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Influence of the initial microstructure on the phase transformation of Ti-10V-2Fe-3Al

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Abstract

Titanium alloys present allotropic phase transformation between α (hcp) and β (bcc) phases. These transformations are controlled by diffusion of mainly one alloying element and by formation of meta-stable phases. In situ high-energy synchrotron diffraction experiments performed during heat treatments allowed the characterization of phase evolution in a near-beta Ti-10V-2Fe-3Al alloy. Quantitative analysis of diffraction patterns gives the transformation kinetics of each phase.

Material

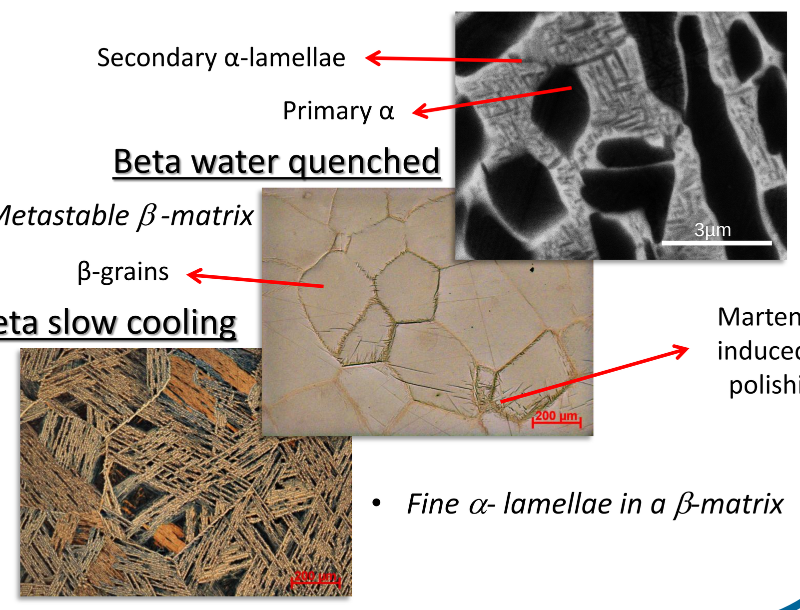
- **Ti-10V-2Fe-3Al**

Beta transus ~808 °C

Composition , wt.% (Ti – balance)							
Al	V	Fe	C	O	N	H	Y
3.25	9.24	1.86	0.023	0.12	0.011	0.0008	<0.005

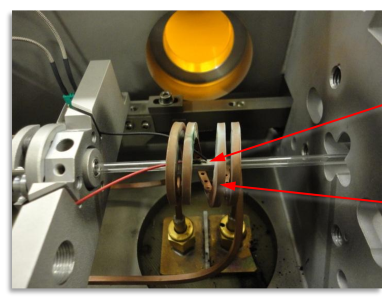
- **Initial microstructures**

Condition	Heat Treatment (Temperature / Time)	Cooling
As received	1st) Forged in several steps in α+β and β field 2nd) 763°C / 2 hours 3rd) 510°C / 8 hours	 Water Air
Beta water quenched	900°C / 30 min	Water
Beta slow cooling	900°C / 30 min	5 k/min

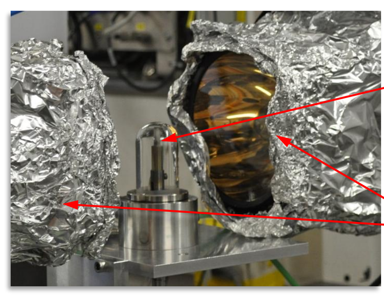


Experimental

- Phase transformation analysis
  - In situ high energy synchrotron diffraction
  - Heating up to 1000°C with 20 k/min
  - Argon atmosphere
- Data analysis
  - Fit2d: Conversion/integration of x-ray patterns
  - Imagej: Image processing
  - Maud: Rietveld refinement
- Petra III (HEMS-P07) experiments
  - Monocromatic beam of 87.385KeV, λ= 0.1419Å
  - Bähr 805A/D dilatometer (induction furnace)
  - MAR 345 image-plate detector
  - Slit-aperture size: 0.5x0.3mm²
  - Adquisition time: 2s
  - Read-out time: ~120s

