Karlsruhe Institute of Technology

PLANSEE

FRACTURE BEHAVIOUR OF TUNGSTEN MATERIALS

DEPENDING ON MICROSTRUCTURE AND SURFACE FABRICATION

Forschungszentrum Karlsruhe
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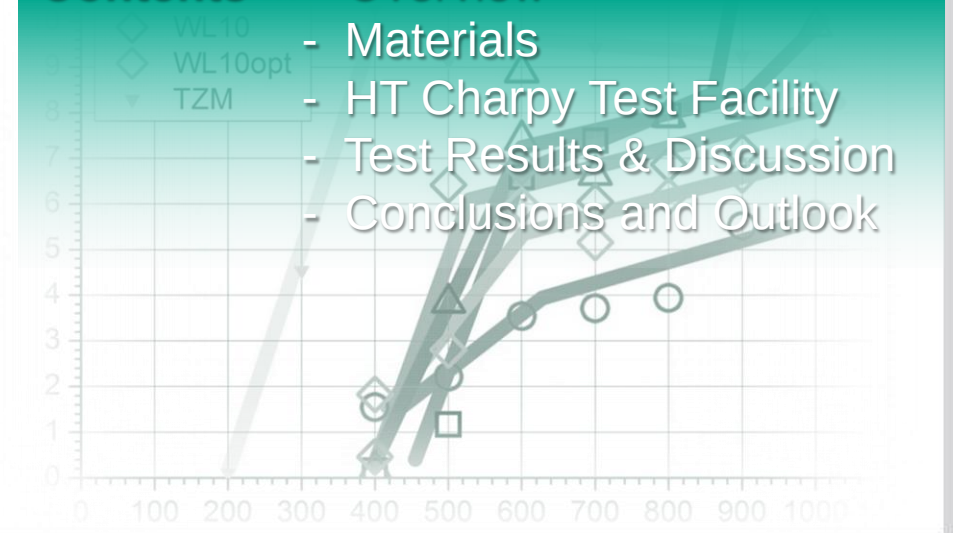
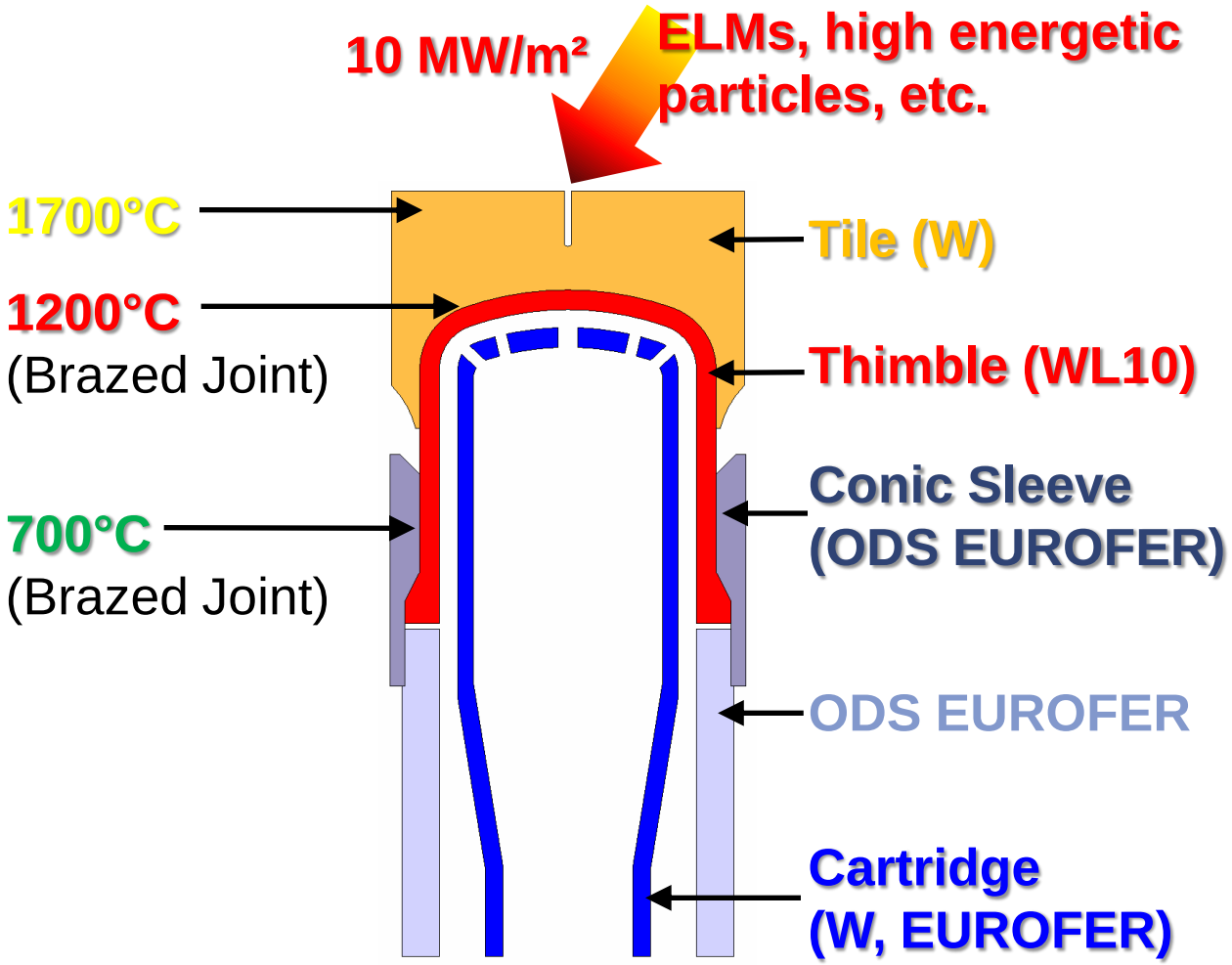
Michael Rieth & Andreas Hoffmann

