

Wolfram-Laminatrohre als Strukturkomponente für innovative Hochtemperaturenergiekonversionssysteme

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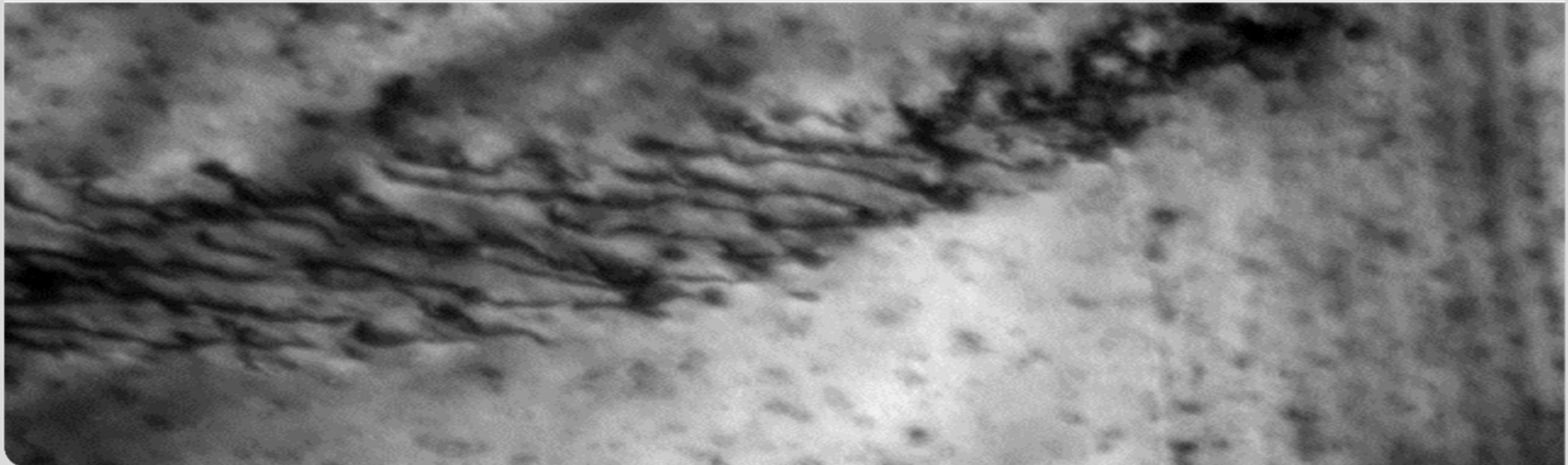
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4) University of Oxford, Oxford, United Kingdom

14.09.15, Werkstoffwoche, Symposium Z2

INSTITUTE FOR APPLIED MATERIALS, APPLIED MATERIALS PHYSICS



Contents

- Introduction
- W plates and foils
- W foil laminates
- W foil laminate pipes

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- **Introduction**
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What is the problem?

- Tungsten (W), $T_s = 3422^\circ\text{C}$, \rightarrow How to make tungsten ductile?

Advanced high-temperature structural materials for

- nuclear fusion,
- concentrated solar power (liquid metal technology), and
- synthesis of biomass-to-liquid fuels (gas cleaning processes).



Wendelstein 7-X, Greifswald, Germany (C. Lünig)



Abengoa Solar

Ductilisation of tungsten (W)

■ Definition

- Decrease of the BDT temperature
- Increase of $K_{I,Q}$, (R-curve behaviour)
- Tensile test: increase of elongation at break

■ Approaches

- Modification of the microstructure through cold-rolling
- Synthesis of a W-laminate (multi-layer material)

