

**Grain Boundary Engineering (GBE) is a technique that enables the control and manipulation of material microstructure to achieve desired macroscopic mechanical and physical properties. In our project, we aim to apply GBE to Al-Si alloys produced by selective laser melting to improve their resistance to radiation and corrosion damage. Ideal materials for radiation environments are those that can maintain their initial properties under prolonged radiation exposure. Increasing the fraction of special boundaries, known as coincidence site lattice (CSL) boundaries, where part of the atomic positions from one grain coincide with the lattice points of another, is a promising way to enhance resistance to radiation and corrosion.**

**In the first phase of the project, we will investigate the effect of temperature gradients in the selective laser melting process on grain boundary migration. This task aims to develop manufacturing strategies ("processing windows") for "programmable" microstructures consisting of axial grains with varying densities of geometrically necessary dislocations (grains with different stored energy).** Experimental work will focus on obtaining fundamental information on the evolution of microstructure/microtexture in the early stages of recrystallization using transmission (TEM) and scanning (SEM/TKD) electron microscopy methods. These changes will be analyzed in two experimental groups: during isothermal annealing of bulk samples and 'in-situ' annealing experiments in TEM with local orientation measurement systems.

In the second phase, grain boundary migration will be analyzed in deformed samples. We plan to produce two types of samples:

- Surface-deformed using shot peening (laser/shot peening)
- Bulk samples deformed by the KOBOL method.

**Experimental work will aim to optimize the grain boundary character distribution and clearly document the mechanisms responsible for forming grains with specific crystallographic orientations. Microstructure characterization in the early stages of recrystallization will be performed using TEM, SEM/TKD, and diffraction contrast tomography (DCT) to map crystallographic orientation and microstructure in 3D.**

The final project phase will focus on understanding the impact of radiation-induced defects on the structure of produced materials, which is fundamental to understanding material degradation during operation. Thorough investigation and understanding of microstructure evolution during service will enable the development and optimization of materials with better radiation and corrosion resistance.

The project will be realized by a consortium including scientists from the Silesian University of Technology (Dr. Eng. Przemysław Snopiński), AGH University of Science and Technology (Dr. hab. Eng. Krzysztof Żaba), and the National Centre for Nuclear Research (Prof. Katarzyna Nowakowska-Langier, Dr. Eng. Marek Barlak). Additionally, scientists from VSB-TU Ostrava (Protolab 3D printing laboratory) and DTU Denmark (Department of Civil and Mechanical Engineering) will be involved, providing unique knowledge on optimizing the selective laser melting process and multidimensional analysis of grain boundary migration.

**The project will acquire new fundamental knowledge on grain boundary migration in Al-Si alloys produced by additive manufacturing, which has not been adequately studied and described. This knowledge will allow discussions on microstructure/microtexture evolution and grain boundary character during annealing/recrystallization, contributing to verifying existing and developing new theoretical models for this phenomenon in the studied materials.**

**Although the project primarily aims to expand knowledge on grain boundary migration, the results may contribute to developing a new generation of aluminum alloys with increased radiation resistance, potentially used in the nuclear, aerospace, and radiation medicine industries.**