The main objective of the project:

The bio- corrosion (in corrosive body fluids) and bio- tribological (wear in body fluids) properties increase together with aesthetic impression improvement of metallic surfaces by application of advanced Zr/ZrN and Zr/ZrN+DLC multilayer coatings.
Sub- goals of the project will be connected with individual tasks realizations (mile stones).

Research to be carried out

The project deals with the development of the bio-compatible, wear resistant, decorative coatings for biological, corrosive fluids interaction. The main objective of the project is the bio- corrosion (in corrosive body fluids) and bio- tribological (wear in body fluids) properties increase together with aesthetic impression improvement of metallic surfaces by application of advanced Zr/ZrN and Zr/ZrN+DLC multilayer coatings. The deposition procedure will be performed basis on the cooperation with an Austrian partner (the project will be realized in cooperation with an foreign partner- accepted option for an OPUS type projects). Coatings will be produced using magnetron sputtering technique. The project applicant will take part in deposition procedures. Sources for exchange visits will be predicted. The JOANNEUM RESEARCH- Materials is (Research and Development) a leading institution for advanced coatings production in Europe.

The multiscale characterization of coatings will be performed in the Institute of Metallurgy and Materials Science Polish Academy of Sciences (the Institution of the project applicant). The characterization will consist on:

1). Complex, unique, in- situ mechanical test in the chamber of the scanning electron microscopy. The tests will involve nano-hardness, the quality of the adhesion of coatings to the substrate (scratch test), tests of mechanical wear. In spite of unconventional in situ mechanical experiments, standard micromechanical test will be done. They will include micro- hardness, scratch and wear (ball on disc) in biological body fluids and fatigue tests using modern, electrodynamic tensile machine equipped with a unique bio- chamber.

2 ) Bio- corrosion, biology and bio- compatibility. The Bio- corrosion resistant properties of coatings will be characterized by the application of Linear Sweep Voltammetry – LSV in the Ringer solution. Bio-engineering tests will consider cell material interaction in the following steps. In the initial analysis, associated with cytotoxic effect, fibroblasts will be applied. Materials influence on necrotic reaction in cells will be analyzed. The selected materials will be undertaken the hemocompatibility. The analysis will be executed based on the rules described in ISO 10993-4, dynamic blood-material interaction. The final analysis will be focused on progenitor heart muscle cells. Materials will be designed to activate progenitor cells to exhibit muscle compression properties. This final analysis will be done in situ applying confocal laser scanning microscopy Carl Zeiss Exciter 5technique equipped with incubation system.

3). Microstructure/ nanostructure analysis of the coatings before and after bio- tribological tests in order to determine the tribological behavior of the coatings under the influence of a mechanical load and under biological conditions. Microstructural diagnosis will be carried out using a high resolution transmission microscopy technique (HRTEM). The Tecnai G2 F20 (200kV) FEG (FEI Company) will be used. Thin foils for TEM and HRTEM analysis will be prepared from a well-defined area (e.g.: defects or wear track), using the focused gallium ion beam (FIB) technique. The QUANTA 200 3D DualBeam (FEI Company) will be used. Microstructural analysis will be carried out by the applicant, who works as an expert in the field as High Resolution and analytical transmission electron microscopy techniques at the Institute of Metallurgy and Materials Science.

Reasons for choosing the research topic

The wear properties of biomedical materials play a major role in determining the overall success of medical devices. Adhesive wear, abrasive wear, fatigue wear and corrosive wear play a key role in degradation of medical devices. Several factors determine the relationship between the in vitro properties of the components materials and the in vivo wear performance of the medical device. Significant improvements in the wear properties of biomedical materials may be achieved through intensive examination of material specific parameters that determine in vivo wear behavior. Minimization of wear in biomedical materials may only be achieved through effective interaction among material scientists, bio- tribologists, and biologists. The development of advanced, modern materials, in particular for medicine is essential because it may have an influence on the life- comfort of thick man.