Metallic implant materials are an important group of materials used in medicine, in particular in orthopaedics. Among them, NiTi alloys with a composition close to that of the equiatomic deserve special attention. These materials exhibit very interesting properties - i.e. the phenomenon of shape memory, good mechanical and plastic properties as well as acceptable corrosion resistance. Owing to these features, NiTi alloys have become widely used in medicine, including the manufacture of surgical instruments and implants, however their mechanical properties make them better suited for bone anastomosis than other metallic biomaterials [1].

However, long-term implantation of NiTi alloys entails a serious limitations. It is related to the high content of nickel in the material and the risk of releasing its toxic ions into the body as a result of the aggressive environment of body fluids. This, in turn, leads to allergic reactions and causes that the implant is not fully accepted by the human body. The solution to the problem is seen in the modification of the alloy surface by creating various surface layers [2]. The coatings provide a barrier to the potential release of nickel ions and, in addition to this primary protective function, may also fulfil additional tasks. For example, layers based on calcium phosphates facilitate the connection of a metallic implant with the bone, i.e. osseointegration [3].

Insertion of an implant in the body is associated with inflammation and peri-implant infections leading to secondary complications. Chronic bacterial infections are currently an extremely important problem, mainly due to the increasing resistance of many bacterial strains to antibiotics. Therefore, searches are constantly undertaken with the aim of finding material solutions which enable proper modification of the implant surface so that it has an antibacterial effect. Nano-sized silver, gold or copper particles exhibit bactericidal properties, but their excessive concentration has a cytotoxic effect on human tissues [4].

Creating a multifunctional layer that fulfils a protective function, has bactericidal properties, and, at the same time, is biocompatible, bioactive and exhibits appropriate mechanical properties is a great challenge for modern science. It is also crucial to choose an appropriate surface engineering method and to optimize the processes so as to obtain a coating of a given thickness, structure, chemical composition, roughness and physicochemical properties, which is important for osseointegration. In the case of NiTi alloys, it is also important to choose a method of surface engineering that does not adversely affect the unique phenomenon of shape memory (e.g. through decomposition of the alloy parent phase). Therefore, the method of electrophoretic deposition (EPD) deserves special attention [5]. In addition, it enables obtaining various types of layers in a wide range of thicknesses. This is extremely important in the case of NiTi alloys as excessively thick and/or stiff layers can limit or completely block the shape memory effect.

The project provides for the functionalisation of the NiTi alloy surface by creating innovative multi-functional hybrid layers. To create them, chemically synthesized complex nanometric molecular systems (i.e. $Ag\text{-}TiO_2$, $Ag\text{-}TiO_2\text{-}SiO_2$, $Cu\text{-}SiO_2$ or $Au\text{-}SiO_2$) and bioactive calcium phosphates will be used. Incorporating small amounts of metal ions into the matrix (silica or titanium oxides) will allow their gradual release, which will ensure a long-lasting antibacterial effect. The coatings will be deposited by the EPD method. Next, the obtained layers will be comprehensively tested for their potential applications in medicine. Characterization will include structure (XRD, RS and XPS methods), chemical composition (SEM + EDS), morphology and topography (SEM, AFM, profilographometric testing), elastic properties (RFDA), resistance to cracking associated with inducing the shape memory effect, adhesion, susceptibility to possible corrosion in the environment of simulated body fluids (OCP, EIS, SKP), bioactivity (Kokubo test) and ion release (ICP). Research will also be performed to determine the influence of the applied methods on the course of the martensitic transformation responsible for the unique shape memory effect in the NiTi alloy (DSC). The investigations will also be aimed at determining the surface wettability of the created coatings, which has a considerable impact on the absorption of molecules favouring the adhesion of bacteria or fibroblasts on the implant surface. Finally, biological tests will be performed in order to determine the effect of the layers on human fibroblast cells and microorganisms.

[1] H. Morawiec, Z. Lekston: Implanty medyczne z pamięcią kształtu. Wydawnictwo Politechniki Śląskiej, Gliwice (2010).
[2] J. Lelątko, T. Goryczka: Modyfikacja powierzchni stopów NiTi wykazujących pamięć kształtu. Oficyna Wydawnicza WW, Katowice (2013).
[3] S. V. Dorozhkin, Materials 2 (2009) 399-498.
[4] A. Farghali, A. M. Fekry, R. Ahmed, H. K. Elkakim, Int. J. Biol. Macromol. 79 (2015) 787-799.
[5] I. Zhsitomirsky, Adv. Colloid Interfac. 97 (2002) 279-317.