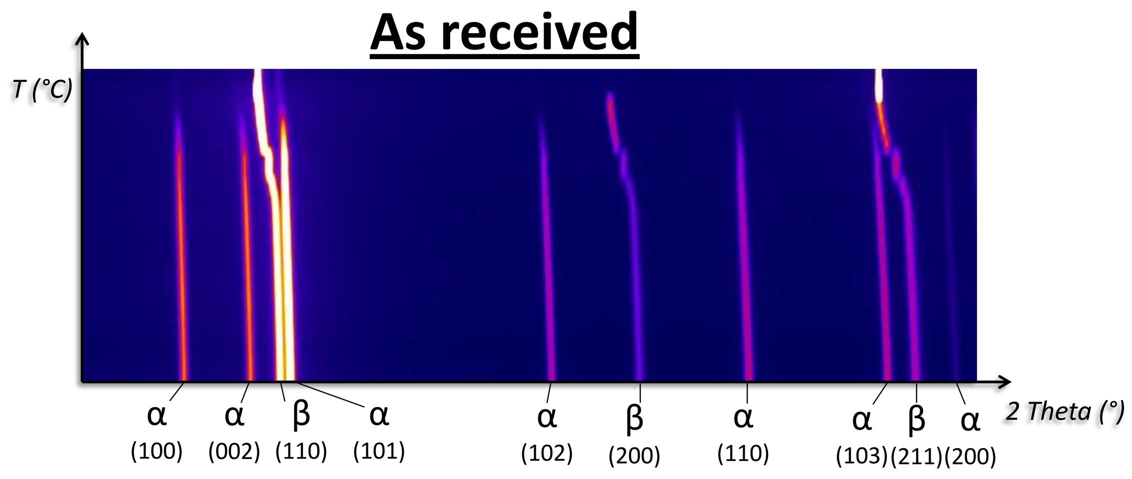


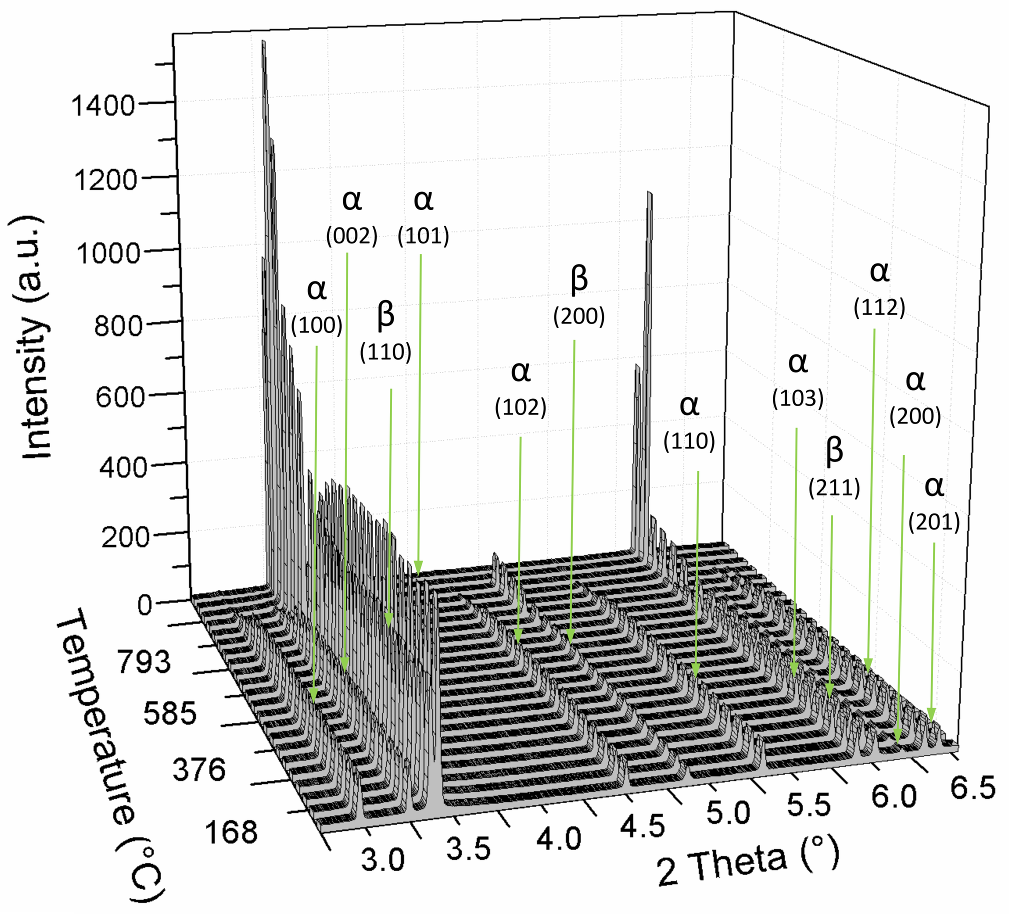
- ESRF (ID15B) experiments
  - Monocromatic beam of 87KeV, λ= 0.1426Å
  - Radiant furnace
  - PIXIUM image-plate detector
  - Slit-aperture size: 0.3x0.3mm²
  - Adquisition time: ~2s
  - Read-out time: ~1s

