

Fracture-Mechanical and Microstructural Characterization of W- alloys

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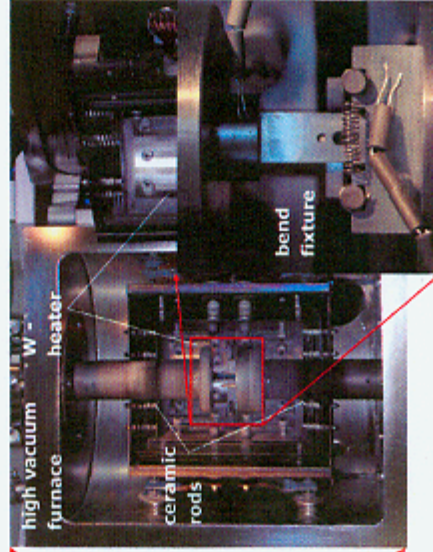
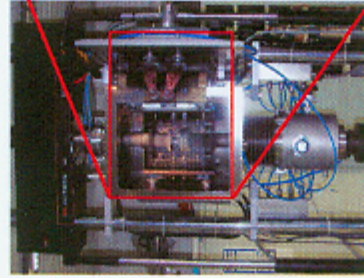
INSTITUT FÜR MATERIALFORSCHUNG II

Activity 2: Structural Materials Development
Task: Basic Fracture-Mechanical and Microstructural Characterisation of W-Ti, W-V, and W-Ta alloys
WP: WP10-MAT-WWALLOY-02-04/KIT/BS
Reporting Period: February 2010 - June 2010
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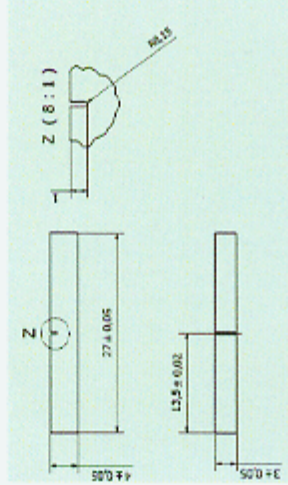
Three Point Bending Experimental Facility Universal Testing Machine INSTRON (RT-1600°C)



Objectives for Work Programme 2010

Basic fracture-mechanical characterization of the tungsten base materials at temperatures relevant for fusion applications (RT-1300°C)

- microstructure (grain size, texture etc.) dependence of fracture toughness (K_{IC})
- load rate dependence of the fracture toughness (K_{IC})



Geometry for
three point bending (3PB)
fracture mechanical tests

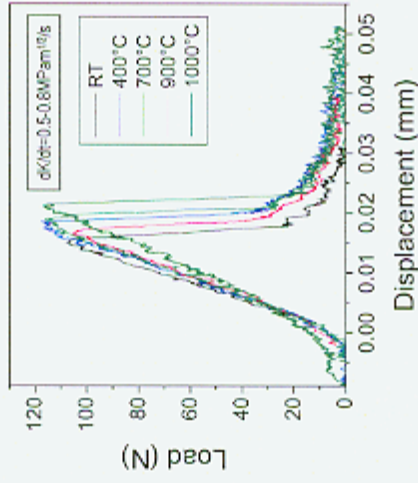
Fracture mechanical characterization of W-2%Y

- Material (N. Baluc, CRPP-EPFL)
 - W powder (99.9%); particle sizes 1-5 μm
 - Y powder (99.99%), particle sizes below 40 μm
 - W-2.0Y (in wt.%) manufactured by MA and HIPping
 - Y_2O_3 particles formation during HIPping (1320°C)
- Specimen (N. Baluc, CRPP-EPFL)
3x4x27 mm with V shaped notch (1mm)
- FM specimen preparation (KIT)
Introduction of sharp crack starter notches by means of a razor blade polishing
 - initial crack length 1040-1200 μm
 - notch final radius 20-25 μm

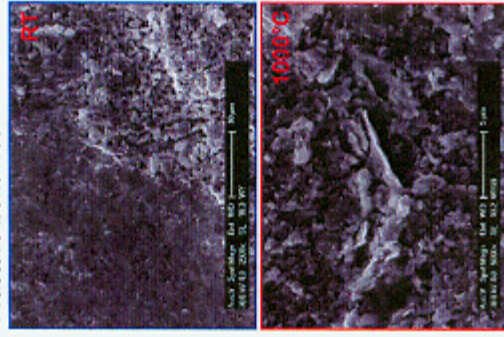


Fracture mechanical properties of W-2%Y

Fracture behaviour

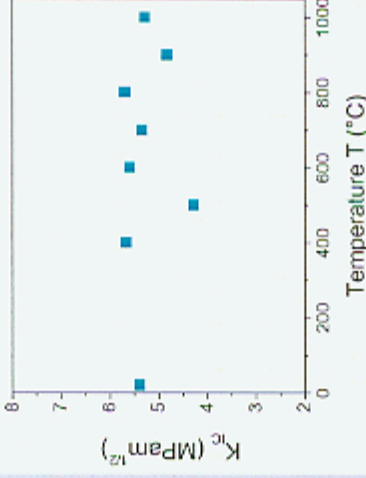


Rapid drop of the load in the elastic range
 ⇨ no indication of the ductile fracture up to 1000°C

