P72

The determination of mechanical properties of nanostructured tantalum nitride and tantalum oxynitride films on the glass and stainless steel surfaces by atomic force microscopy

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One of the main advances in the interventional cardiology is the development of metal stents. The requirements for stents are quite strong: high flexibility, plasticity, strength and rigidity, X-ray contrast, biocompatibility with the organism. For the stents production different materials are used such as stainless steel, platinum-iridium alloys, etc. The surface of the stent is covered with various types of ceramic coatings to prevent changing their properties. The study of mechanical properties of tantalum films and the evaluation of its operational properties is an important task because the surface of stents is often subjected to chemical and mechanical effects The aim of this work is to define the friction coefficient, adhesion force and roughness of tantalum nitride and tantalum oxynitride coatings on the glasses and stainless steel substrates using atomic force microscopy (AFM).

The TaN, TaON coatings were deposited on glass and stainless steel substrates in a high-vacuum system with a turbopump (a base pressure was about 10^{-2} Pa) using Direct Current planar magnetron sputtering (the magnetron power was about 6 kW). The samples were cleaned by standard methods in the ultrasonic bath before the deposition process. The study of the mechanical characteristics of the surface was carried out on NT-206 device (Belarus). Roughness values were determined by AFM-method using CSC 38 cantilevers (Mikromasch, Estonia). The stiffness of cantilevers was 0.03 N/m according to the manufacturer's passport, the radius of curvature – was less than 10 nm. The NCS 11 cantilevers (Mikromasch, Estonia) were used to determine the coefficient of friction and adhesion force. The stiffness NCS 11 was 3 N/m. For determine the friction coefficient the radius of curvature of the cantilever was increased to 100 nm by scanning the silicon surface with high load.

Tantalum nitride and tantalum oxynitride coatings on the glasses and 316L SS stainless steel substrates were studied using AFM. It was found that the microstructure of the surface of coatings is largely determined by the used substrate. The mean square roughness (R_q) of the initial steel was 5 nm, the friction coefficient was 0.072, and the value of the adhesion force was 12.5 nN. After tantalum nitride or tantalum oxynitride films deposited on the steel, R_q increased to 7-8 nm. It should be noted that the roughness of surface of tantalum coatings practically was not change with increasing of scan area. This is indicating about uniformity of the applied coating. The roughness values of glass slides surfaces reduced by 2 times after deposited tantalum oxynitride coatings. The coefficient of friction of coatings on stainless steel substrates decreases in 2-3 times. The use of materials with low friction coefficient as stents is promising, because they allow retaining and not reduce the blood flow along the vessel walls. But it slightly decreased on the surface of the glass, within the confidence interval. So, the tantalum films can be used to produce implanted materials to reduce the formation of blood clots on their surface.