Metal-ceramic bulk composites with gradually changing volume fractions of the phase materials (FGMs) are attractive structural materials since they can meet several requirements induced by the operating conditions (e.g. external side of a structural element made of an FGM can be wear resistant due to a dominating ceramic content, whereas a prevailing metal content in the remaining part of the element ensures its mechanical strength). By controling the composite morphology and the gradient structure the macroscopic properties of FGMs can be controlled. Aluminum-matrix composites (AMCs) are one of the most investigated metal-ceramic composites due to low specific weight, good thermal conductivity, enahanced specific strength and low cost of the constituent materials.

The scientific goal of the ALU-FGM project is to investigate the effect of microstructure of aluminum-matrix graded composites (FGM) on the processing-induced residual stresses in metal and ceramic phases of the FGM and on the selected thermal and mechanical properties. To reach the project objectives a number of experimental methods and numerical models making use of the micro-CT images of the real FGM microstructure will be applied. The FGM to be investigated is composed of an aluminum alloy (AlSi12) and aluminum oxide (Al_2O_3) or silicon carbide particles (SiC) which form four layers with different metal/ceramic volume ratio (a stepwise gradient).

A comprehensive research methodology adopted in the project comprises fabrication of Al_2O_3/AlSi12 and SiC/AlSi12 FGMs, microstructure characterization, mechanical testing (e.g. flexural and compressive strength, fracture toughness), measurement of thermal conductivity and thermal expansion, and experimental evaluation of residual stresses in AlSi12 matrix and ceramic reinforcement. An important part of the project is the modeling of thermal residual stresses and the selected thermal properties and fracture parameters. The influence of microstructure on the target properties will be analyzed by (i) applying two different ceramic powders as reinforcing particles, (ii) varying the volume fractions of Al_2O_3 and SiC, and (iii) using two sizes of Al_2O_3 and SiC particles. Thermal residual stresses will be determined by diffraction methods (neutrons and X-ray) and by optical methods. Numerical micro-CT based FEM modeling approach will be applied to predict thermal residual stresses, thermal conductivity and fracture toughness. The numerical results will be compared with the experimental data obtained within the project.

In materials science and mechanics of materials investigations the relationships „processing-microstructure-property" are among the most often investigated research topics. In the case of FGMs such investigations are particularly complex due to spatially changing microstructure. Therefore, even though bulk aluminum matrix composites have been intensively studied in the past, in case of graded AMCs many research issues, including the ones in the project title, are still awaiting systematic analysis. The ALU-FGM project belongs to fundamental research but selection of the particular FGMs, i.e. Al_2O_3/AlSi12 and SiC/AlSi12, was motivated by their potential applications in the automotive and electronic industries.