Surface Modification of Ti 13Nb 13Zr by Plasma Electrolytic Oxidation

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Introduction

• Titanium alloys used as standard material for biomedical implant technologies
• Excellent corrosion resistance and acceptable biocompatibility
• Problem: damage of thin passive layer leads to corrosion, wear and release of harmful metal ions (e.g. Al, V)
• Plasma electrolytic oxidation (PEO) improves corrosion behavior + wear resistance of the material
• Thickening of titania passive layer
• Improved osseointegration by formation of biocompatible hydroxyapatite
• Enhanced mechanical properties by incorporation of ceramic nanoparticles

Experimental

• Coating technique: Plasma Electrolytic Oxidation (PEO)
• High potentials (~100-800 V) and current densities (~10-1000 mA/cm²) applied -> exceeding the material’s dielectric breakdown potential $U_b$
• Formation of a dense, crystalline ceramic layer
• Influence of current density $i$ and charge density $\sigma = \int i\, dt$ investigated

Results

Coating formation

Phase analysis

Corrosion resistance

Mechanical properties

Concentration

• Variation of surface morphology depending on applied charge density; transformation from grooved surface structure to crater-like, homogeneous surface
• Formation of crystalline titania layers consisting of rutile and anatase; phase composition depends on current density and charge density
• OCP stabilization in all samples after initial decrease due to residual oxidation of defects
• Decrease of $i_{corr}$ with increasing PEO current density $\sigma$ -> const. due to increasing coating thickness
• Enhancement of mechanical properties by incorporation of monoclinic ZrO₂ nanoparticles with $H_m=11.4$ GPa and $E_{\text{norm}}=200$ GPa