Karlsruhe Institute of Technology

Ductilisation of tungsten through cold rolling:
Change of brittle to ductile transition temperature in high deformed tungsten

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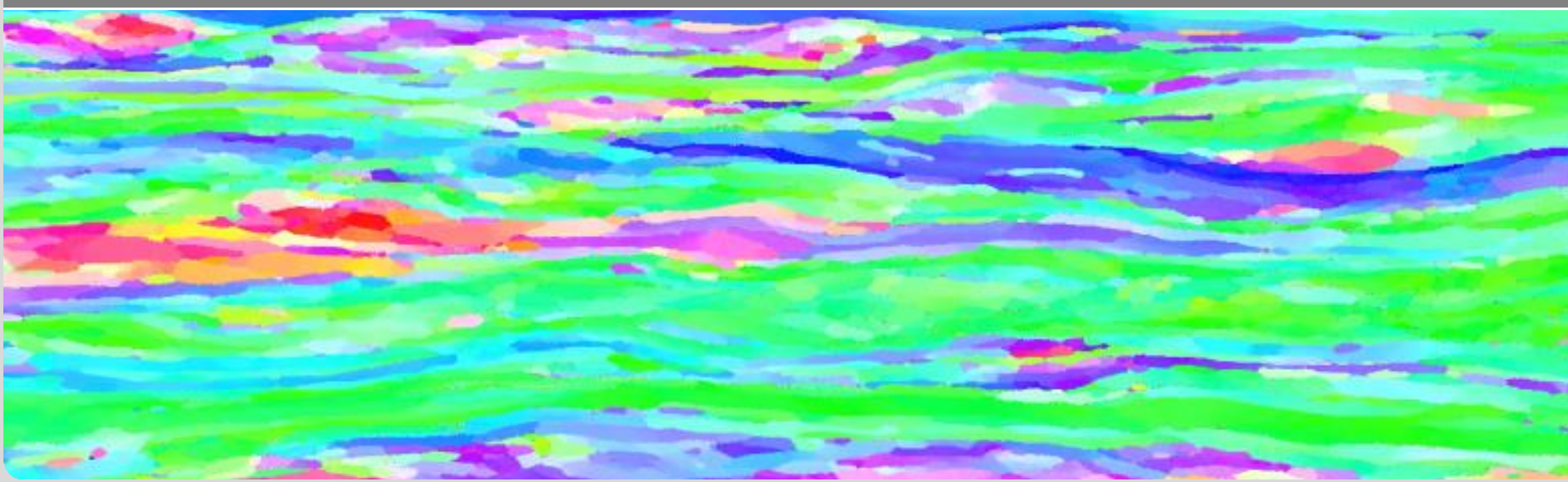
IAM-AWP, HIGH TEMPERATURE MATERIALS
MSE 2016, DARMSTADT 29.09.2016

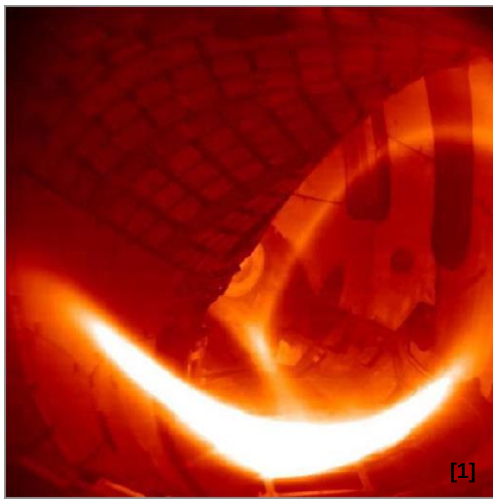


Outline

- The BDT of tungsten
- Material
- Microstructure
  - Inverse pole figure maps
  - Orientation distribution function maps
  - Grain size distribution
  - Grain boundary character
- K-testing
  - Influence of specimen geometry
  - Influence of microstructure
- Summary

The BDT of tungsten

- Highest melting temperature 3422 °C
- High heat conductivity, temperature strength and low thermal expansion coefficient
- Tungsten (W) - perfect material for high temperature applications

