

Current Situation

- Potential cytotoxic behavior of vanadium when using alloy Ti-6Al-4V as implant material for bio applications
- Comparatively low strength and wear properties of CP titanium in contrast to alloy Ti-6Al-4V



Artificial hip joint



Artificial knee joint

Background

- Titanium shows an extremely high solubility of oxygen
- Oxygen is dissolved interstitially and promotes the formation of hcp α -structure
- Strength and hardness of Ti are increased
- Simultaneously ductility is decreased

Motivation

- Intentional addition of oxygen to increase the strength of pure titanium
- Further improving of ductility by a currently investigated method

Experimental Procedure

- Remelting of Ti-sponge electrodes under a technically pure CaF₂-slag
- Inserting of oxygen during remelting by different methods of TiO₂ addition:
 - constitution of the powder (conventional powder vs. nano-powder)
 - type of introduction (via electrode vs. via slag)
 - amount of powder
- Oxygen pick up by dissolution of TiO₂

$$(\text{TiO}_2)_{\text{slag}} = [\text{Ti}]_{\text{Ti}} + 2 [\text{O}]_{\text{Ti}}$$
- Homogenous solidification structure provides uniform distribution of oxygen in the as-cast material



ESR lab-scale unit with a 2.5 kg Ti-sponge electrode



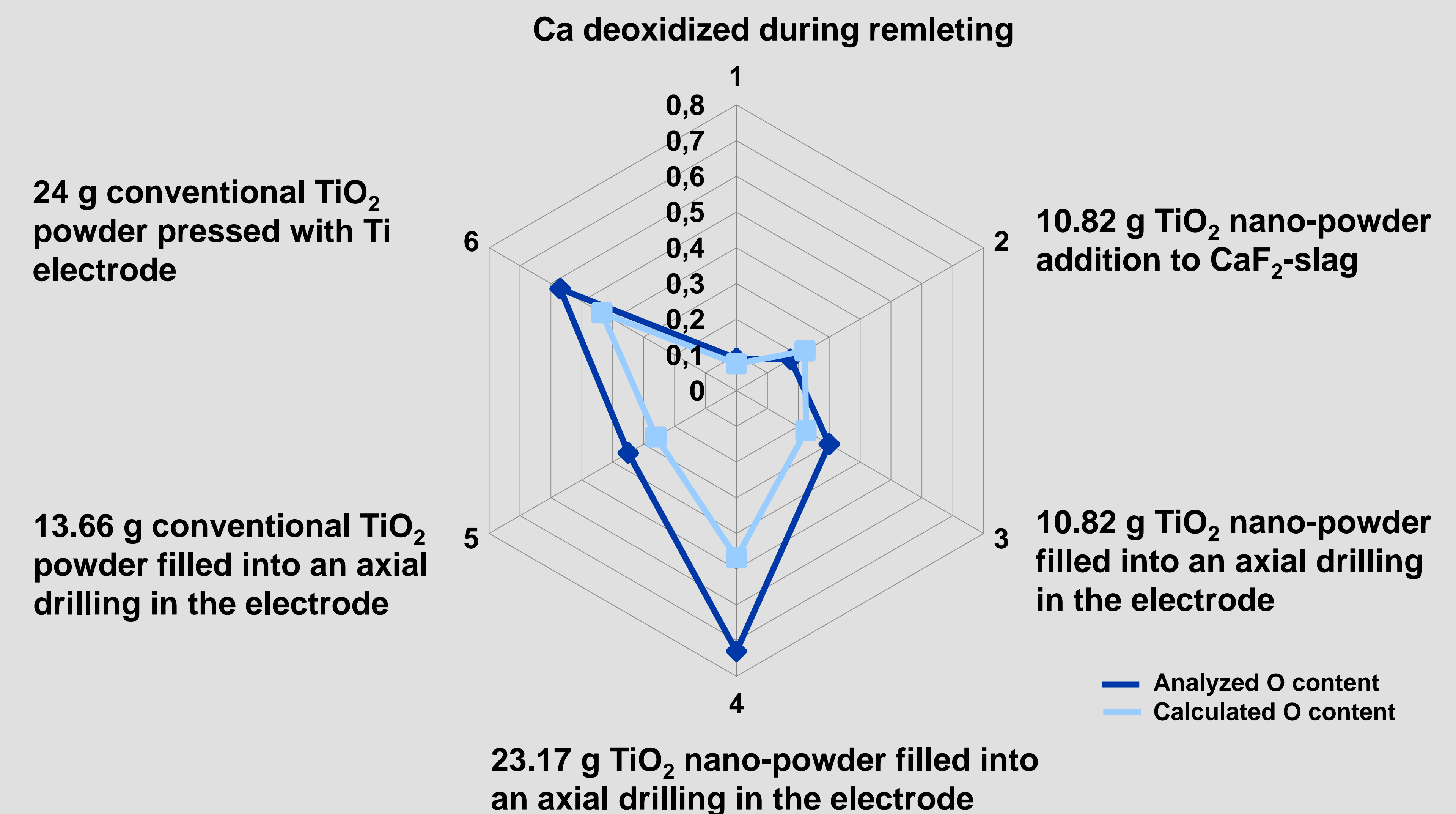
Remelted ingot showing a smooth surface

Process Characteristics

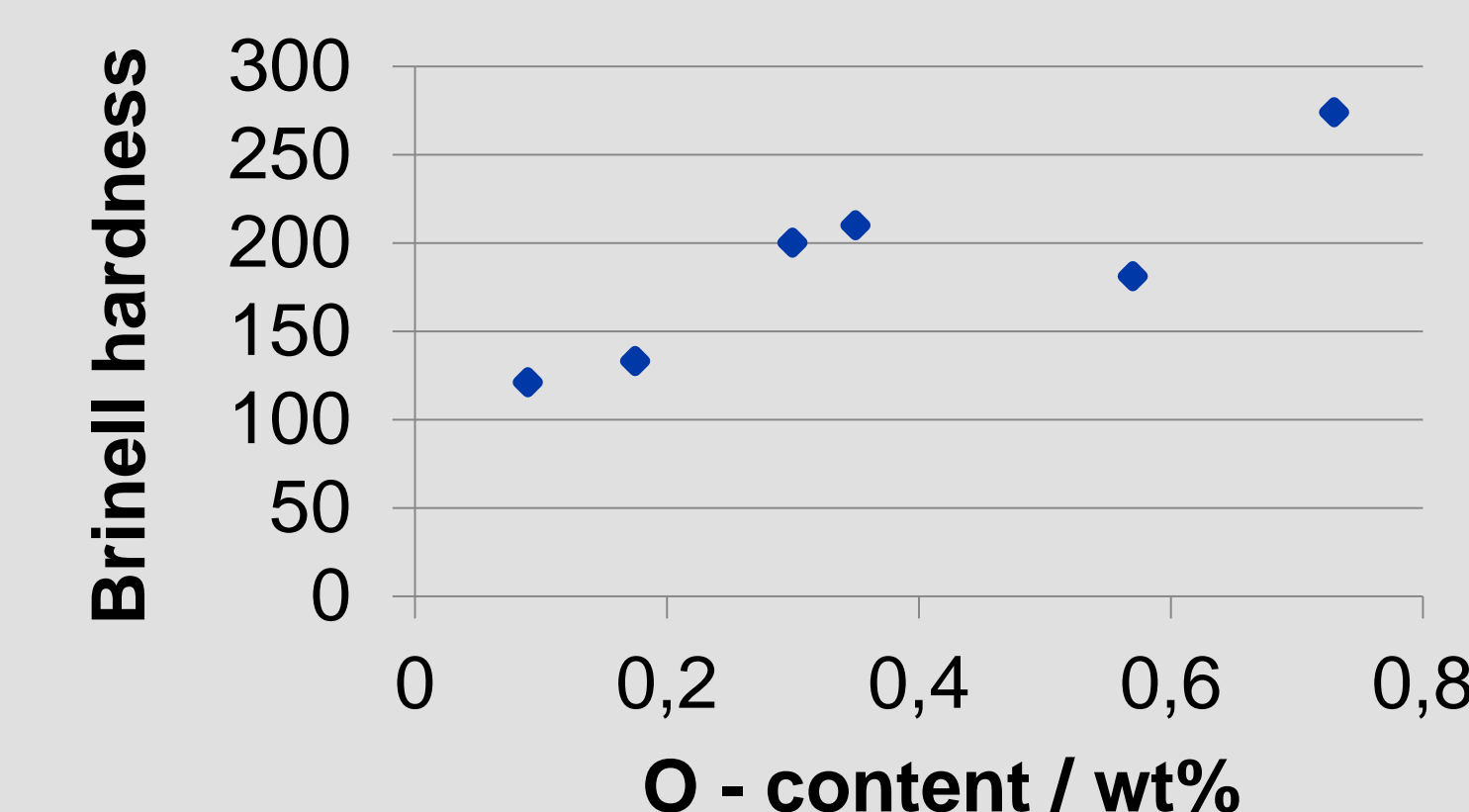
- Power supply: 724 kW
- Electrode weight: 2.5 kg
- Utilized amount of CaF₂ slag: 400 g
- Protective argon atmosphere

