Fabrication of different armour prototype materials by PIM

Activity 1: Armour Materials

WP12-MAT-01-HHFM-01-01/KIT/PS
Reporting period: June 2012 – February 2012
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Objective

→ **Fabrication** of a variety of different armour prototype **materials** by PIM

(1) Material development

(2) Producing of PIM plates (incl. heat-treatment process)

(3) Basic material characterization:

- Microstructure: FIB
- Crystallographic texture: EBSD
- Mechanical testing: 4-Point-Bending-Tests

(4) High heat flux tests

(5) Characterization after (4)

2013

Cooperation with the colleagues from FZ Jülich and IPP Garching

(1) Material development

Powder particle size (as-delivered)**:**

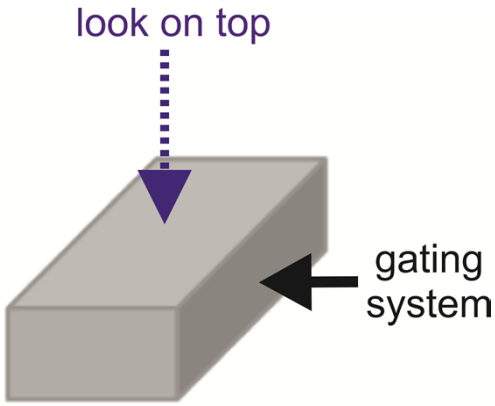
- W 0.7 – 1.7 µm
- La_2O_3 1.5 µm
- Y_2O_3 2.5 µm

powder mixing

Materials:

- W (pure)
- W-2La_2O_3 (5.7 vol.-% La_2O_3)
- W-2Y_2O_3 (8.1 vol.-% Y_2O_3)

(2) Producing of PIM plates

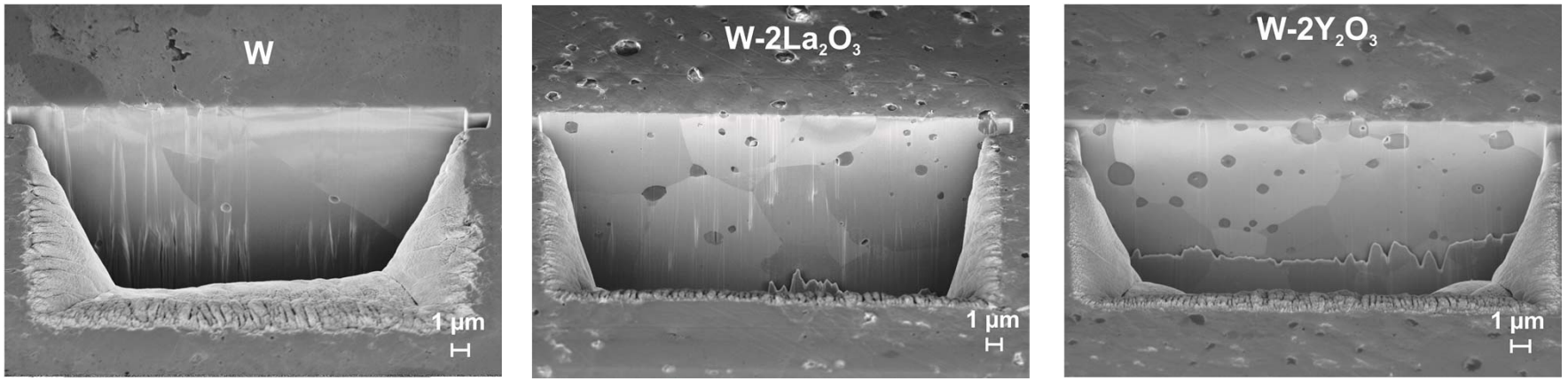


Heat-treatment (only Sintering)**:**

- 2 hours
- dry H_2 atmosphere
- 2400 °C

(3) Basic material characterization

Microstructure: FIB

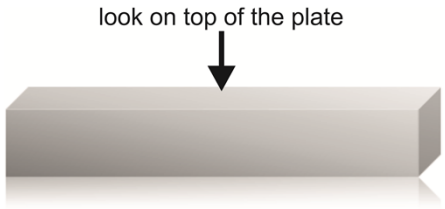


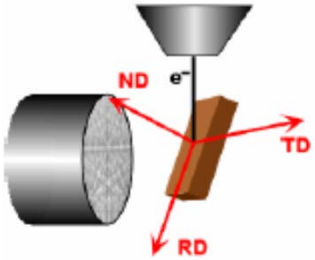
→ The embedded particles (La_2O_3, respectively Y_2O_3) are homogeneous around the tungsten grain boundaries and act as grain grow inhibitor.

