Otto–von–Guericke–Universität Magdeburg
Institut für Werkstoff– und Fügetechnik

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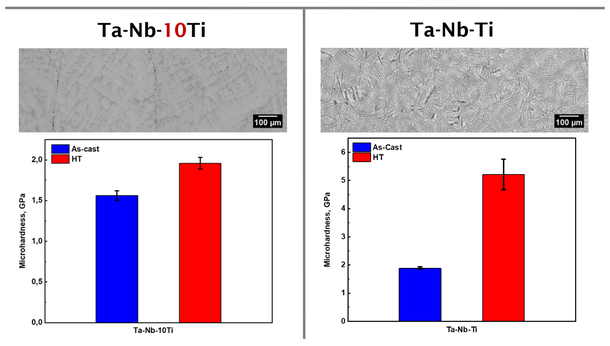
Development of a Ta-Nb-Ti multi-component alloy for biomedical applications

Maximilian Regenberg[1], Janett Schmelzer[1], Georg Hasemann[1], Manja Krüger [1], Caroline Grimmer[2], Jessica Bertrand[2] and Andreas Heyn[1]

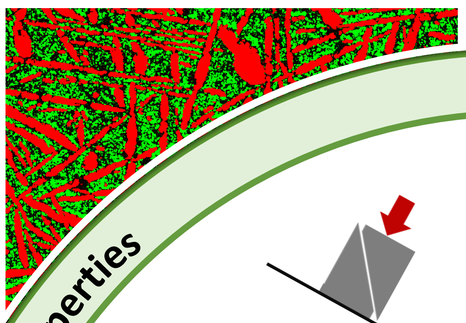
[1]Otto-von-Guericke-University Magdeburg, Institute of Materials and Joining Technology, Universitätsplatz 2, 39106 Magdeburg, Germany

[2] Otto-von-Guericke-Universität Magdeburg, Department of Orthopedic Surgery, Leipziger Str. 44, 39120, Magdeburg, Germany

Composition-dependent microhardness (heat treated condition (ht))



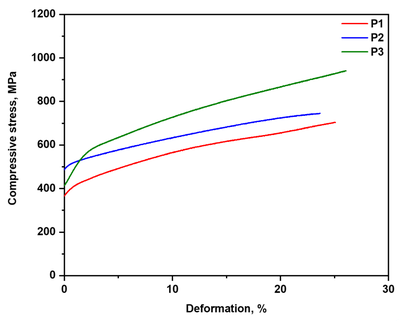
EBSD Phase-analysis (ht)



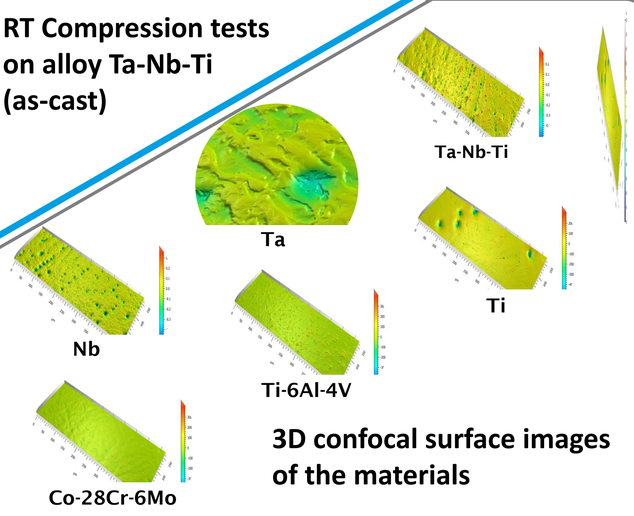
Mechanical testing

(f.e. tensile, compression, hardness, etc.) and microstructural development (f.e. heat treatment experiments)

- Force transmission between implant and bone/ surrounding structure
- Bone-like implant stiffness is desired (stress shielding)



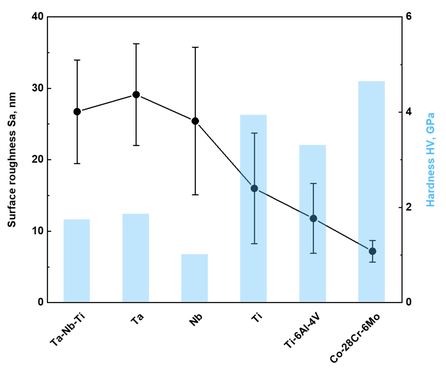
RT Compression tests on alloy Ta-Nb-Ti (as-cast)



