INVESTIGATION OF STRUCTURAL CHANGES IN TI-6AL-4V VIA HIGH ENERGY X-RAY DIFFRACTION

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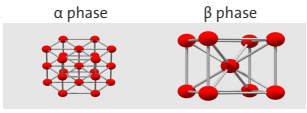
MOTIVATION

- Positron source needed for the International Linear Collider
  - Synchrotron radiation used for positron generation
  - Rotation of the target to distribute the load
  - High cyclical irradiation and thermal load on the material
- Ti-6Al-4V is a promising candidate material

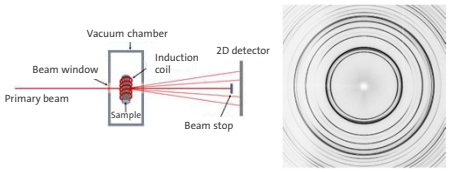
MATERIAL

- Target material
  - Ti-6Al-4V
  - Two phase material
  - α phase and high temperature β phase
  - Phase fraction and crystal structure have a major impact on the properties



EXPERIMENT

HIGH-ENERGY X-RAY DIFFRACTION

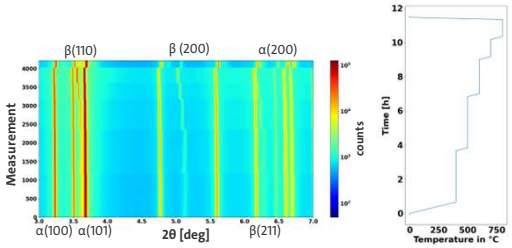


Radial integration of all diffraction patterns

DILATOMETER

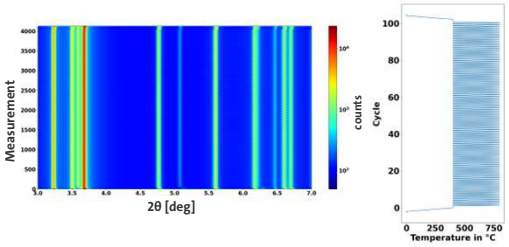
- **HEMS beamline** at DESY operated by HEREON
  - High-energy XRD
  - Transmission geometry
  - Destruction free analysis of the targets
- **Dilatometer**
  - Cyclical heating and cooling
  - Temperatures in accordance with previous irradiation experiments
  - Peak and base temperatures varied
  - Cooling rates varied

SYNCHROTRON DATA



Reference measurement with continuous heating

- Impact of continuous heating
- Measured during the heating process



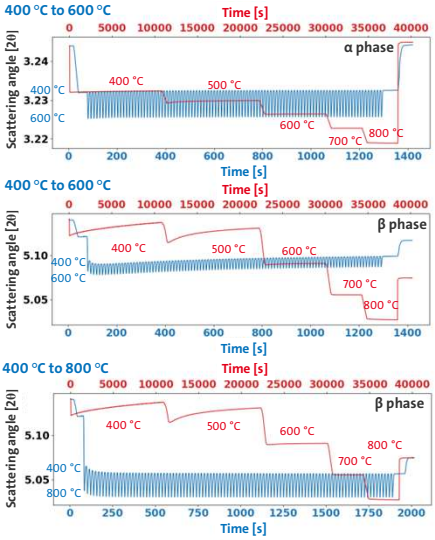
Multiple measurement series for different heating parameters

- Study the impact of repeated heating and cooling
- Controlled heating and cooling rates
- Measured during the heating process

EVALUATION

PEAK ANALYSIS

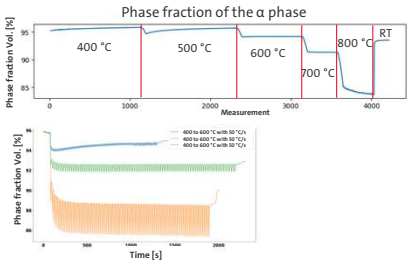
Continuous and **cyclical** heating



- For both phases select peaks were studied
- Scattering angle, intensity and width of the peak were analyzed
- Focus here on **changes in scattering angle**
  - For the **α phase**:
    - changes dependent on current temperature
    - Thermal lattice expansion
  - For the **β phase**:
    - changes mainly depend on **peak temperature**
    - Remain after subsequent cooling
    - Potentially changes in chemical composition

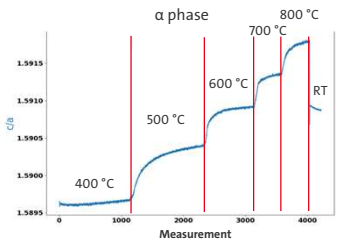
No major difference for **cyclical and continuous heating** for the same peak temperatures

PHASE ANALYSIS



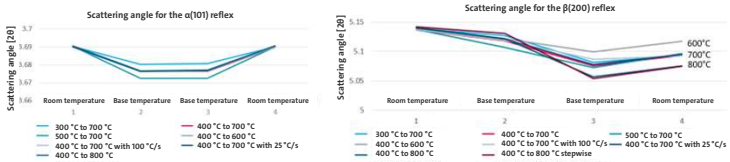
- Change in phase fractions
  - High temperature β phase increases with temperature
  - After cooling the initial value is not reached again
- Higher amount of β phase after the heating process
- Phase fractions for cyclical heating dominated by peak temperature

C/A RATIO OF THE α PHASE



- Ratio of the two base vectors of the α phase
- Possible explanations are
  - Changes in the chemical composition
  - Lattice distortions
- c/a ratio remains changed after cooling

RESULTS



- Changes could be measured in the
  - Phase fraction
  - Peak parameters
  - And c/a ratio (α phase)
- After the heating experiment:
  - Strong correlation between β phase lattice parameter and peak temperature
  - Determine peak temperatures for ex-situ experiments

OUTLOOK

- **Irradiation experiments** in Mainz
  - Realistic beam parameters for the ILC
  - Build upon previous tests
- For high temperatures
  - similar results as with heating experiments
- Low temperatures:
  - Different effect for the studied material
  - Potentially effects due to local heating or displacement of lattice atoms
- Further analysis to get accurate temperatures