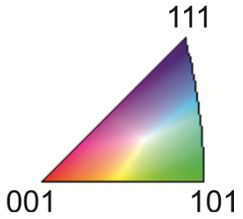
→ Powder preparing by mixing was successful.

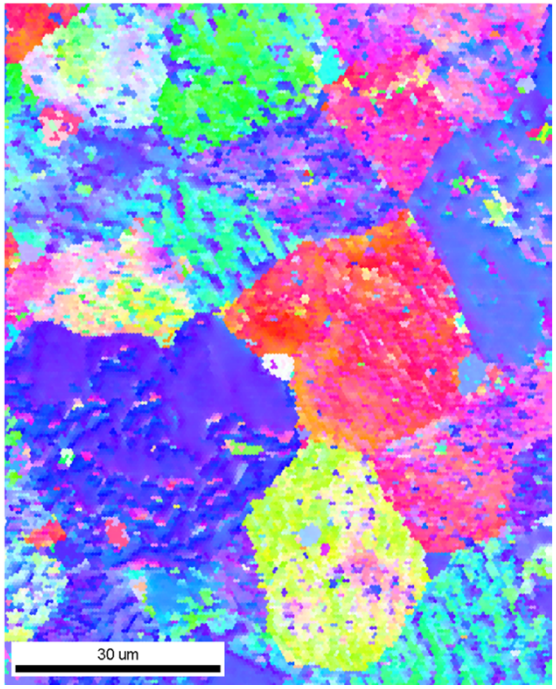
(3) Basic material characterization

Crystallographic texture: EBSD

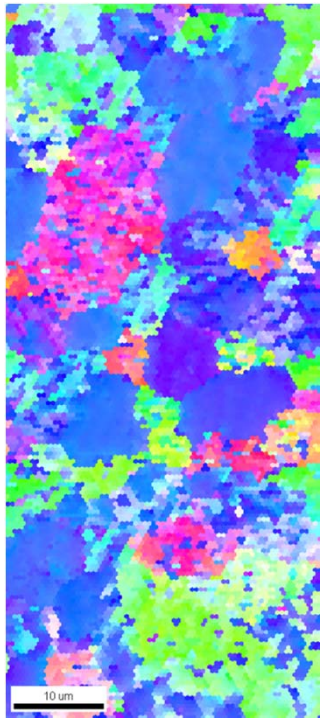




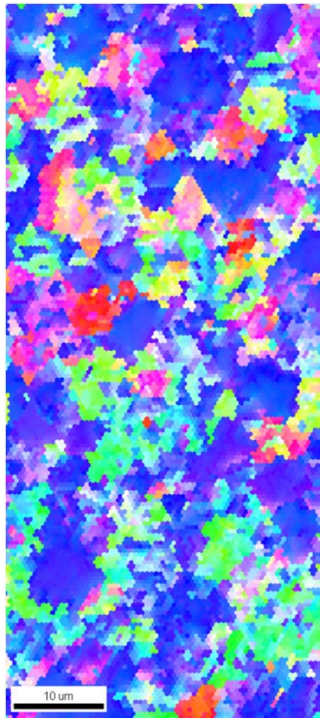




Pure W



$W\text{-}2La_2O_3$



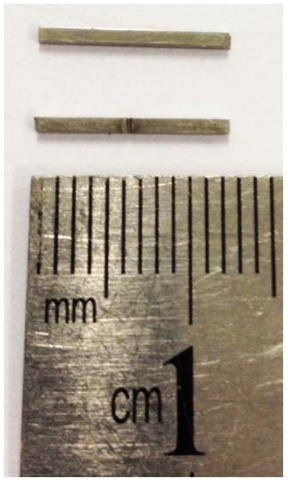
$W\text{-}2Y_2O_3$

Grain grow in [111]-direction to the free surface → preferred orientation in [111]-direction.