Contents



Thanks for contributions and discussions to:
C. Bichler, B. Dafferner, C. Grubich, S. Heger, U. Jäntsch, M. Klimenkov, W. Krauss, P. Norajitra, J. Reiser, W. Schulmeyer, H. Zimmermann

Overview, DEMO Divertor Design



→ J. Reiser, P. Norajitra, this conference

Motivation, Testing Method

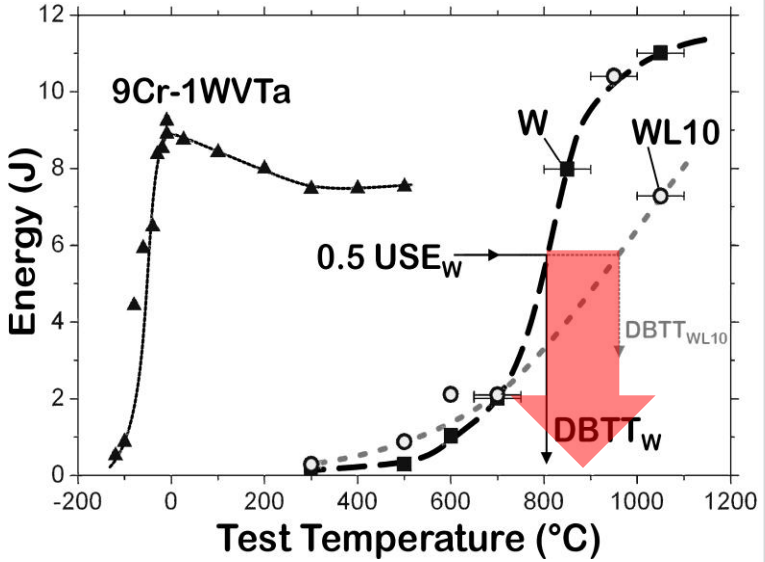
Fracturing

- thermal load
- mechanical load ⟸
- manufacturing ⟸
- maintenance events

→ P. Norajitra, W. Krauss, et al.