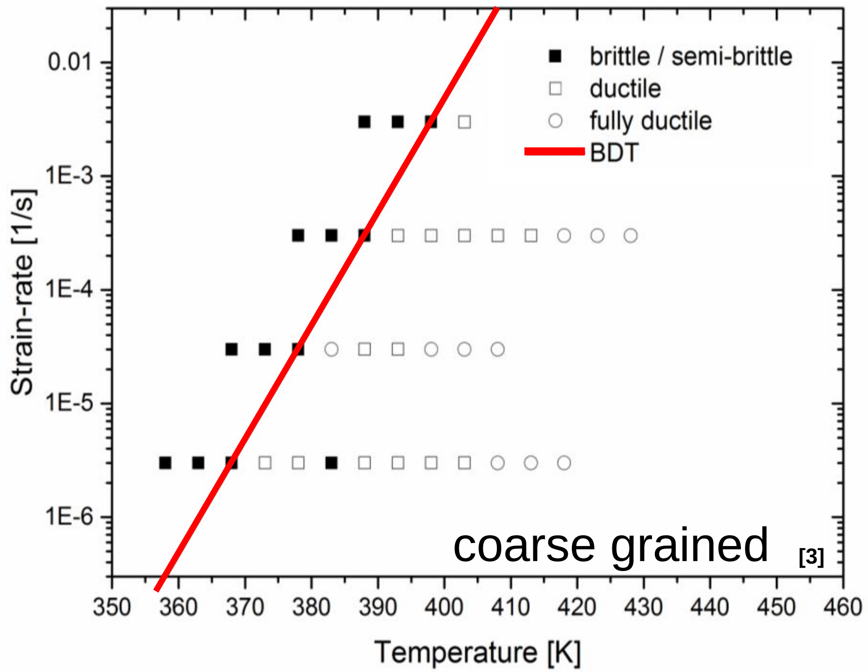


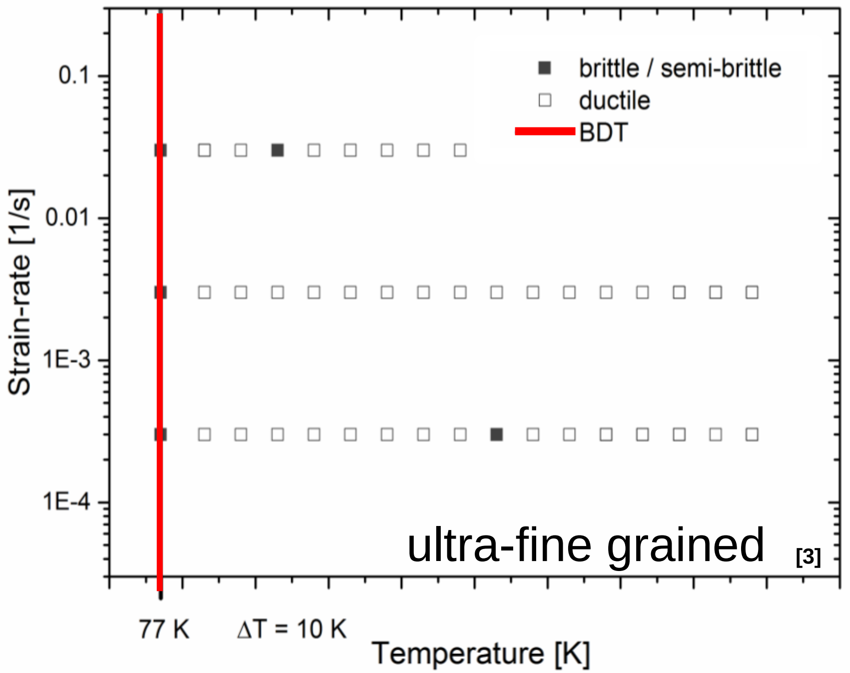
- Brittle fracture at ambient temperature
- Not in use as structural material, only applied as functional material nowadays

[1] Wendelstein X7 Newsletter
[2] Jülich solar tower; http://www.dlr.de/sf/en/desktopdefault.aspx/tabid-8560/

The BDT of tungsten

- UFG microstructure shifts BDTT and affects strain rate sensitivity of BDT
- Change of screw dislocation controlled transition to new mechanism





- Goal: Identification of BDT controlling mechanism in UFG W
- Methods: Indirectly by K-tests; directly via electron microscopy

[3] Németh, A. et al.: The nature of the brittle-to-ductile transition of ultra fine grained tungsten (W) foil

Material

- Five W sheets produced exclusively at PLANSEE SE; Reutte, Austria
- Material made of same sintered compact for similar chemical composition
- Five sheets causing five microstructures and five sheet thicknesses