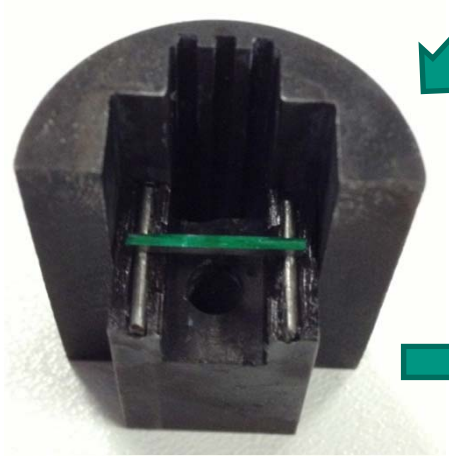
(3) Basic material characterization

Mechanical testing: 4-Point-Bending-Tests

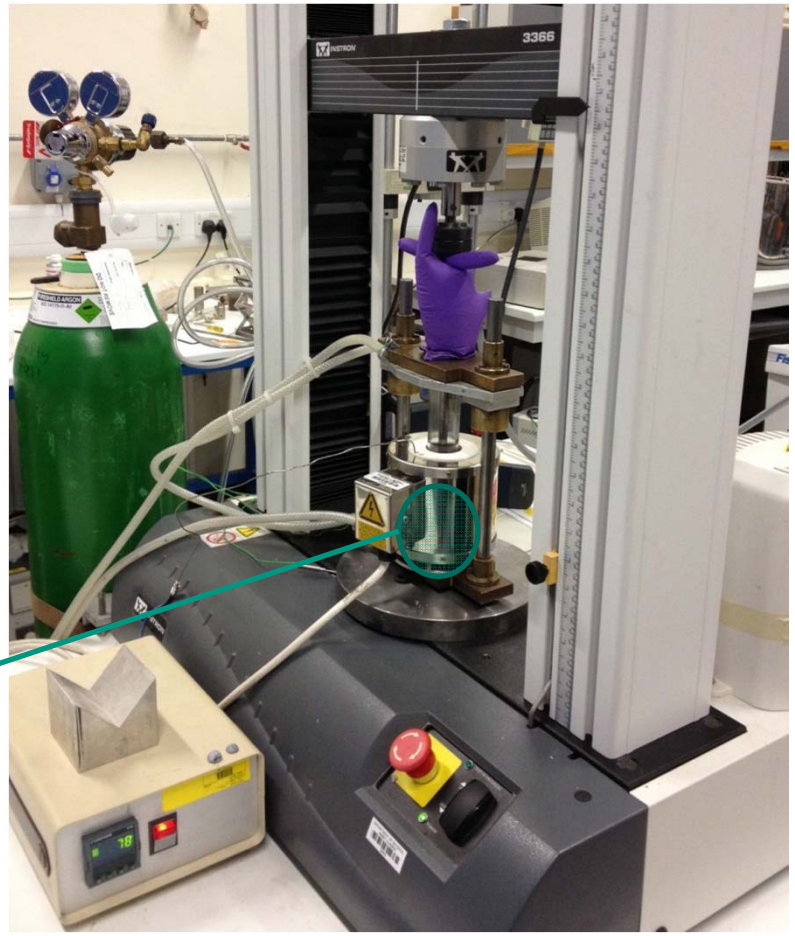
