Titanium and its alloys are a very attractive group of materials that find applications in numerous areas of industry, in particular in the healthcare sector. Titanium-based alloys, currently used for the production of implants, possess specific drawbacks, such as mechanical incompatibility (significantly higher Young modulus when compared to the one of the human bone), chemical content that can cause allergic reactions (e.g. nickel) or difficult formability.

The project concerns a comprehensive, multiscale study of the role of nitrogen in biomedical nickel-free shape memory alloys (SMAs) based on Ti-Nb and Ti-Zr. Depending on the nitrogen content, these alloys can be characterized by shape memory effect, i.e. after deformation at a specific temperature and subsequent heating, they will return to their original shape or superelasticity, i.e. large reversible deformation, which is significantly larger than deformation of conventional metals. These alloys are also characterized by favorable properties in the context of biomedical applications in particular the lack of nickel, which can cause allergic reactions as in the case of commonly used Ti-Ni based SMAs as well as lower Young modulus when compared to conventional Ti-based alloys. The addition of nitrogen hinders the stress-induced phase transformation in Ti-Nb-N SMAs, however, this deformation mechanism is unconventional and still remains unclear. Mechanical characteristics of N-added Ti-Nb SMAs can be tailored so that they can exhibit shape memory effect, superelasticity or superelastic-like behavior combined with high strength. In addition, these SMAs have very good cold-workability which is an important advantage over Ti-Ni based SMAs. As a result, N-added SMAs have wide application potential as a new generation of biomaterials in the production of e.g.: stents, orthodontic archwires and surgical or dental implants. Furthermore, according to the latest scientific publications, the addition of nitrogen allows for similar modifications of mechanical characteristics in other alloy systems, including those based on Ti-Zr. Specifically, recently developed N-added Ti-18Zr-3Nb-2Mo-3Sn SMAs have an ultralow Young modulus of approx. 40 GPa, which is very close to the one of the human bone. The potential use of these alloys may significantly improve the compatibility of the bone/implant interphase. The failure of this interphase is one of the adverse effects of currently used implant materials that have a high Young modulus (above 100 GPa). Within the frame of the project, the effect of nitrogen content on the martensitic transformation, shape memory effect and superelasticity will be investigated on various scales in Ti-Nb-N and Ti-Zr-Nb-Mo-Sn-N SMAs using theoretical approach and experimental techniques. The fabrication of the SMAs will be realized within the frame of the collaboration with one of the world's leading laboratories located at the University of Tsukuba, Japan which is focused on the development of Ti-based SMAs. Ab initio calculations, selected tools for characterization of microstructure, crystallographic orientation and phase composition as well as tensile tests monitored by full-field measurement methods will be used in order to answer the following questions.

1. What is the effect of nitrogen on elastic and shape memory properties of Ti-Nb and Ti-Zr based SMAs?
2. How does the nitrogen content change the microstructural features, local and global deformation characteristics and thermal responses of the nitrogen-added Ti-Nb and Ti-Zr based SMAs under tension?

The project is expected to bring synergistic effect leading to innovative results. The outcomes clarifying the behavior of N-added SMAs at various scales can be important for both industry and basic research. Better understanding of the research topic will allow further development of the advanced alloys and consequently improvement of products needed in the biomedical sector.