DECHEMA FORSCHUNGSINSTITUT

Corrosion

Qualifying the Metastable, Biomedical β-Titanium Alloy Ti-13Nb-13Zr via Tuning of Gradiental Mechanical Properties and Partial Surface Modification

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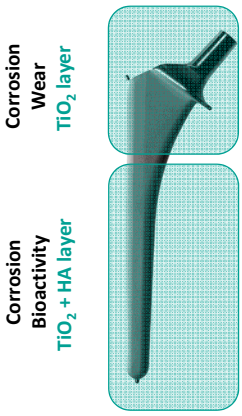
Background and Problem

- Titanium alloys used as standards for biomedical implants because of convenient corrosion resistance and acceptable biocompatibility
- anodizing of the material improves corrosion behavior + wear resistance
- ➢ Thickening of titania passive layer
- enhanced bioactivity by incorporation of hydroxyapatite (HA) in titania layer
- ➢ Problem: poor bonding of HA-layer formed on titania leads to delamination
- anodizing experiments performed on standard alloy Ti-6Al-4V and Ti-13Nb-13Zr



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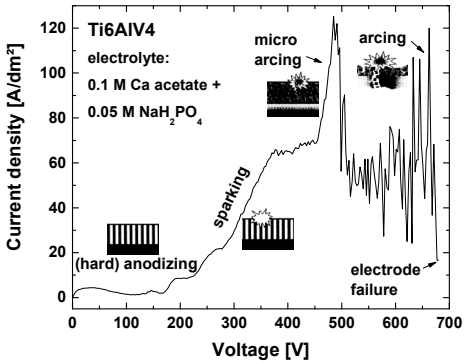
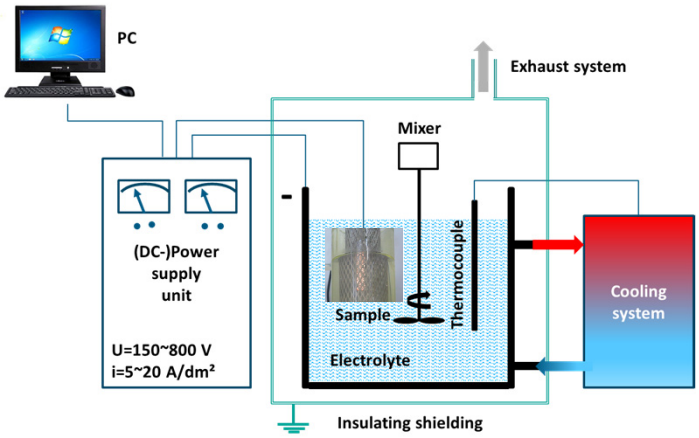
Approach

- simultaneous formation of HA + titania during one coating process
- coating technique: Plasma Electrolytic Oxidation (PEO)
- workpiece serves as anode (+), water electrolysis at cathode (-)
- high potentials (100~800 V) and currents (5~20 A/dm²) applied
- ➢ exceeding dielectric breakdown potential U_B*
- ➢ formation of a dense, crystalline oxide layer



Setup



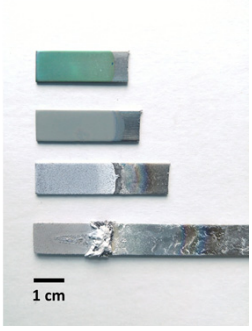
Investigations

- Plasma electrolytic oxidation for anodizing upper part of stem
- conventional anodizing of lower part of stem
- influence of electrical parameters and chemical parameters on coating performance

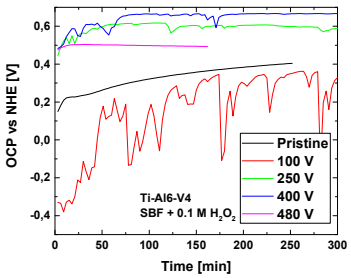
Electrical parameter	Chemical parameter
• Voltage: 100 – 480 V	• electrolytes: phosphoric acid, sulfuric acid, sodium hydroxide
• Current density: 5 – 100 A/dm²	• incorporation of HA-nanoparticles
• Duty cycle: 10 – 90%	• electrolyte concentration
• Repetition rate: DC – 10 s^{-1}	

- Characterization methods: Electrochemical investigations, EIS, REM, XRD, Raman

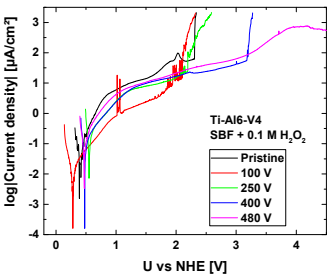
Results



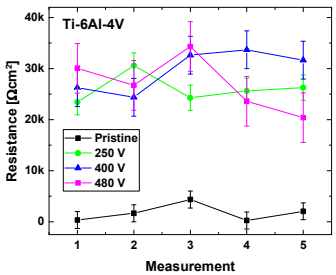
Ti-6Al-4V samples PEO treated at different voltages. DC mode for 10 min. Electrolyte: 0.1 M Ca-acetate + 0.05 M NaH_2PO_4



OCP curves of untreated Ti-6Al-4V and PEO samples treated in 0.1 M Ca-acetate + 0.05 M NaH_2PO_4. Electrolyte for corrosion measurements: simulated body fluid (SBF) + 0.1 M H_2O_2, T = 37 °C.



Polarization curves of untreated Ti-6Al-4V and PEO samples treated for 10 min at different voltages in 0.1 M Ca-acetate + 0.05 M NaH_2PO_4 solution. Corrosion measurement performed in simulated body fluid (SBF) + 0.1 M H_2O_2, T = 37 °C.



Polarization resistances of untreated Ti-6Al-4V and PEO samples treated in 0.1 M Ca-acetate + 0.05 M NaH_2PO_4 solution. Electrolyte during corrosion measurements: SBF + 0.1 M H_2O_2, T = 37 °C.

Outlook

- Investigation of influence of electrical and chemical parameters
- Characterization of formed coatings w.r.t. corrosion, mechanical performance and bioactivity
- Transfer the results to other systems, e.g. Ti-13Nb-13Zr

Acknowledgements

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Technische Universität Braunschweig
Institut für Werkstoffe IfW

[1] http://www.bjj.boneandjoint.org.uk/content/93-B/5/665/F2.large.jpg