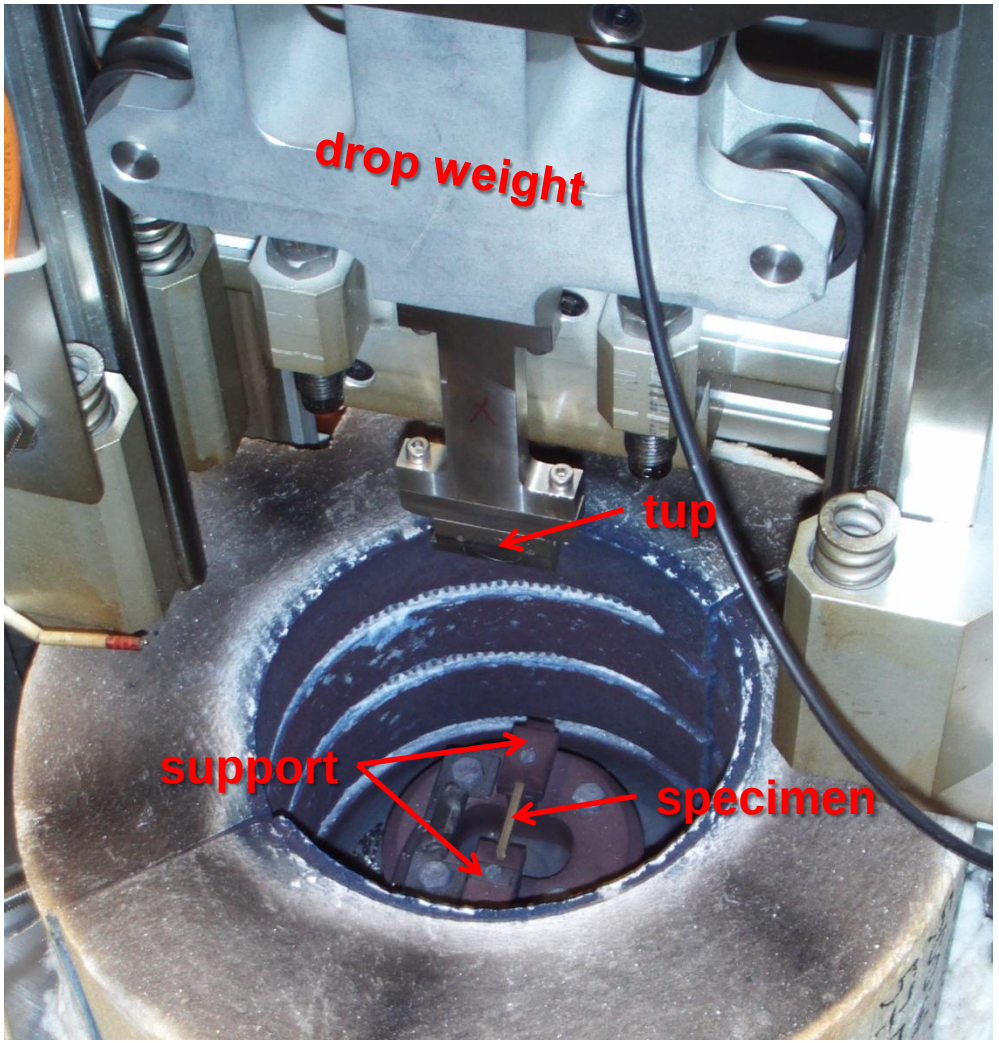
Charpy Test

- DIN EU ISO 148-1, …
- 3 mm x 4 mm x 27 mm
- notch depth 1mm