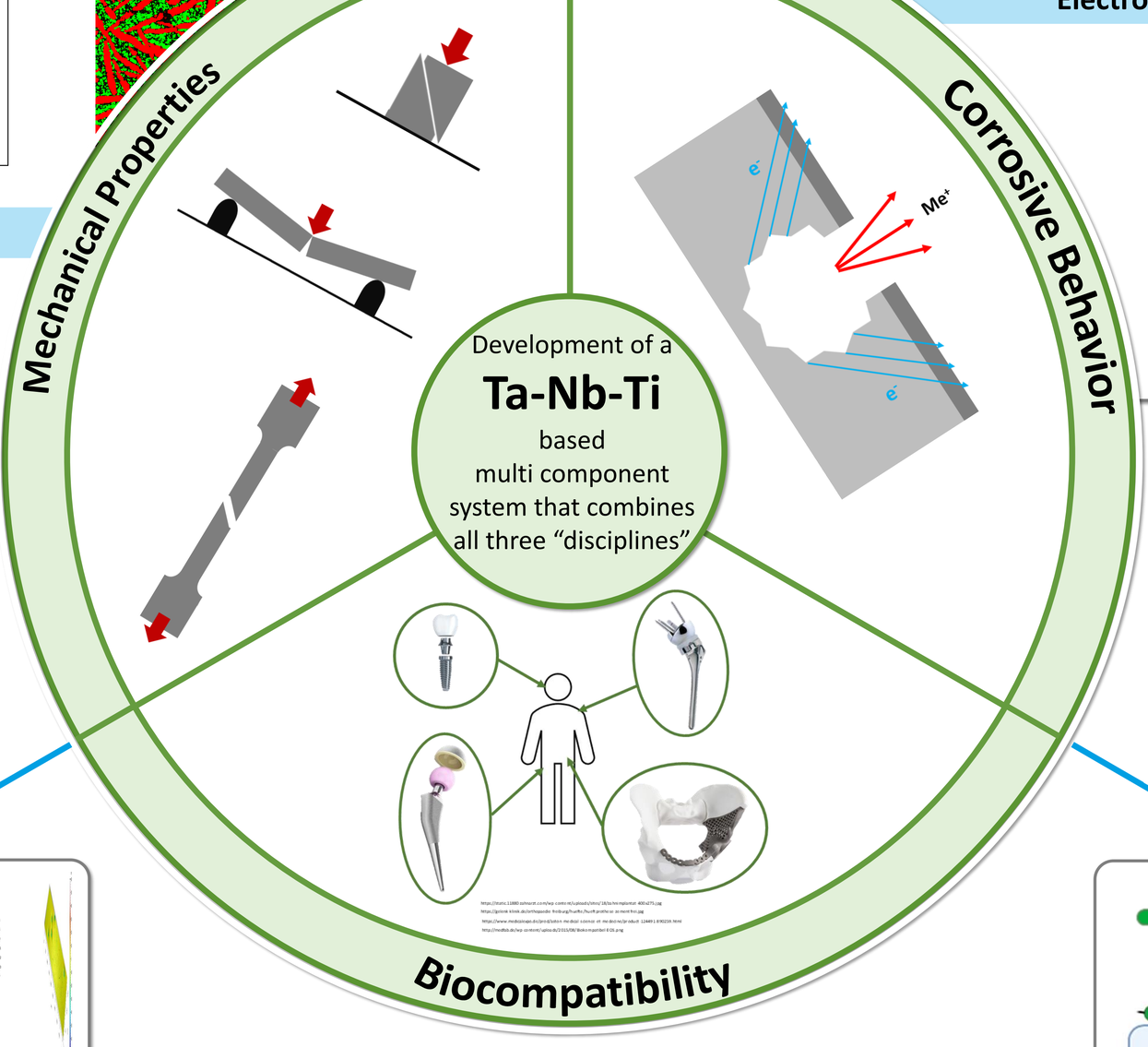
3D confocal surface images of the materials

Surface analysis

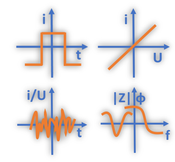
- Metallographic preparation of the samples (grinding, polishing)
- Confocal microscopy
- Microhardness analysis (Vickers)



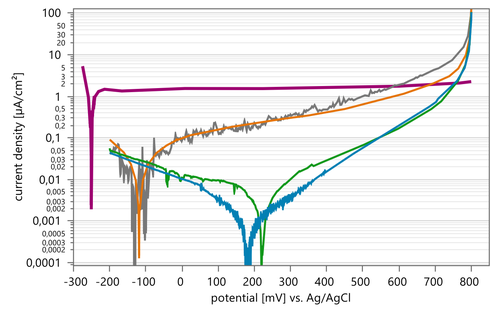
Surface roughness S_a vs. microhardness of the materials



- Open circuit potential (OCP)
- Cyclic polarization (anodic/cathodic)
- Electrochemical impedance spectroscopy (EIS)
- Mott-Shottky-Analysis (MS) of passive layers

