The main goal of submitted proposal is the investigation of the behavior of gradient cellular structures with controlled morphology and geometry under quasi static and dynamic loading conditions. Laser based additive manufacturing (Laser Engineering Net Shaping ) will be used to freeform thin walled cellular structures development made of titanium alloys.

The subject of planned fundamental research is directly related with materials science and solid state mechanics. It focuses on material and technological aspect of manufacturing of titanium cellular structures with LENS technique implementation and afterwards on mechanical behavior of gradient, regular cellular structures subjected to quasi static and high strain rate loading conditions. Next issue is related the geometrical optimization of cellular structures with consideration to impact energy dissipation ability in various dynamic loadings.

Technological and scientific potential of additive manufacturing techniques used in process of building regular cellular structures is one of the main reason that justifies considered subject of research. These techniques in comparison to conventional methods of producing cellular stochastic structures (e.g. aluminum foams) enable determination of functional features of received structures. Irregular structures (e.g. metallic and polymer foams) are difficult to be controlled during manufacturing and are not optimal enough from the relative mass point of view comparing to their strength parameters. Optimization of fabrication process of these materials is strongly limited by narrow range of geometrical parameters (e.g. single cell dimensions). Application of modern additive manufacturing techniques in building process of regular, cellular materials with multidimensional gradient, significantly broadens the scope of possibilities of these kind of structural materials application. The main problem is geometry optimization in order to achieve the lowest material density with high mechanical properties (e.g. specific strength, stiffness) and high impact energy absorption.

Authors of this research project will try to solve above mentioned problems based on concurrent design and manufacturing approach. Experimental and numerical investigations on behavior of various regular and irregular cellular material structures manufactured by LENS technique will be performed. Based on achieved results, the dependence between cellular structures geometry and deformation process as well as mechanical damage under quasi static and dynamic loading conditions will be elaborated. The measurable effect of this project will be contribution to general knowledge about mechanical behavior of new cellular structural materials made of titanium alloys. Moreover, the developed numerical simulation will enable the geometrical optimization of cellular structures in order to increase their strength and impact energy absorption parameters. The final goal of considered project will be cellular structure for given titanium alloy which will be able to absorb significant amount of impact energy.