- span 22 mm



→ M. Rieth, B. Dafferner, JNM

High Temperature Charpy Tests

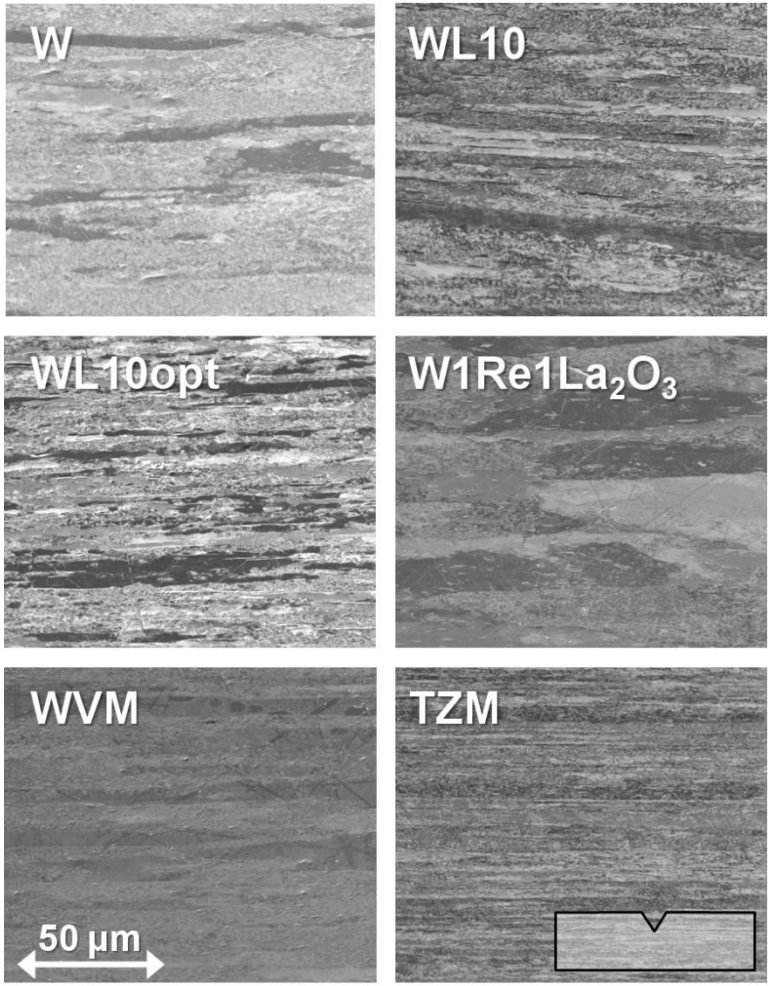