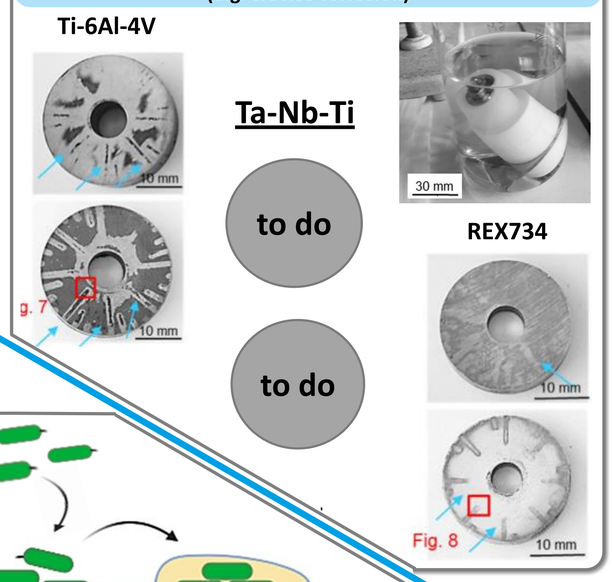


Electrochemical Investigation



Polarization curves of biomaterials under different conditions

Exposure Testing
(e.g. crevice corrosion)



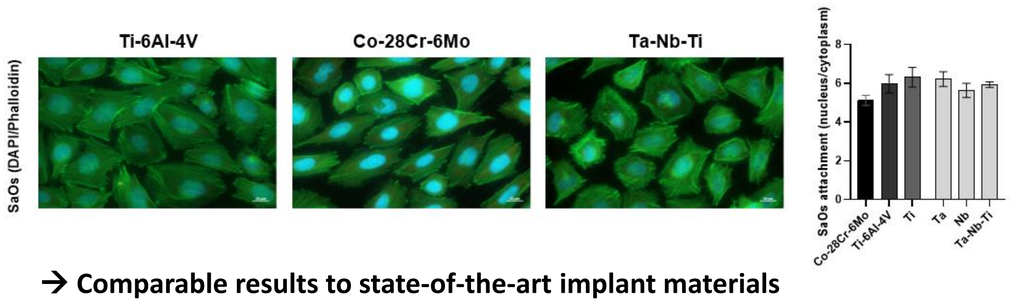
Refractory alloying systems are of interest because they often contain one or more potentially biocompatible elements.

The tasks in this regard are f.e.:

- Cell adhesion and proliferation assessments
- Validation of the inflammatory potential with respect to new alloying compositions and/ or emerging particles (in vivo)
- Verification of bacteria – surface interactions

Assessment of osteoblast attachment and absorption (SaOs-2)

- Mineralization (10 days) > Alizarin Red Assay > Absorption measurement
- Analysis of spreading (ratio between nucleus & cell plasma)

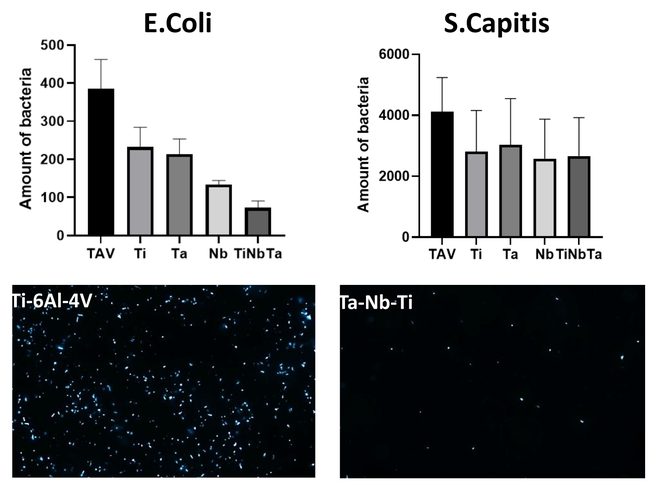


→ Comparable results to state-of-the-art implant materials (f.e. Ti-6Al-4V)

Procedure:

- Cultivation for 24h > Optical density (OD) measurement
- Colony forming units (CFU) on agar for 24h > CFU counting
- DAPI > Counting bacteria on surface

Bacteria – material interactions



E.Coli bacteria on alloy Ti-6Al-4V & alloy Ta-Nb-Ti

- First results of microstructure investigations before/ after heat treatment experiments, as well as mechanical testing indicate pronounced microstructural changes which lead to modified mechanical properties and thus possibilities to adjust the mechanical properties of alloy Ta-Nb-Ti in desired directions
- Results from corrosion experiments with regard to different mechanisms, as well as in different environments (solutions) will follow in the near future

- Biocompatibility experiments by means of osteoblast (SaOs-2) attachment and spreading, as well as mineralization analysis on the alloys examined indicated no negative effects on the cells, respectively comparable results with state-of-the-art biomaterials
- Investigations of the interactions between bacteria (E.Coli, S.Capitis) revealed a strong tendency towards antibacterial behavior of alloy Ta-Nb-Ti with regard to attachment and proliferation of bacteria on the surface, compared to other biomaterials

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Experimental Orthopedics