Additive manufacturing, also known as 3D printing, is a modern production technique that creates objects by depositing material layer by layer based on a digital 3D model. This manufacturing method makes it possible to produce very complex shapes that would be difficult or even impossible to achieve using traditional techniques such as casting or machining. Among the most valuable additive methods are those that use metal powders, including Selective Laser Sintering and/or Melting (SLS/SLM). However, a major drawback of these techniques is the high cost of metal powders. These powders are produced through a multi-stage, energy- and resource-intensive process involving metallurgy and atomization to prepare feedstock for the 3D printer.

Recent scientific advancements have led to the emergence of the *in situ* method, in which alloys or composites are synthesized directly during the 3D printing process. This approach allows for the easy creation of new, precisely designed materials tailored to specific applications without the need for costly and time-consuming powder preparation. The concept shows strong potential for further development, particularly in Materials Science and Mechanical Engineering.

Titanium and its alloys have long been used in many industries, including aerospace, automotive, and biomedical fields. Their popularity stems from unique properties: high strength combined with relatively low weight, excellent corrosion resistance, and outstanding biocompatibility, meaning they can be placed inside the human body without causing adverse reactions. In implantology, which deals with the surgical placement of artificial implants in the body, these properties are especially valuable. Due to their poor machinability, titanium alloys are among the most commonly used materials in additive manufacturing.

Currently, the most widely used alloy is Ti6Al4V, a titanium–aluminum–vanadium alloy valued for its good mechanical strength, corrosion resistance, and biocompatibility. Mechanical and chemical properties of Ti6Al4V are significantly better than those of pure titanium. It is a popular choice for implants and prosthetics. However, some scientific studies have shown that corrosion of Ti6Al4V in the human body can release potentially toxic aluminum and vanadium ions. These may cause inflammation, allergic reactions, or even contribute to neurological disorders such as Alzheimer's disease. From a biomechanical perspective, Ti6Al4V is also not ideal material: its Young's modulus is about 3.5 times higher than that of human bone. This mismatch can lead to a phenomenon known as stress shielding, in which the implant takes too much of the load, causing improper bone remodeling and eventual weakening.

This project aims to develop modern titanium-based materials using the innovative *in situ* technique during SLS/SLM 3D printing. The materials will be designed to combine satisfactory mechanical strength with a reduced Young's modulus. The study focuses on titanium–molybdenum and titanium–niobium compositions with varying alloying element contents. Both molybdenum and niobium are biocompatible and have been confirmed to lower the Young's modulus of cast titanium alloys when used at specific concentrations. In the long term, the project results could benefit implantology by offering new, safer materials with improved performance compared to Ti6Al4V.

The research will include the *in situ* fabrication of new titanium-based materials with varying molybdenum and niobium content, the selection of optimal SLS/SLM processing parameters, structural and mechanical characterization, and the development of numerical models using finite element analysis (FEA).

The results of this project have the potential to significantly advance materials science and mechanical engineering. The materials developed may find applications not only in the medical field but also in other industries. The in situ approach can also help reduce production costs and enable the development of materials tailored to specific needs—supporting the broader trend of mass customization.