Magnesium alloys are intensively researched as promising biomaterials for implants, mainly because of their density, similar to the density of natural bone, which is lower than that of the recently used materials, such as stainless steels and titanium alloys. Moreover, the proper design of chemical composition, microstructure and mechanical properties of magnesium alloys lets to create biodegradable implants, which controllably decompose in the body, eliminating the necessity of further operations in order to remove them after the healing process. On the other hand, magnesium alloys are characterised by relatively poor corrosion resistance, particularly in aqueous solutions, like human body fluids. Exposition to such a corrosive environment leads to rapid deterioration of their properties and formation of hydrogen, which has an additional tremendously harmful influence on mechanical properties of magnesium alloys and may lead to unpredicted failure of the implant, subjected to the loads significantly lower than expected strength of the material. In the same time the majority of research is focused on improvement of overall corrosion resistance of magnesium alloys, while the knowledge on their corrosion in hydrogen-containing simulated body fluids, particularly under mechanical loads is limited and incomplete, what justifies the necessity of tackling this complex problem in this project.

The main aim of the project is recognition of phenomena and mechanisms occurring during hydrogen-assisted corrosion processes of selected magnesium alloys for biodegradable implants, exposed to static and dynamic mechanical loads and activity of bacteria in simulated body fluids environment and determination of the role of chemical composition and microstructure in these processes and mechanisms. These conditions reflect the typical working conditions of biomaterials for implants, creating the possibility of complex investigation and deep understanding of these important phenomena, their meaning in the future implants design and possibilities of preventing the harmful and unexpected failures of magnesium implants through the proper design of their microstructure and properties. Three alloys, representing three different groups of magnesium alloys for biomedical applications have been selected as the research material: WE43 alloy containing rare earth elements, ZX50 magnesium alloy without the addition of rare earth elements and novel Mg Am35 amorphous magnesium alloy. Rare earth elements, present in some of the commonly used commercial magnesium alloys, considered as potential biomaterials, are known to have harmful effects on the human organism, hence it is of special interest to investigate the new alloys, which do not contain these elements, such as ZX50 alloy. Novel amorphous alloys posses superior strength and corrosion resistance and thus they are considered as one of the most promising candidates for future biomedical applications, but they need further investigation, also in terms of hydrogen-assisted corrosion.

The research material will be varied both in terms of chemical composition and microstructure - the investigated alloys will be processed with heat treatment, conventional forming and novel severe plastic deformation KoBo method to check the possibility of improvement of their properties, particularly plasticity, which is crucial in case of stress corrosion cracking. Degradation of their mechanical properties will be evaluated under static and dynamic (periodically changing) mechanical loads in hydrogen-containing simulated body fluid environment and in the presence of selected bacteria. This complex research method will simulate the actual working conditions of these materials and will help to better understand and describe their degradation processes in hydrogen-containing environment. The studies of hydrogen content and microstructural investigation let to identify the role of hydrogen in deterioration of mechanical properties and premature cracking of investigated materials. It is also planned to investigate the changes of ion concentration in corrosive environment, reflecting the transmission of individual elements to human organism during the gradual degradation of magnesium-based implants.

The planned research, which are expected to be one of the first of this kind in the world, should allow to recognise the phenomena and mechanisms, occurring during corrosion of magnesium-based biomaterials and processes of their degradation caused by hydrogen in simulated body fluids environment, with particular attention given to novel ZX50 alloy and amorphous Mg Am35 bulk metallic glass. The role of chemical composition and microstructure in hydrogen-induced cracking will be determined and possible ways of preventing this phenomena will be proposed. In practical terms, investigation planned in this project will verify the potential of microstructural modifications, caused by heat treatment, forming and severe plastic deformation (KoBo method) as possible ways of protection against negative effect of hydrogen by the increase of alloy’s plasticity and other mechanical properties.