Polishing



10 µm Notching

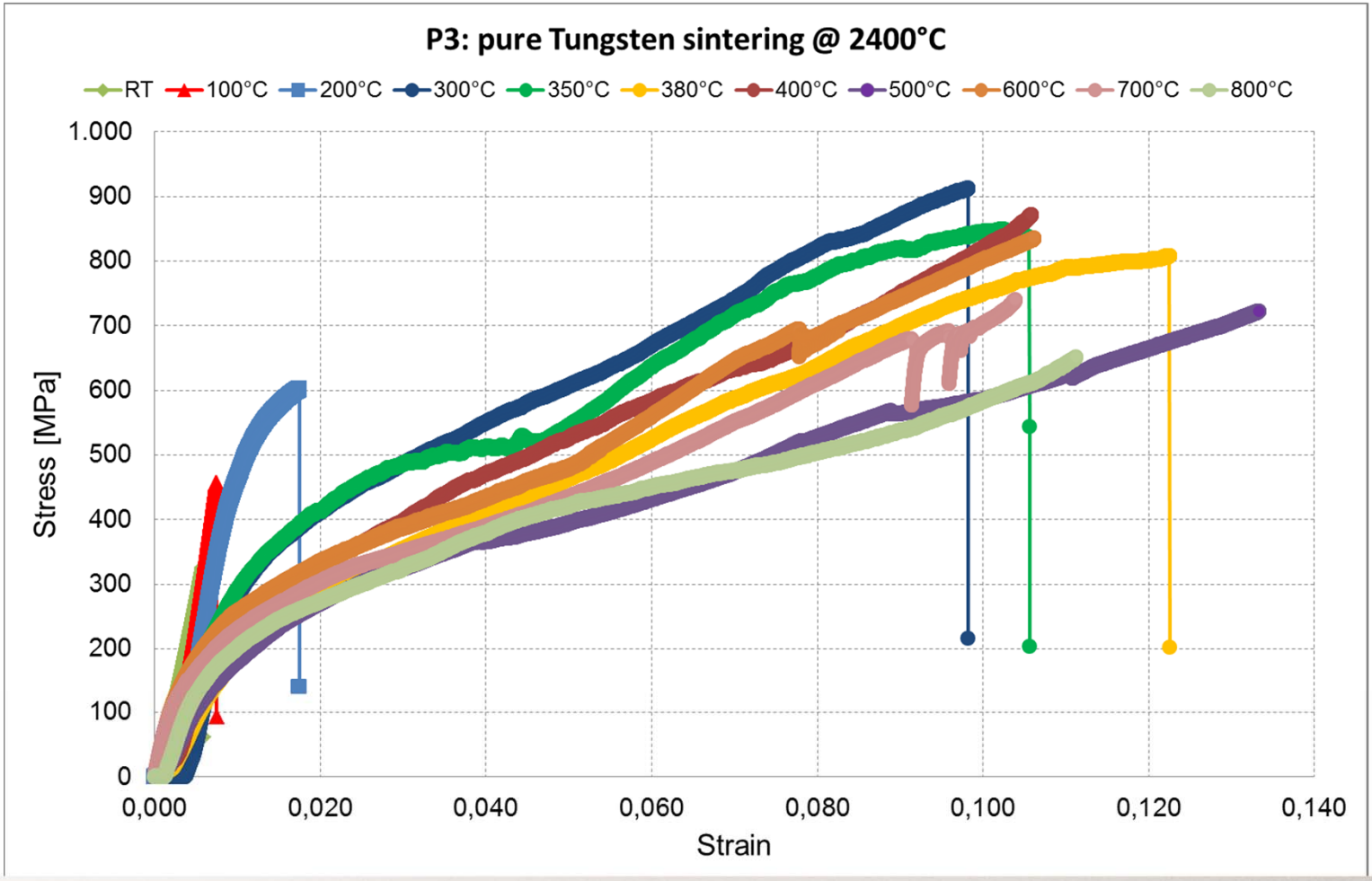


Sample geometrie: (12 x 1 x 1) mm