drop weight design, vacuum vessel

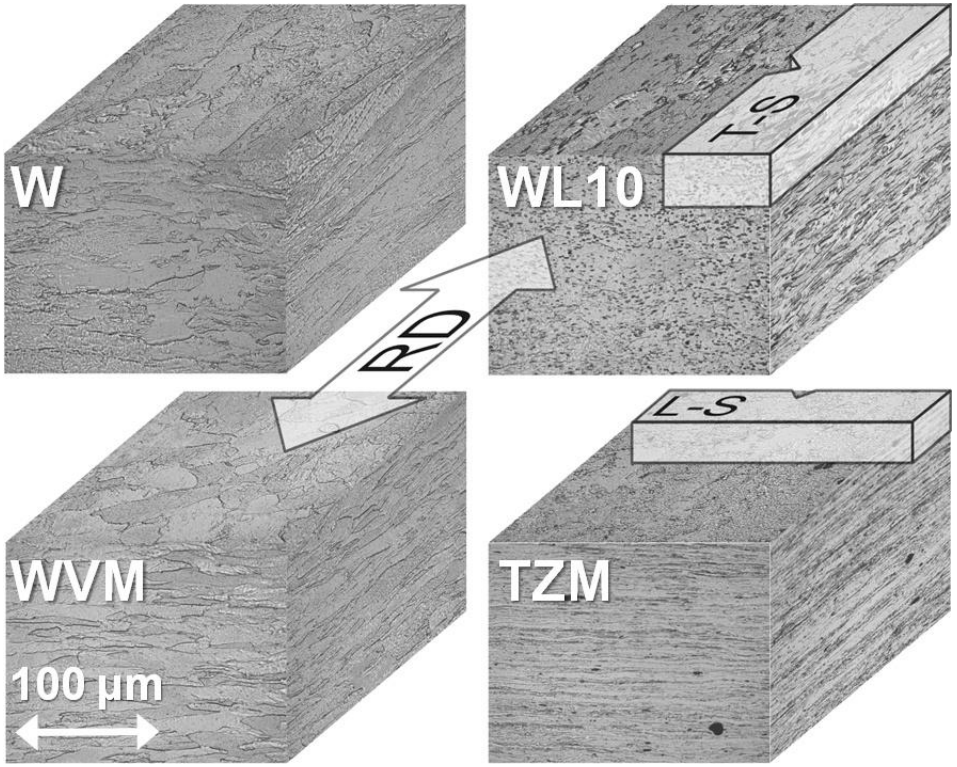
opened furnace: view on support

Materials, Rolling Texture