■ Discussion

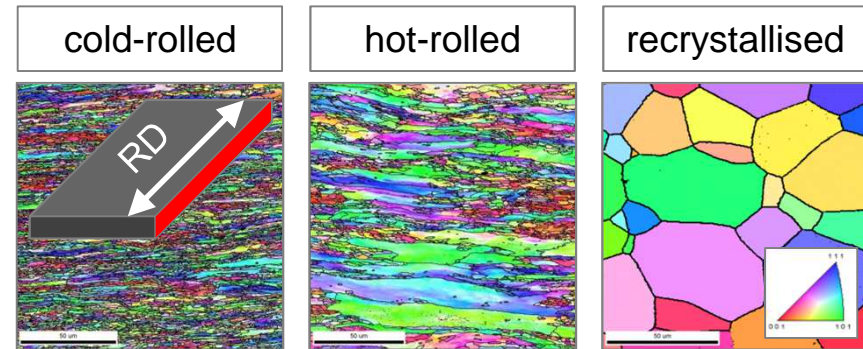
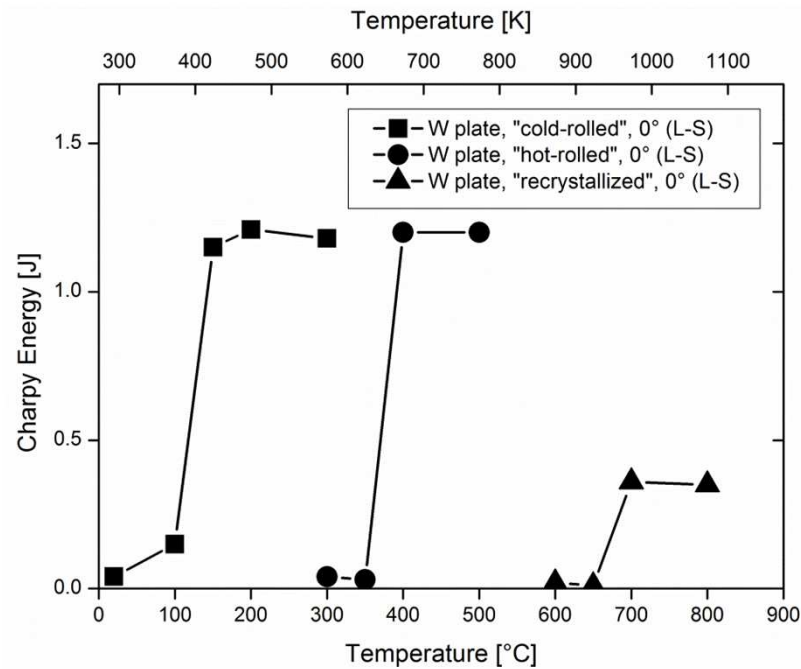
- Dislocations
- Texture
- Microcracking and crack bridging
- Impurities and sinter pores
- Size effects

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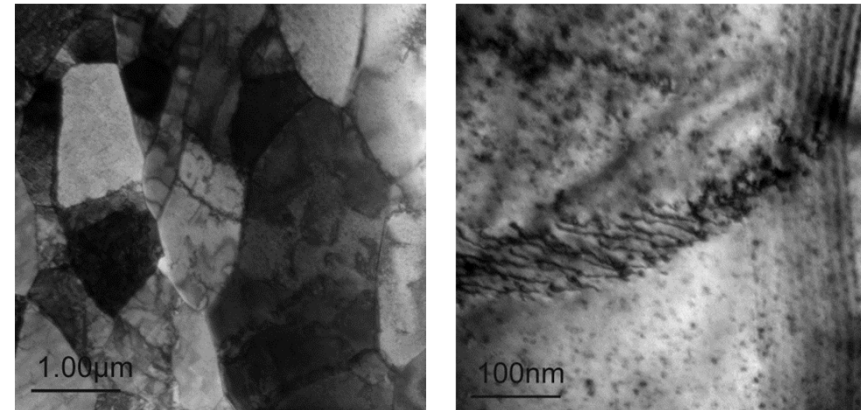
- Introduction
- **W plates and foils**
 - **BDT**
 - **K_{IQ} , R-curve**
 - **Tensile behaviour**
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W plates and foils: BDT

- The BDT temperature decreases through cold-rolling. Why?