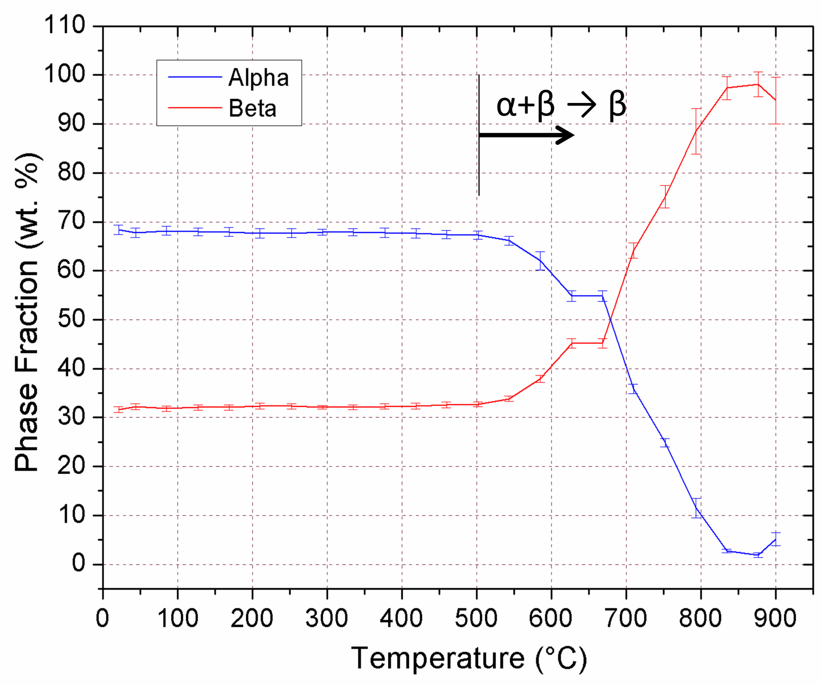


Results

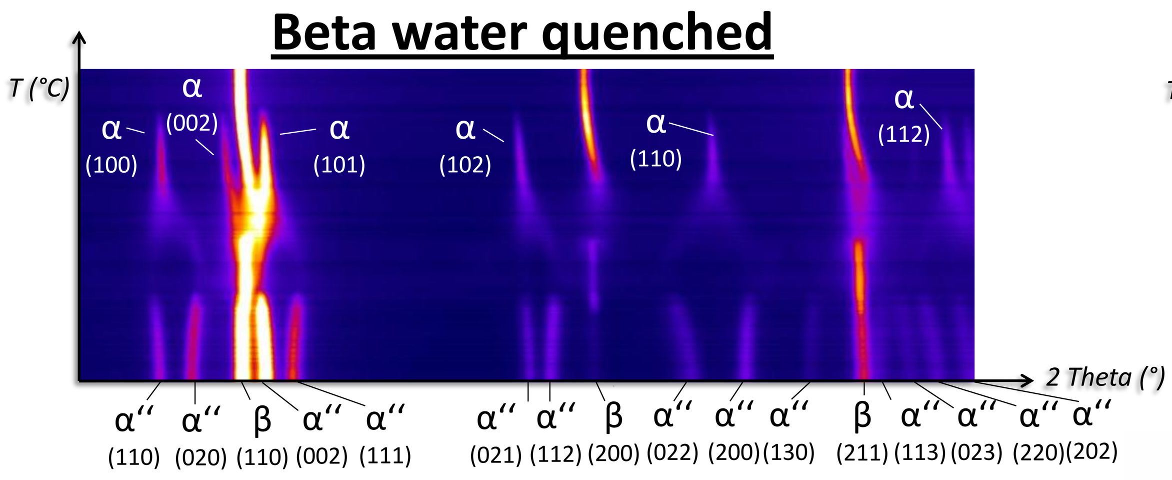
As received

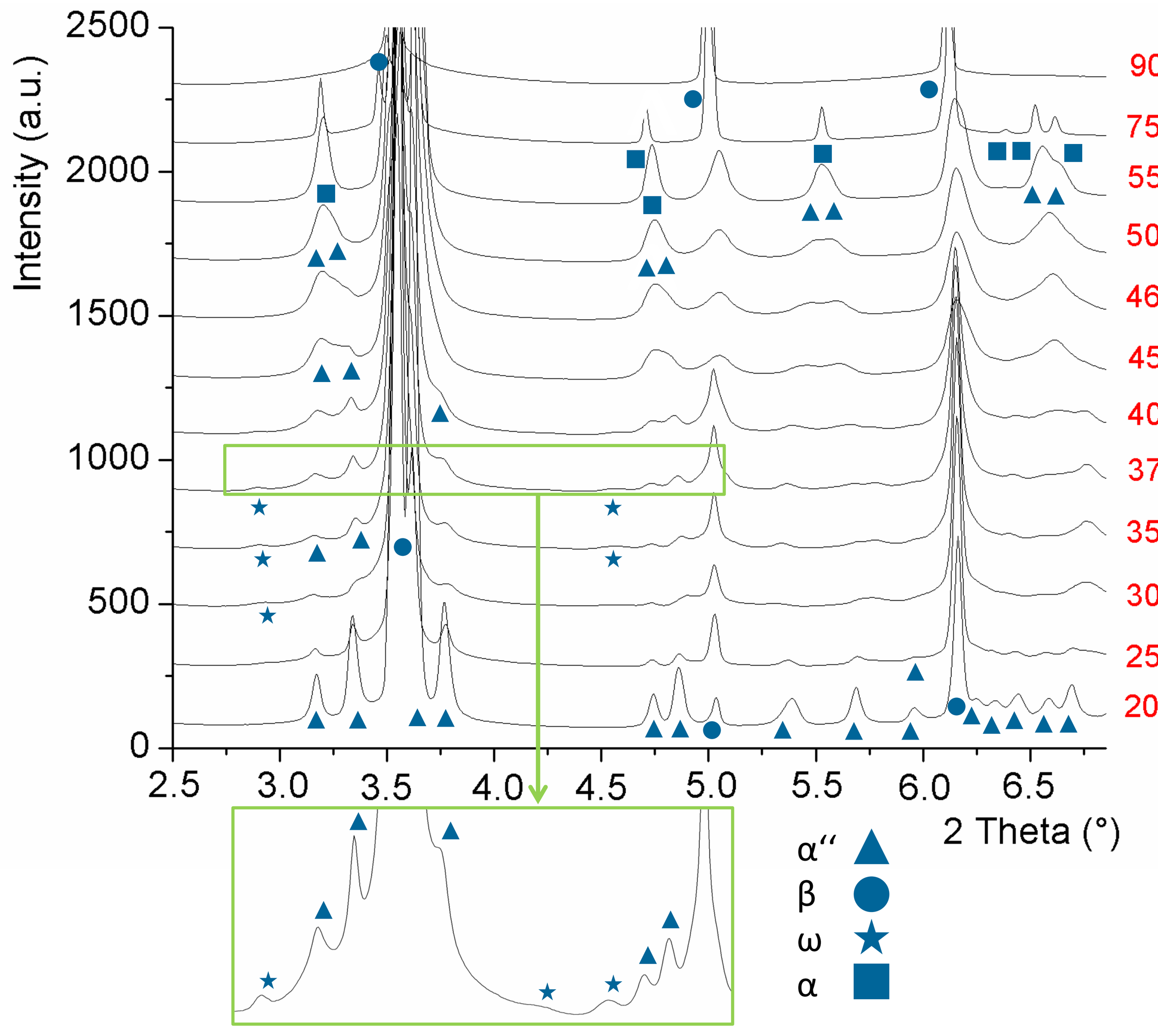


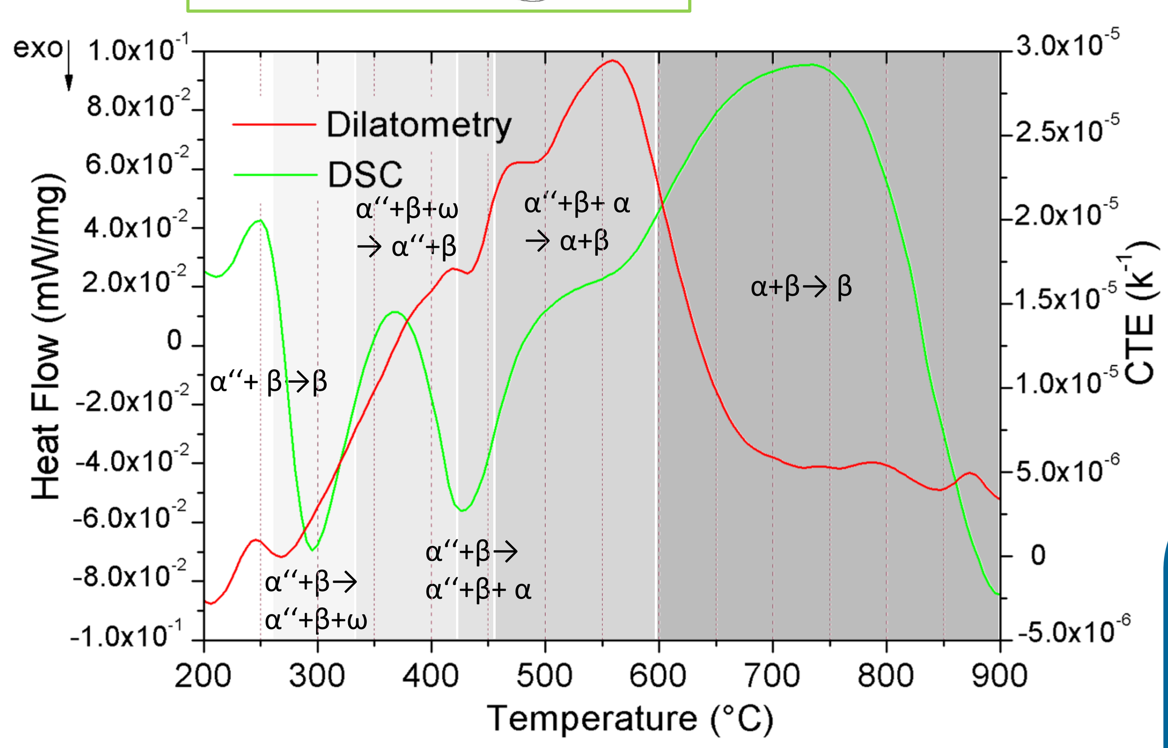




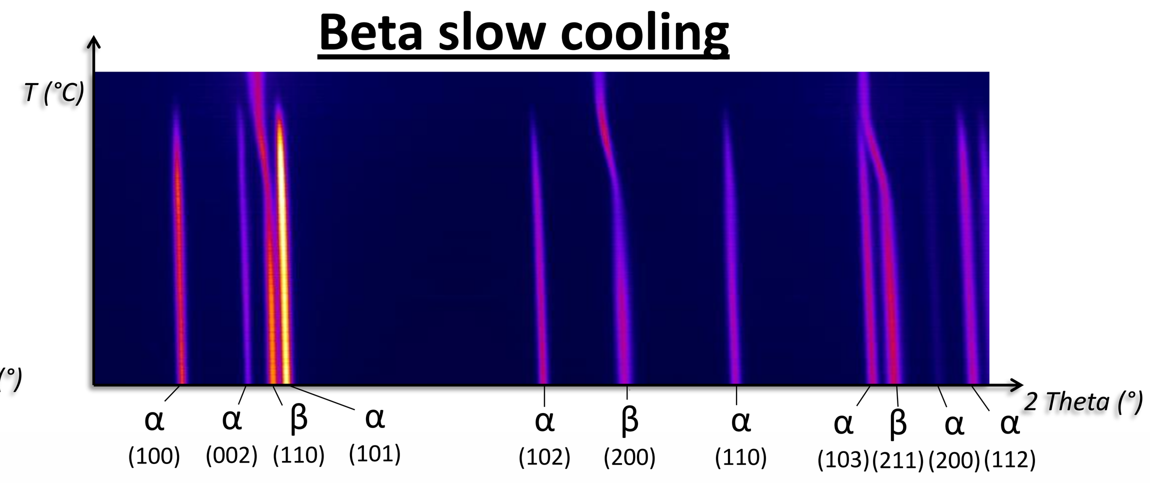