Results

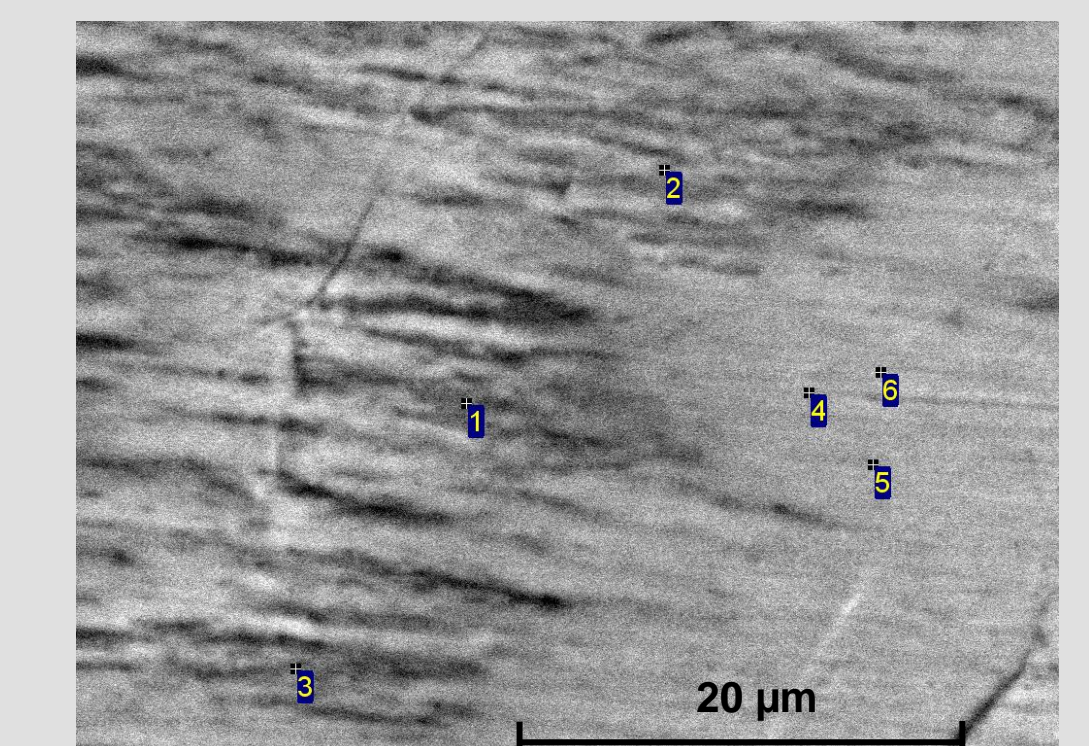
Analyzed and calculated oxygen content in the remelted material / wt%



- Increasing oxygen content with rising TiO₂ addition
- Higher oxygen pick up by TiO₂ introduction via the electrode compared to previous mixing with the CaF₂-slag
- No significant difference between conventional and nano-powder addition
- Deviation between analyzed and calculated oxygen content due to minor CaF₂ impurities and residual atmospheric oxygen



- Increased hardness with higher oxygen contents



- Complete dissolution of TiO₂ particles in the ingot material (no TiO₂ inclusions detected)