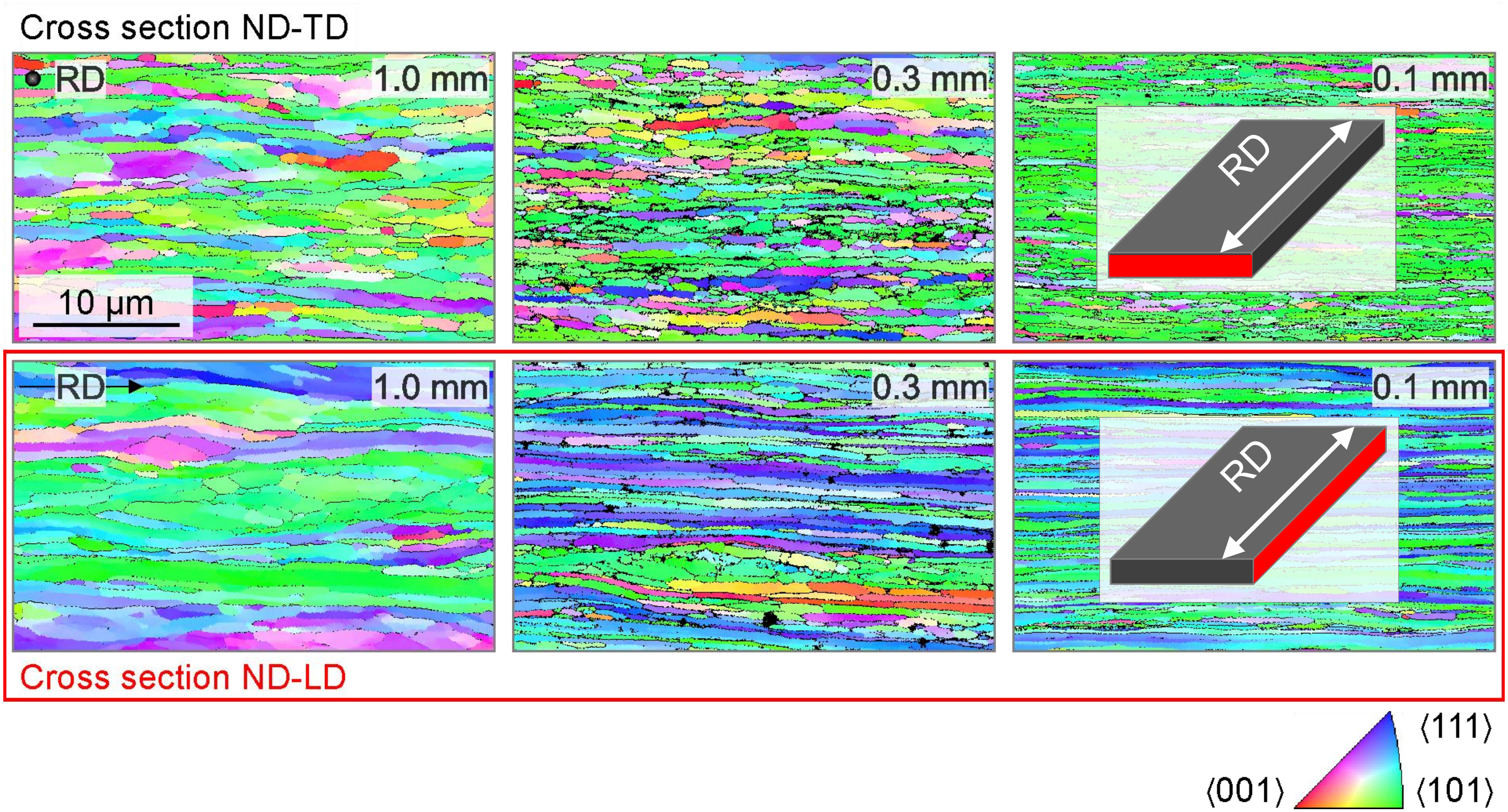
- Processing through hot and cold rolling
- Rolling consequently unidirectional

Sheet thickness s /mm	1.0	0.5	0.3	0.2	0.1
Degree of cold work φ /-	1.8	2.5	3.0	3.4	4.1

- Extremely high degree of deformation through cold-rolling

- No further heat treatment after rolling applied

Microstructure: Inverse pole figure maps



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- Goal: Identification of mechanism causing BDTT in UFG tungsten
- Five cold rolled sheets, five microstructures made of same sintered compact

- HAGBs density growth, amount of LAGBs is reduced

- BDTT is less dependent of sheet thickness and is shifted significantly to -100 °C for the 0.1 mm UFG W
- Tremendous BDTT shift of about 500 K downwards

- Further BDTTs at other loading rates needed to calculate activation energy of BDT and identify the mechanism behind

Thank you for your attention

The author is grateful to:

PLANSEE SE,
University of Oxford,
Erich Schmid Institute of Materials Science,
DFG RE3551/4-1