Beta water quenched

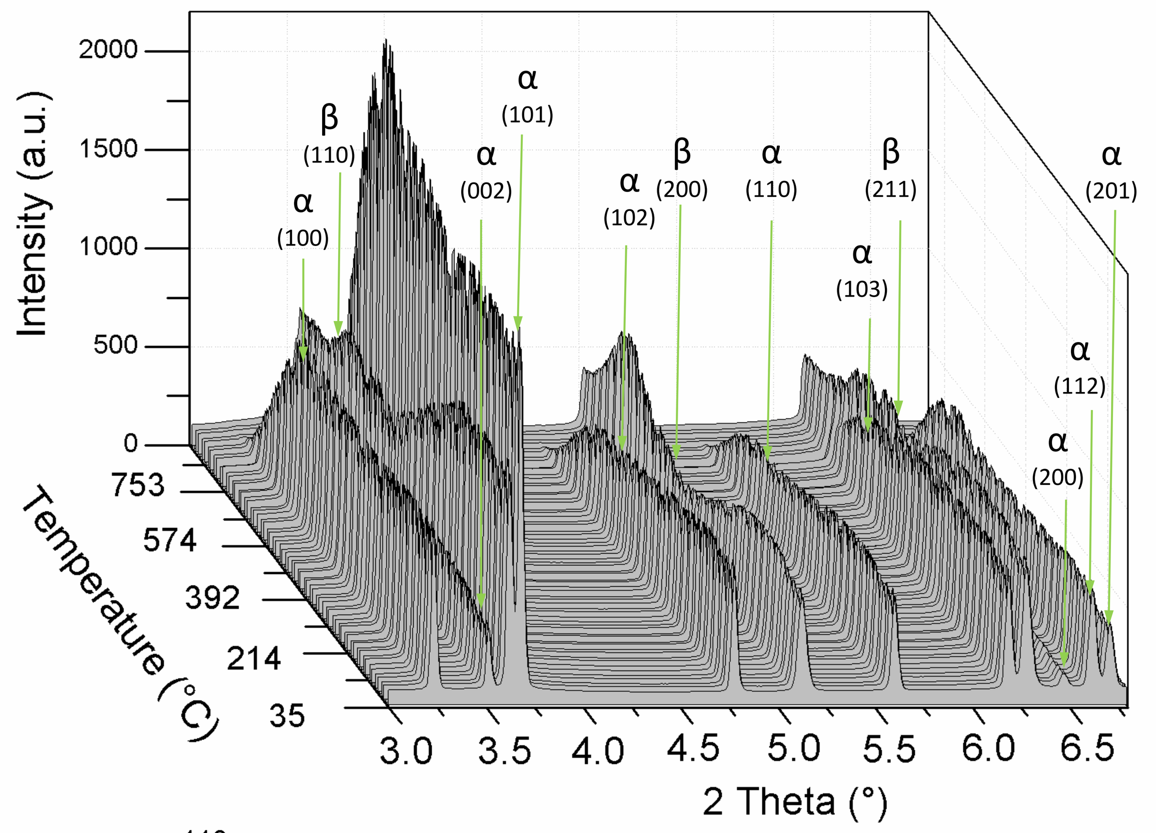


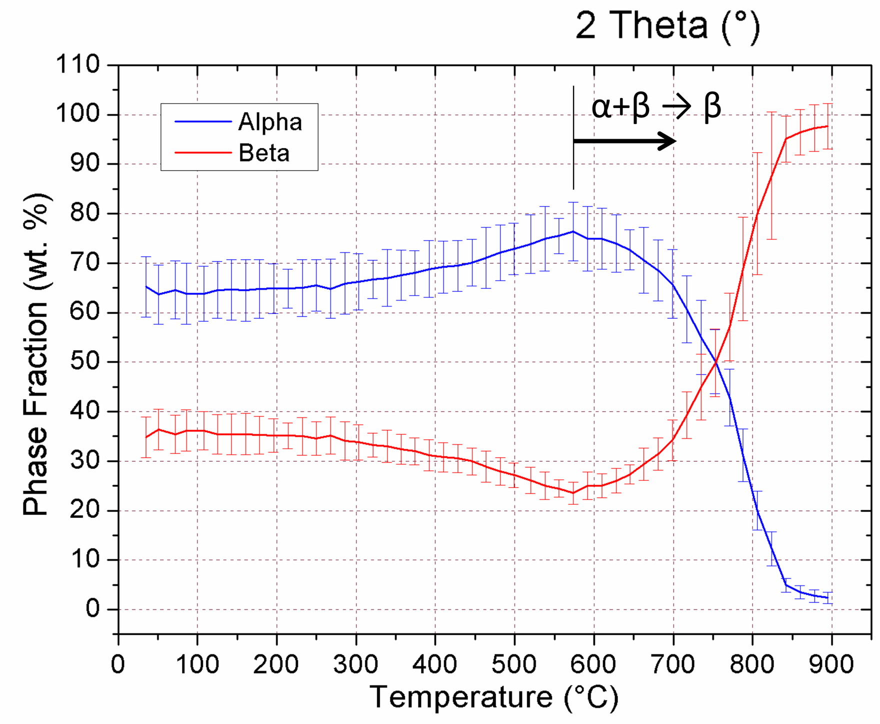




Beta slow cooling







Summary

- **The evolution of the α and β phases was determined in *"as-received"* and *"Beta slow cooling"* conditions :**
  - Similar initial phase weight fractions are obtained for both phases.
  - The α–β phase transformation → starts at ~500°C for the *"as-received"* condition
    → is displaced to ~570°C for the *"Beta slow cooling"* condition
  - There is a stabilization period above ~200°C in the *"Beta slow cooling"* condition that results in a decrease/ increase of about 10 wt% of the weight fraction of β/α
- **In the *"Beta water quenched"* condition the evolution of the following four different phases was observed:**
  - α''+β→ α''+β+ω → α''+β → α''+ α+ β → α+β → β
  - The phase transformation sequence agrees with dilatometry and DSC (differential scanning calorimetry) results.

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