Constant strain rate of 0.0330 mm/min



(3) Basic material characterization

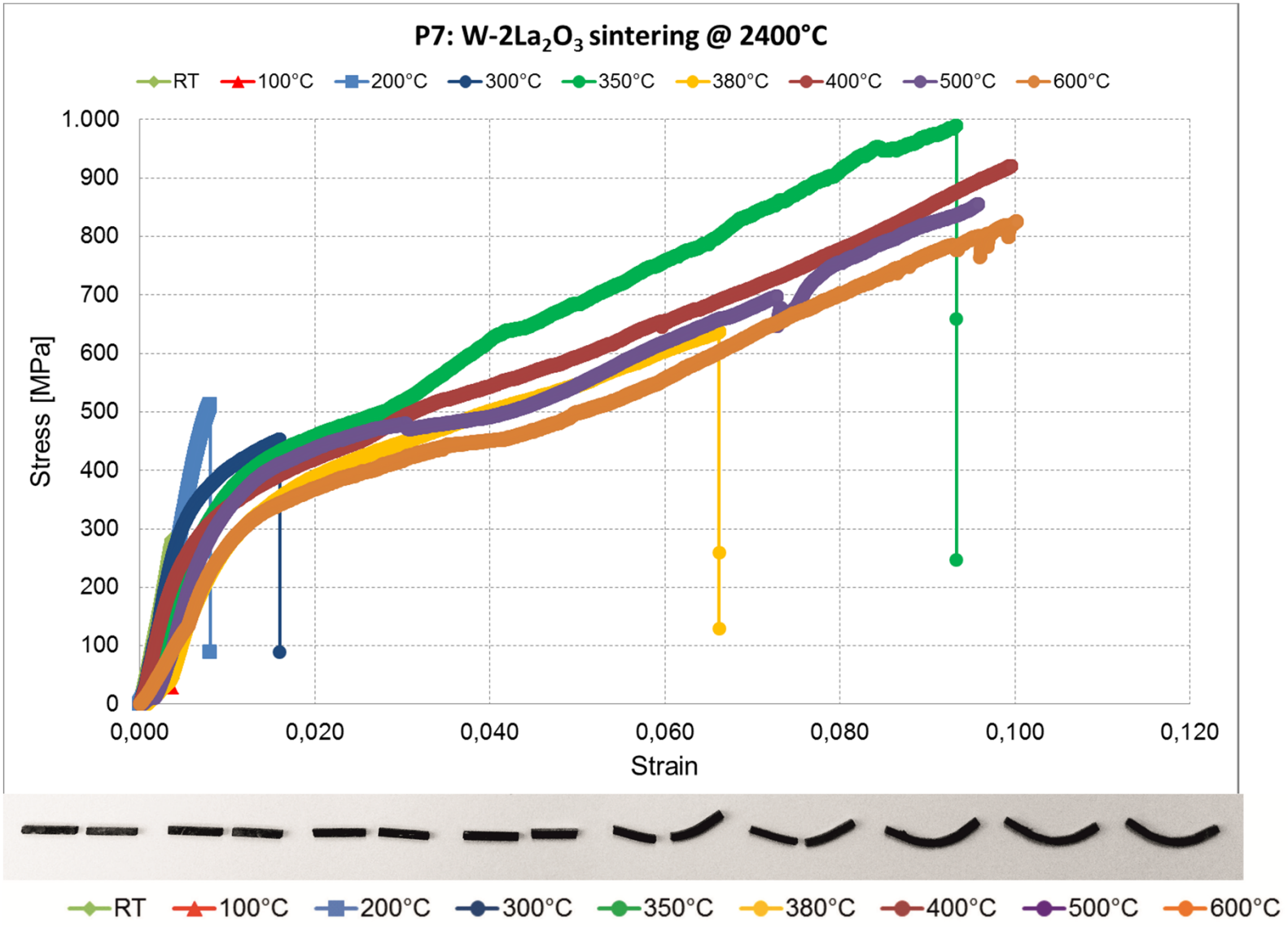
Mechanical testing: 4-Point-Bending-Tests