$$T_{BDT} = T_0 - k_{BDT} * d_s^{-0.5}$$



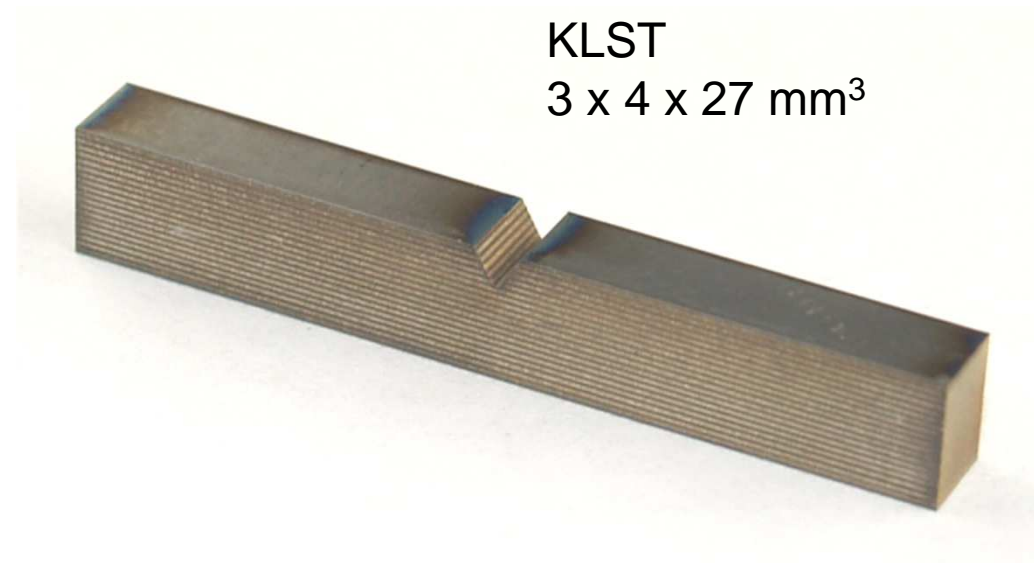
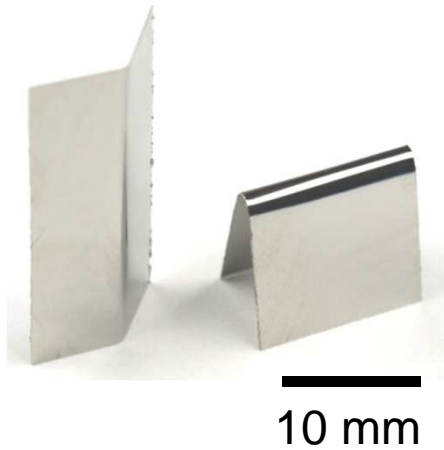
- BDT of UFG W foil: at 77 K

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- **W foil laminates**
 - **Charpy impact properties**
 - **Ageing**
- W foil laminate pipes

