proposed doctoral research topic focuses on a specific group of aluminum alloys, namely the Al–Cu system. The primary objective is to develop, through LPBF technology, a modified Al–Cu alloy with enhanced resistance to hot cracking, suitable for the production of dynamically loaded components. Within the doctoral thesis, the properties of the developed alloy will be evaluated not only in terms of its basic mechanical properties but, in particular, its fatigue performance. Special emphasis will be placed on the role of intermediate phases (typically Ti_3Al , among others) and the substructure formed during the LPBF process in the initiation of fatigue cracks.



3D printed multimaterial structures for biomedical applications

Supervisor: doc. Ing. Klára Částková, Ph.D.

Institution: IMSE

Specialist supervisor: Ing. Přemysl Šťastný, Ph.D.

Multimaterial additive manufacturing is currently a challenging area of research for ceramic and composite materials for biomedical applications. Multi-material co-printing enables the creation of complex, functionally differentiated structures that mimic natural biological structures, supporting organism regeneration and thus potentially making a substantial contribution to personalized medicine.

The goal of the doctoral thesis will be to study the co-printing of bioceramic materials using Digital Light Processing (DLP) 3D printing, which will include not only the optimization of ceramic suspensions for printing and process parameters, as well as thermal treatment of the printed structures, but also the study of chemical and physical compatibility of materials, their stability and integrity, and the control of porosity and microstructure. An important aspect will be the description of bioactivity and mechanical characteristics of the prepared structures, which will be designed for specific applications in bone tissue engineering, with an emphasis on optimal integration of bioactive materials with mechanically robust materials.



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.



Precipitation Engineering in Multicomponent Aluminum Alloys: Microstructure-Controlled Pathways to Tailored Mechanical properties

Supervisor: Ing. Michal Jambor, Ph.D.

Institution: IPM, IMSE

Specialist supervisor: Ing. Simona Hutařová, Ph.D.

The dissertation aims to investigate the possibilities for manipulating the microstructure in terms of the strengthening precipitates and the aluminum matrix grain structure in multicomponent aluminum alloys, to produce a wide spectrum of mechanical properties within a single alloy system.

At first, candidate alloy systems will be systematically evaluated, with emphasis on the coexistence of multiple competing precipitate phases and their response to the different thermal treatments.

Alloy systems exhibiting the greatest potential for the precipitates formation manipulation will be selected for extensive characterization of the precipitation sequences, the nature of individual strengthening phases and their effect on the mechanical behavior of the alloys.



Design and Optimization of Alloy Properties for Hydrogen Storage

Supervisor: Ing. Lubomír Král, Ph.D.

Specialist supervisor: doc. Ing. Vít Jan, Ph.D.

Institution: IPM, IMSE

For efficient hydrogen storage at temperatures close to room temperature, it is essential to properly design the structure and chemical composition of alloys suitable for hydrogen storage.

This work will focus on investigating the influence of key parameters used in alloy design and their impact on the resulting structure and properties for hydrogen storage. Both the thermodynamics and kinetics of hydrogen sorption in these alloys will be studied.



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

Supervisor: Ing. Petr Dymáček, Ph.D.

Institution: IPM, IMSE

Specialist supervisor: prof. Ing. Ivo Dlouhý, CSc.

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.



High-temperature degradation mechanisms of oxide dispersion strengthened high-entropy alloy prepared by additive manufacturing

Supervisor: Ing. Ivo Kuběna, Ph.D.

Institution: IPM, IMSE

Specialist supervisor: prof. Ing. Libor Pantělejev, Ph.D.; Ing. Milan Heczko, Ph.D.

The doctoral study will focus on investigating the high-temperature degradation mechanisms and mechanical properties of a new class of materials – oxide dispersion-strengthened high-entropy alloys (ODS-HEA) prepared by laser powder bed fusion (L-PBF). These materials are known for their exceptional high-temperature resistance, making them promising candidates for applications in extreme environments.

The aim of the study is to systematically characterise the mechanical behaviour of CrCoNi- and FeCrCoNi-based materials under monotonic loading, creep, and low-cycle fatigue at 800–1000 °C. The experimental results will be correlated with multi-scale microstructural characterisation using advanced electron microscopy techniques (SEM, EBSD, STEM), enabling identification of the key degradation mechanisms governing material performance. The outcomes of the study will contribute to the development of new cost-effective materials for applications in the energy and aerospace industries, where increased operating temperatures directly lead to reduced CO₂ emissions and improved energy efficiency.



Deformation microstructure evolution of of austenitic steels subjected to cyclic loading by correlative electron microscopy

Supervisor: Ing. Miroslav Šmíd, Ph.D.

Institution: IPM, IMSE

Specialist supervisor: prof. Ing. Libor Pantělejev, Ph.D.

The dissertation will focus on a detailed analysis of the dislocation substructure evolution in austenitic steels upon cyclic loading in relation to the recorded cyclic behavior.

The analysis will be performed using a combination of scanning electron microscopy (SEM) techniques, specifically digital image correlation (DIC), electron channeling contrast imaging (ECCI), and electron backscatter diffraction (EBSD). The combination of these data will lead to an effective correlative technique in bulk specimens, enabling detailed analyses of dislocations and their interactions at a level comparable to transmission electron microscopy, but without the practical and physical limitations of that technique.