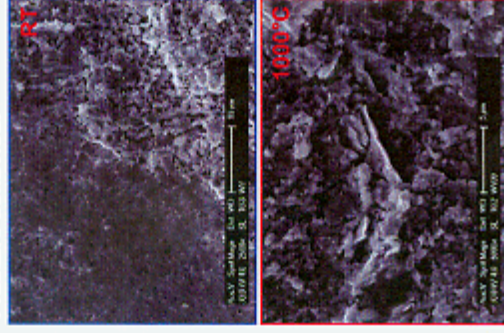


Fracture mechanical properties of W-2%Y

Fracture behaviour



Temperature independent fracture toughness up to 1000 °C

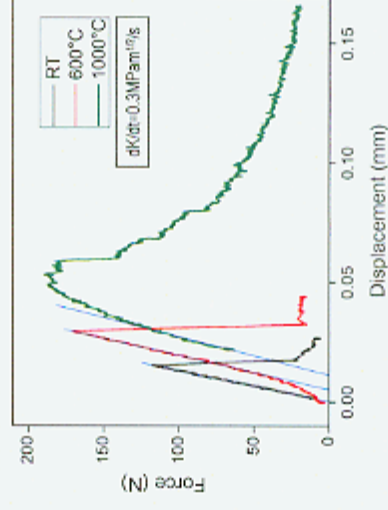


Fracture mechanical characterization of HIPped W

- Material (N. Baluc, CRPP-EPFL)
 - W powder (99.9%); particle sizes 1-5 µm
 - HIPped at 1320°C
- Specimen (N. Baluc, CRPP-EPFL)
 - specimens 3x4x27 mm with V shaped notch (1mm)
- FM specimen preparation (KIT)
 - Introduction of sharp crack starter notches by means of a razor blade polishing
 - initial crack length 1100 µm
 - notch final radius 20-25 µm

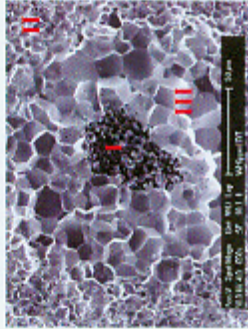
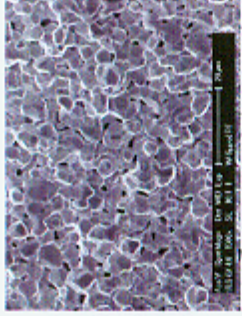
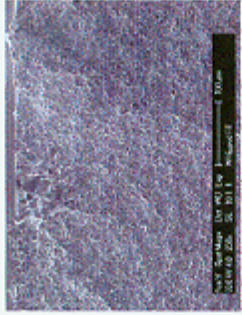
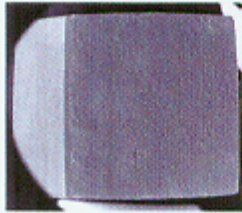


Fracture mechanical properties of Hipped W



- unstable crack propagation below 600 °C ⇨ no indication of ductile behaviour
- crack emission and arrest events at 1000 °C

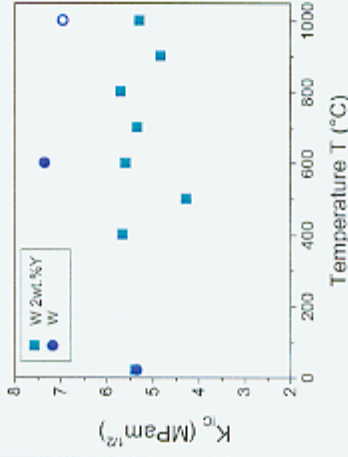
Fracture behaviour of HIPped W (RT)



- I necking between particles, open pore structure
- II neck blunting, channel closure
- III pore break down into discrete isolated pores

E. Lassner and W.-D. Schubert, Kluwer Academic / Plenum Publishers, 1999

Fracture toughness of W and W-2%Y alloys

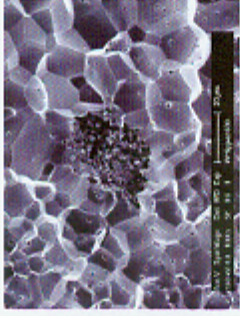
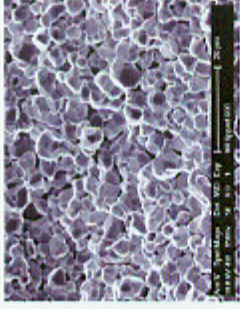
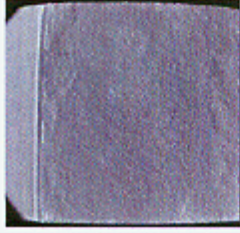


- > **MA & HIPped W-2%Y:**
low, temperature independent fracture toughness ascribed to poorly consolidated matrix; islands of higher degree of consolidation
- > **HIPped W:**
low, weakly temperature dependent fracture toughness ascribed to poorly consolidated matrix; onset of isolated grain growth