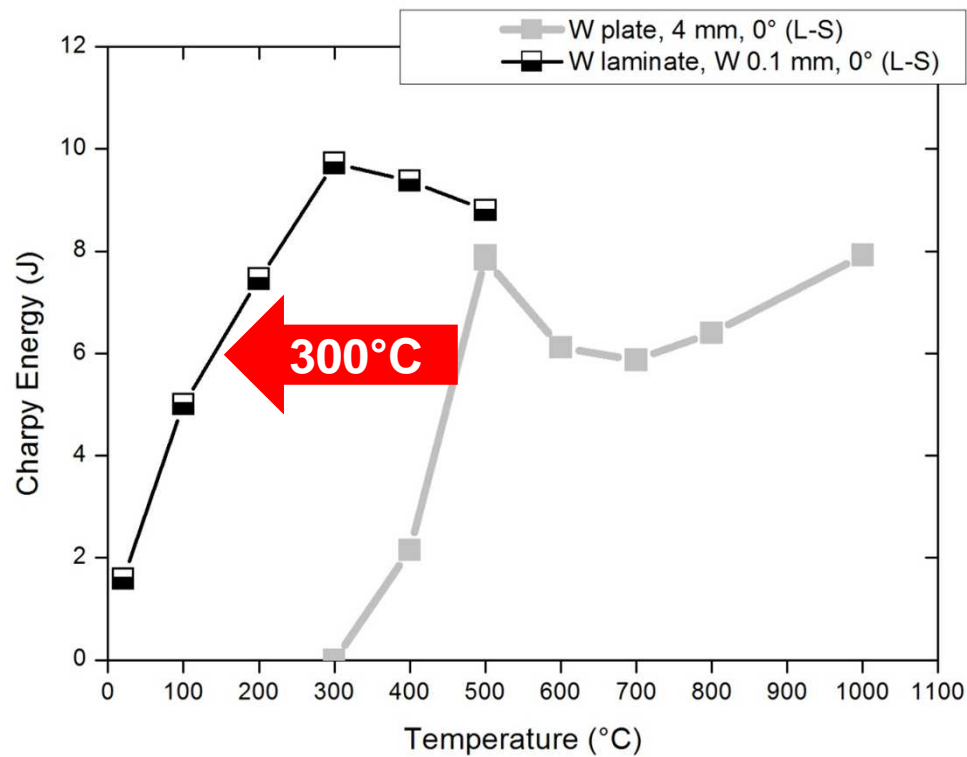
W foil laminates: Charpy properties

- Motivation: bulk material that retains the ductility and toughness of the foils.



W foil laminates: Charpy properties

- Motivation: bulk material that retains the ductility and toughness of the foils.
 - As produced: improvement of 300 K



Ductilisation of tungsten (W)

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■ Approaches

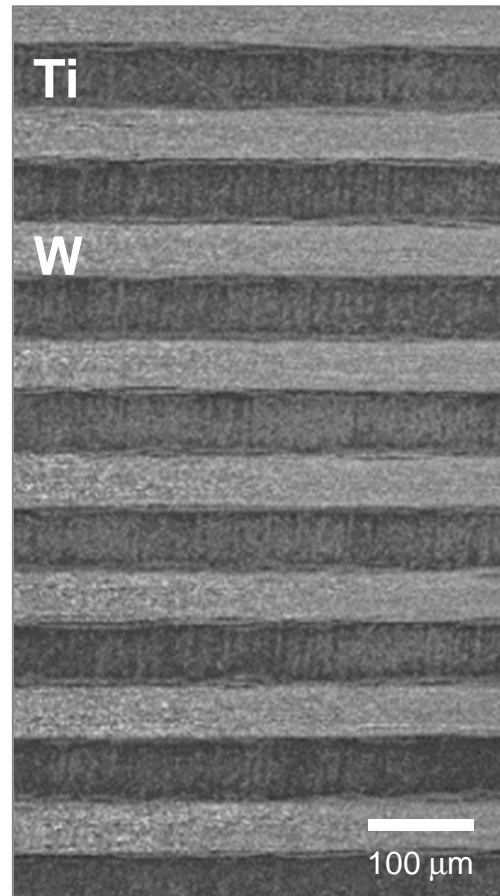
- Modification of the microstructure through cold-rolling
- **Synthesis of a W-laminate (multi-layer material)**

■ Discussion

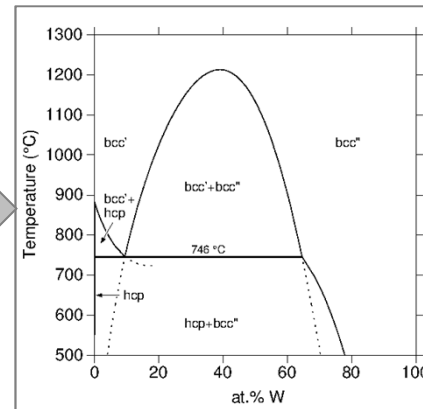
- Dislocations
- Texture
- Microcracking and crack bridging
- Impurities and sinter pores
- Size effects
- **Creation of surface**
- **Diffusion**
- **Dislocation interface interaction**
- **Residual stresses**
- **Stress redistribution (deviatoric → volumetric)**
- ...