6 RODS

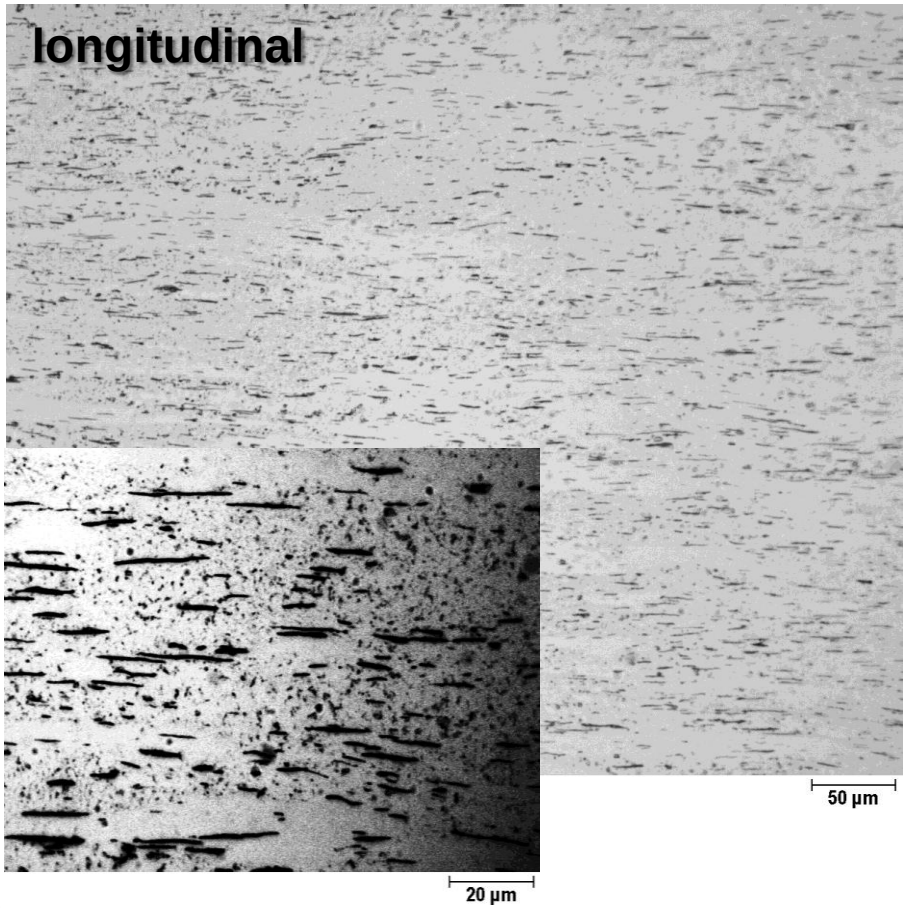


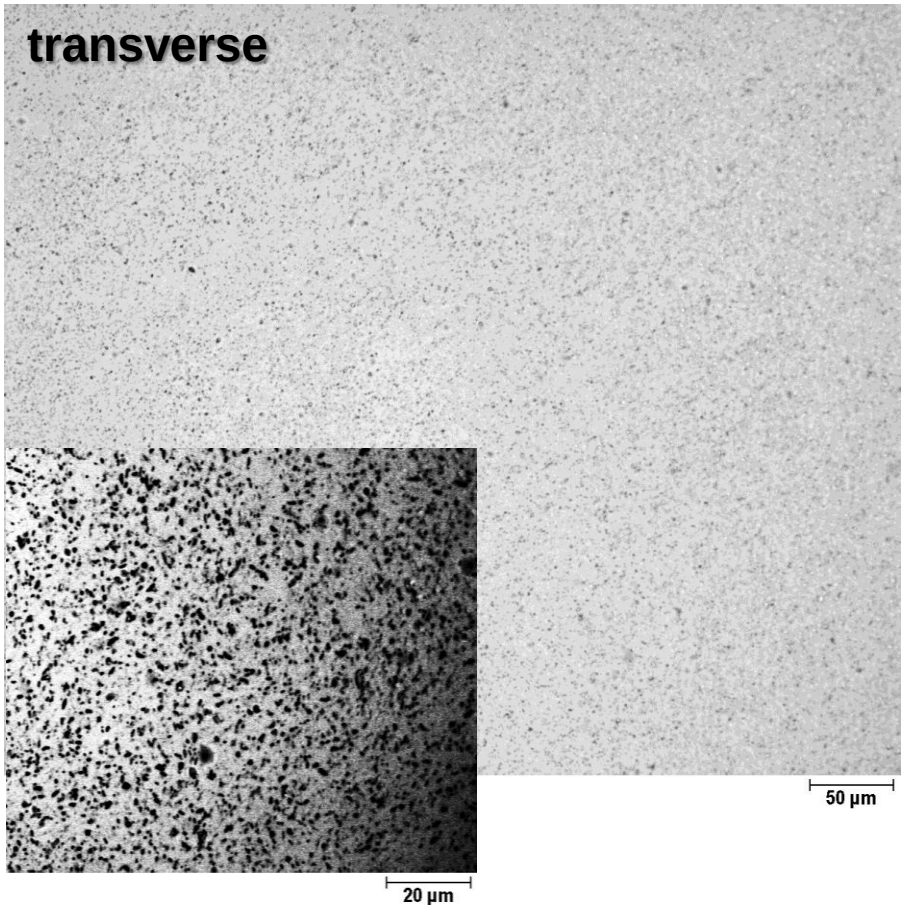
4 PLATES



Microstructure

