Cell-Material Interaction (Metals)

S13-01

Is there a Yin and Yang of ultrafine grained titanium alloys for biomedical applications?

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Introduction

Titanium and its alloys are widely used for biomedical applications due to their excellent corrosion behavior and biocompatibility, both primarily caused by the properties of their passive layers [1]. Equal channel angular pressing (ECAP) has been shown to significantly improve mechanical properties of metals by reducing the grain size [2]. The focus of our work was to study for titanium based materials consequences of an ECAP treatment for the physico-chemical properties of their oxide layers and potential biological consequences thereof

Materials and Methods

ECAP resulted in a grain size reduction from several micrometers to a few hundred nanometers for both cp titanium and Ti6Al4V. As received (AR) and ECAP treated samples (diameter 20 mm; thickness 3.5 mm) of both materials were used for electrochemical studies in different electrolytes including cell culture medium containing fetal calf serum.

Results and Discussion

Electrochemical impedance spectroscopy measurements showed a strong increase of the oxide layer defect density N_d for ECAP treated materials for all electrolytes, most pronounced for Ti6Al4V. Current densities for galvanostatic and cyclic potentiodynamic polarization confirmed the expected influence of N_d on the oxide layer electronic conductivity. The effect may be due to the large increase in grain boundary density and its influence on the oxide layer properties above the grain boundaries; for the alloy, vanadium may be an additional effector. This may impact the biocompatibility of ECAP treated materials due to enhanced redox reactions with adsorbed proteins that lead to conformational changes and antigen formation.

References

[1] Scharnweber et al. J Mater Sci Mater Med 13:1215-20, 2002.

[2] Mingler et al. Ti-2011: Proceedings 12th World Conference on Titanium, 3: 2067-71, 2012.

Acknowledgments: The authors appreciate the financial support of the Austrian Research Promotion Agency (FFG), "HighPerformBioMat", Research Studios Austria.

S13-02

***In vitro* short-time procedure for the determination of long-term stability of UHMWPE implant materials**

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Ultra-high-molecular-weight polyethylene (UHMWPE) is an intensively used implant material in the orthopaedic field due to its excellent chemical and mechanical properties. Today's state of the art contains few application-oriented *in vitro* investigations regarding fatigue behaviour. However, frequently performed *in vivo* tests rather reflect the biocompatibility.

This study focusses on the development of a biomimetic short-time test procedure to determine long-term properties of UHMWPE. The implemented experimental setup allows the simulation of a biological environment by superimposed medial and mechanical loading. First, multiple amplitude tests were performed to generate hysteresis values for estimating fatigue strength. Validation was done over constant amplitude tests at characteristic load steps to define a S-N curve. Tests series were performed at room temperature as reference condition and in tempered simulated body fluid (SBF). Material's chemical and mechanical stability was examined both before and after the mechanical tests by Fourier-transform infrared spectroscopy (FTIR) and ultra-micro-hardness measurements in order to detect a possible influence of the different loading conditions.

Both, the mechanical characteristics and the analytical methods show clear differences between the purely mechanical and the superimposed medial and mechanical loads. Therefore, this short-term method of multiple and constant amplitude tests in combination with analytical measuring equipment provides a short-time method for lifetime assessment of bioimplants.

Keywords: UHMWPE, implants, *in vitro* experiments, FTIR spectroscopy, fatigue assessment, short-time test procedure

S13-03

Surface modifications of PEOT/PBT scaffolds for the improvement of cell adhesion and proliferation

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Introduction

Polymer scaffolds made from 3D printed PEOT/PBT are an interesting new approach for the regeneration of missing bone fragments. The PEOT/PBT copolymer is known to be biodegradable. The scaffold replace the non-healing bone fragments until new bone cells (osteoblasts) have grown and matured into it. Therefore, it is crucial for the bone regeneration process that the scaffolds offer good osteoblast adhesion and proliferation, which can be influenced by the surface chemistry of the scaffolds.

Objectives

Our aim was to investigate, how the surface chemistry of these scaffolds can be influenced by an atmospheric pressure vapour phase deposition process.

Materials & methods

For this purpose, a plasma jet was modified and integrated into a 3D printer for polymer scaffolds. As precursor gases for the deposition processes hexamethyldisiloxane (HMDSO), tetramethylsilane (TMS), (3-aminopropyl) trimethoxysilane (APTMS) and mixtures of vinyltrimethoxysilane (VTMOS) and maleic anhydride (MAA) were investigated. The influence of the process parameters (temperature, gas flows, power) on the layer properties like group density and layer thickness was studied. Furthermore, proliferation of osteoblasts on planar PEOT/PBT surfaces coated with the plasma jet was investigated.

Results

The deposition parameters have a significant influence on the layer properties. It was found, that the nucleophilic group density in APTMS layers can be increased with low energy input using pulsed power supply. The stability of electrophilic VTMOS-MAA layers in water and PBS was improved by decreasing the amounts of the MAA precursor. It was also observed that surfaces with nucleophilic APTMS and with electrophilic VTMOS-MAA layers show an improvement on the osteoblast cell proliferation.

Conclusion

We showed that nucleophilic and electrophilic functional groups can be generated on the scaffold surface by coating it with a PECVD process using an atmospheric plasma.