

Oxide films with electret properties as coatings for medical implants

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The direction connected with influence of the electric field to optimization of different biological processes is very interesting and perspective. But the use of electrical stimulation requires applied of external current sources, which one not only result in complicating used devices and techniques but also demand commuting wires and limits application of such technologies. The replacement of external sources of electrical fields by electrets is alternative decision of this problem. The electret can be used as thin film coatings on the implant surface that simplified the design of implant. In a biology and medicine the work on usage of polymers and surface oxides films with electret properties is conducted for recovery of internal and external tissues damages by electrical field that considerably increases the efficiency of treatment and decrease its terms than traditional techniques. The mining of new chemically inert and high-strength stuffs having surface electric activity is an actual direction at research of problems connected with creation of bioactive coatings on implants. One of ways of such activation is the formation of surface charge on the oxide surface that will be optimum on value and stable in time. The oxide coatings on the base of Al, Ti, Zr, Nb, Ta are especially interesting because they on the one hand have high durability, record high chemical resistance against aggressive environment and ability to suppression of electrochemical corrosion processes due to high own electric resistance and on the other hand are capable to accumulate and store electric charge in the oxide volume. Thus the coatings of such type will simultaneously execute function of passive protection of different materials and also influence on rate of biological processes in tissues. These electret oxide coatings demonstrate also abnormal high durability and elasticity, especially films of small thicknesses.

Purpose of the work is the elaboration of physical principles of multi-purpose coatings formation on the medical implants surface as oxide layers with electret properties on the base of IV and V groups metals (Ti, Zr, Nb, Ta) using electrochemical technologies.

Thin oxide showed ability to elastic deformation up to enough high values. The observable values of oxide deflection without approach of destruction almost twice exceeded its thickness. The increase of oxide thickness to 100 nm and, especially, up to 300 nm reduced the effect connected with high elasticity of oxide and easy deformation of soft metal substrate and was accompanied by growth of plastic deformation approaching to results of ceramic materials tests. It was established that at anodic oxidation of valve metals the high electric fields ($\sim 10^9$ V/m) provides oxide coating with electret properties. The negative superficial charge density of oxide was $\sigma = 7.3 \cdot 10^{-4}$ C/m² for TiO₂ and $\sigma = 1.53 \cdot 10^{-4}$ C/m² for Nb₂O₅. During interaction of electret coating with inorganic components of blood plasma the formation of calcium phosphate masses which are the basis of hydroxyapatite crystals formation took place. This process was intensified at increase of electret coating thickness. Electrostimulation by electret oxide coating of metabolic processes in the contact zone with bone tissue increased the adhesion of oxidized metal and bone by 20%.