W foil laminates: Ageing

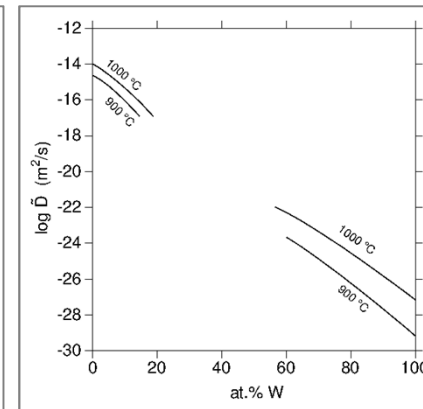
- How do the Charpy impact properties change through annealing?



simulation



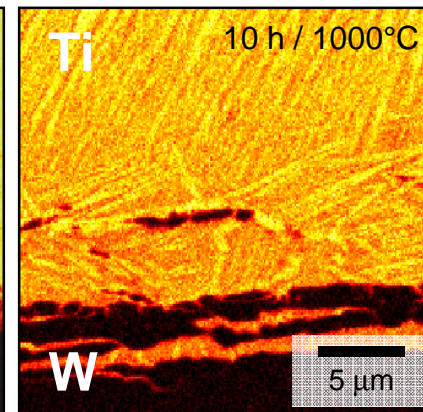
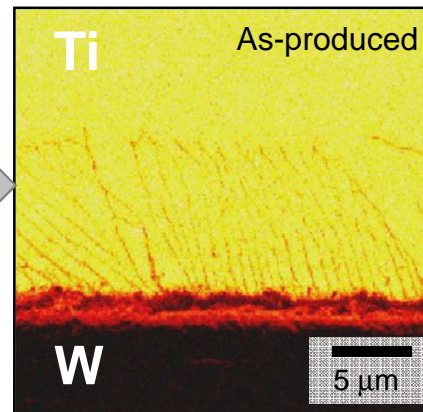
thermodynamics



kinetics

P. Franke (KIT)

analyses



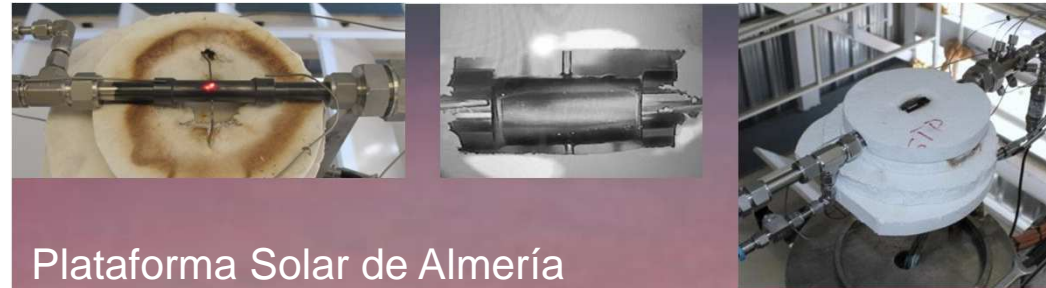
T. Weingärtner (KIT)

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 - Ageing
- **W foil laminate pipes**
 - **Mechanical properties (Charpy, burst)**
 - **HHF tests (Almeria, IPP)**
 - **1000 mm pipe**

W foil laminate pipes

- Characterised by
 - Charpy tests
 - Burst test
 - HHF tests



Plataforma Solar de Almería

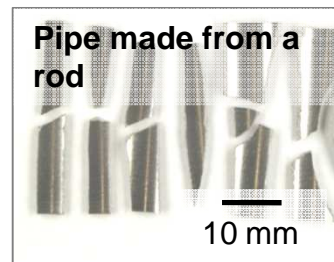


Austenitic steel W pipe made of W foil

Burst test, RT, 1000 bar (in cooperation with PLANSEE SE, T. Huber, A. Zabernig)

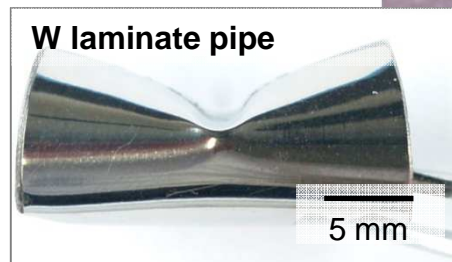


Charpy impact test at 300°C



Pipe made from a rod

10 mm



W laminate pipe

5 mm



GLADIS, IPP, Garching

H. Greuner, IPP

Thank you for your attention

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EUROfusion