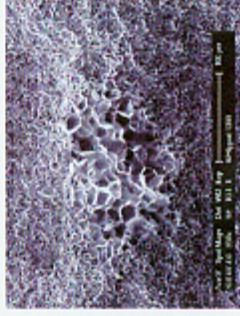
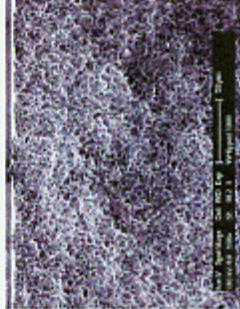
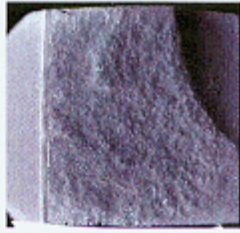
Outlook

- > Fracture-Mechanical characterization of **MA W-2%Y compacted from Plansee**

Fracture behaviour of HIPped W (600°C)



Fracture behaviour of HIPped W (1000°C)



Outlook:

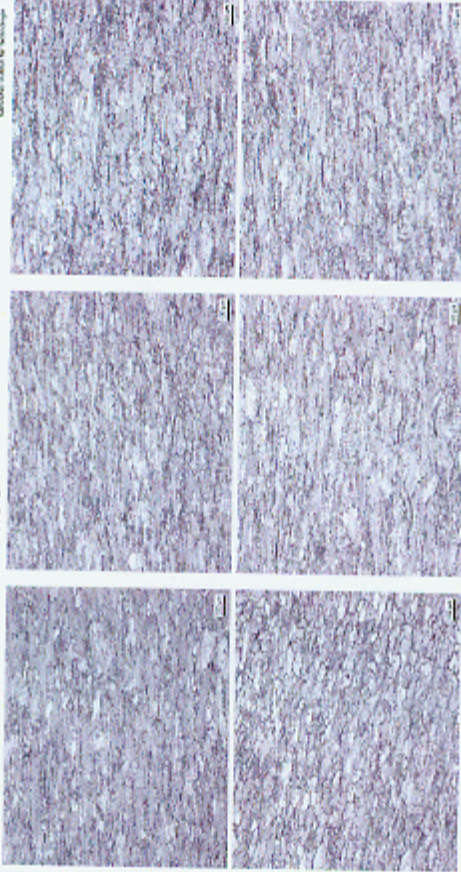
Fracture-mechanical characterization of W alloy

- **Material:**
 - tungsten (technical purity)
- **Manufacturer:**
 - Plansee
- **Manufacturing route:**
 - sintering in rods
 - forging
- **Final product form:**
 - disk



Layout for specimen extraction for microstructure investigation

Microstructure of W alloy – Plane transverse to base



- elongated grains transverse to a disc axis

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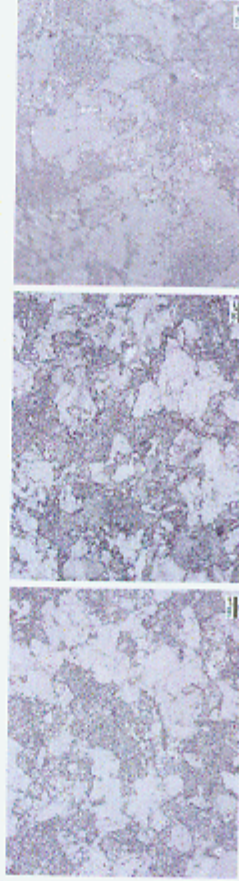
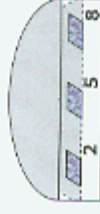
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Microstructure of W alloy – Plane parallel to base



- large area grains with no preferential orientations

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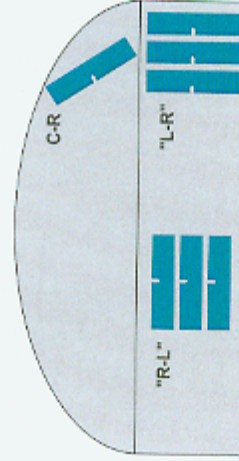
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Specimen Manufacturing



Specimen orientations for study
the influence of anisotropy on
the fracture toughness



Performed Work (February 2010 - June 2010)

- Fracture toughness investigation of Mechanically Alloyed and HIPped W alloys
- Fractography of the W-alloy specimens by SEM

Status of the whole task (level of achievements)

- Fracture mechanical and microstructural characterisation of W-alloys developed and provided within EFDA WP2010

Work planned for the next period

- Continuation of the fracture mechanical characterization of the novel tungsten alloys; The study of the influence of anisotropic microstructure and load rate on the fracture behaviour
- Equipping of the high vacuum furnace with an optical system for in-situ observation of crack initiation and growth

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Work planned for WP 2011



Fracture mechanical and microstructural characterization of novel tungsten alloys

- Investigation of upper shelf fracture toughness of tungsten alloys by using J-Integral and/or COD methods