

THE INFLUENCE OF MODIFICATION OF METALLIC MEDICAL IMPLANTS COATED MULTI-DOPED CARBON LAYERS (DLC, DLC-Si AND DLC-Si/Ag) ON CHANGES ON THE IMPLANTS SURFACE AS A RESULT OF IMPLANT - BONE CONTACT CONSIDERING ORTHOPEDIC SCREWS

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Introduction

There is an increasing demand for metallic implants, new technology of them manufacturing and improvement their mechanical and tribological properties. In USA, the annual increase of total hip and knee arthroplasty declared for 2010 was estimated on the level of 4.3% [1], while in England and Wales between 2008 and 2010, the number of such treatment changed from 109825 to 166000 [2]. One of the most important aspects is the interaction of biomaterials with the tissue through its surface. The possible path of implant development is connected with the use of diamond-like carbon coatings (DLC). DLC coatings determine a diffusive barrier [3] preventing tissue near implantation site from penetration by metal ions, which can lead to their deposition (in spleen, liver, blood, etc.), allergies or irritation effect [4]. To improve the biological properties, with the invariance of the mechanical and physicochemical properties, new ways of metallic implants surface modification are searched.

Materials and Methods

Presented work concerns surface properties of carbon layers synthesized on metal substrates with use the RF PACVD method. The process of the synthesis comprised two stages. The first stage was heating and making uniform the temperature on the coated elements (at the pressure 20 Pa and negative potential electrode polarization -1200 V). The second stage was aimed at the production of the coating (about 35 Pa and polarization of the electrode -1000 V). Investigated layers were deposited from methane plasma onto stainless steel 316LMV substrates. For the investigations samples were used orthopaedic screws and 16 mm in diameter, 6 mm in thickness samples made of stainless steel [5].

Results and Discussion

DLC, DLC-Si and DLC-Si/Ag layers presented very good mechanical properties e.g. good adhesion to the substrate surface. The layers are characterized by the homogeneity and uniformity. The AFM investigations indicate the structure being typical of nanocrystalline layers.

To define the mechanical properties to the surface there was a device NanoIntender G200 applied. The nano-hardness of the layer surface established on the level 13 GPa, and Young Modulus 230 GPa and the critical adhesion force was equal to 50 mN.

Manufactured DLC layers presented thickness about 200 nm.

To provide the chemical composition of the coatings X-ray electron spectroscopy was used.

Investigations of the orthopaedic screws were performed on a UMT-2 Bruker. The test consisted in realization of drilling process. During the test, the screws were tightening and loosening in beef bone.

Firstly the bones were carefully cleaned from soft tissue. The bones were kept in an airtight container at a temperature approx. 6°C. Before the test, bones were drilled. The holes have 8 mm diameter. The rotational speed of machine was 12 rev/min. During the test constant axial force of 40 N was applied, increasing load on screws. The tests were conducted on the screws with DLC and DLC-Si modification and unmodified ones [6-8]. Investigations of the orthopaedic screws were performed on a UMT-2 Bruker. The test consisted in realization of drilling process. During the test, the screws were tightening and loosening in beef bone. Firstly the bones were carefully cleaned from soft tissue. The bones were kept in an airtight container at a temperature approx. 6°C. Before the test, bones were drilled. The holes have 8 mm diameter. The rotational speed of machine was 12 rev/min. During the test constant axial force of 40 N was applied, increasing load on screws. The tests were conducted on the screws with DLC, DLC-Si and DLC/Si-Ag modification and unmodified ones [6-8].

Conclusions

The obtained results showed that the DLC and DLC doped Si and Ag layers manufactured by RF PACVD method have very good mechanical and tribological properties. On the surface of modified orthopaedic screws, after cycles of drilling, is formed tribofilm made of mineral components. The tribofilm is homogenous and uniformity.

After testing with required parameters, the DLC, DLC-Si and DLC-Si/Ag coatings were not broken.

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