RT 100°C 200°C 300°C 350°C 380°C 400°C 500°C 600°C 700°C 800°C

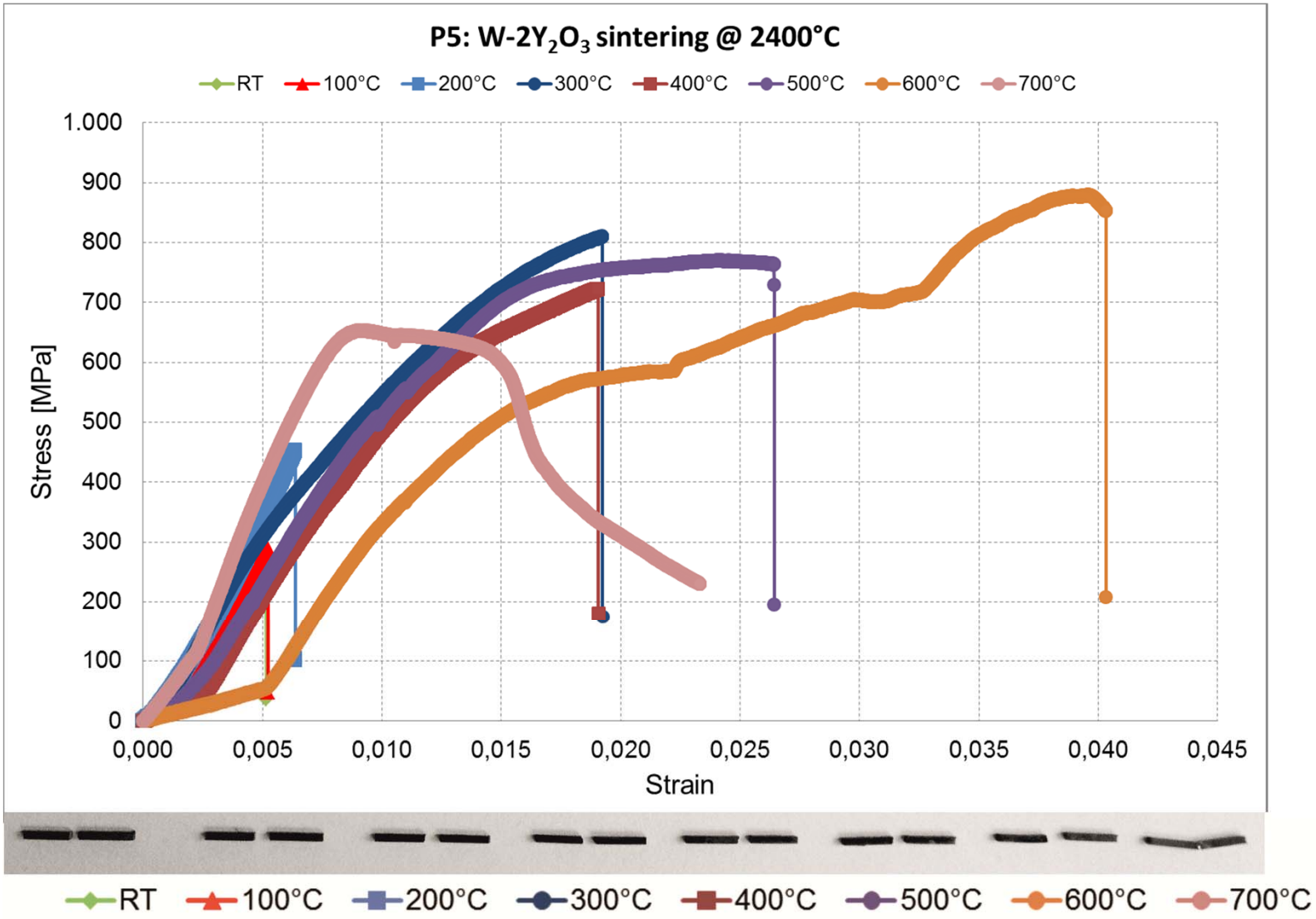
(3) Basic material characterization

Mechanical testing: 4-Point-Bending-Tests



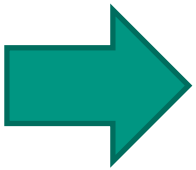
(3) Basic material characterization

Mechanical testing: 4-Point-Bending-Tests



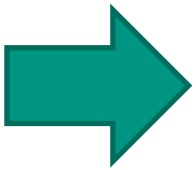
(3) Basic material characterization

Ductile → brittle transition between 200 °C and 400 °C



Fractography on selected samples @ KIT in progress

The samples break until 380 °C and don`t break @ 400 °C



Which kind of effect or mechanism?

Conclusions

Preparing of the materials only by mixing was successful.

A new heat-treatment process with a sintering temperature @ 2400 °C was developed.

Preferred orientation in [111]-direction.

Ductile to brittle transition between 200 °C and 400 °C?

Outlook Work Programme for 2013

HHF tests on samples of WP12 (FZ Jülich and IPP Garching)

Goal 2013: Fabrication and optimization of different W armour materials by PIM
(alternatives to the usual W-La_2O_3 and W-Y_2O_3 compositions)

(1) Development of PIM materials with different chemical compositions

(2) Production / fabrication of prototype grades via PIM

(3) Adaptation of the heat-treatment process (in close cooperation with PLANSEE SE)

(4) Characterization of mechanical and physical properties (in close cooperation with OXFORD Materials)

(5) HHF testing (in close cooperation with FZ Jülich and IPP Garching) and characterization after testing

Thank you very much!