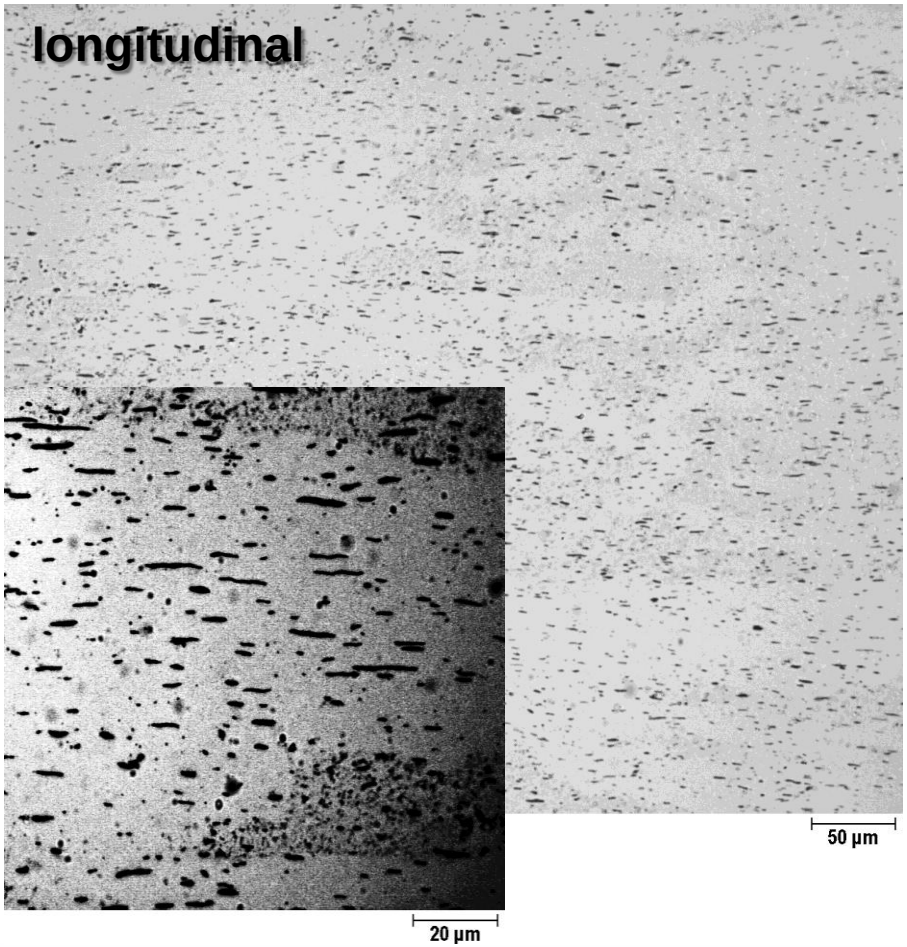
WL10 Rod, Ø7 mm

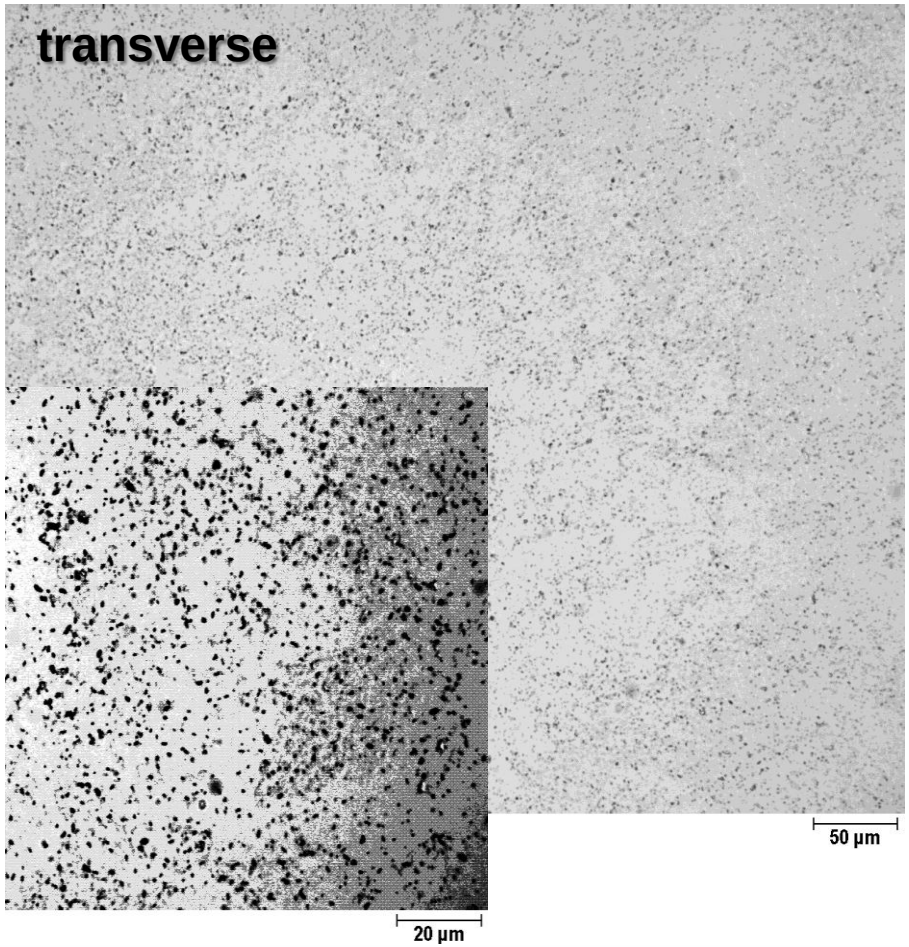




Microstructure

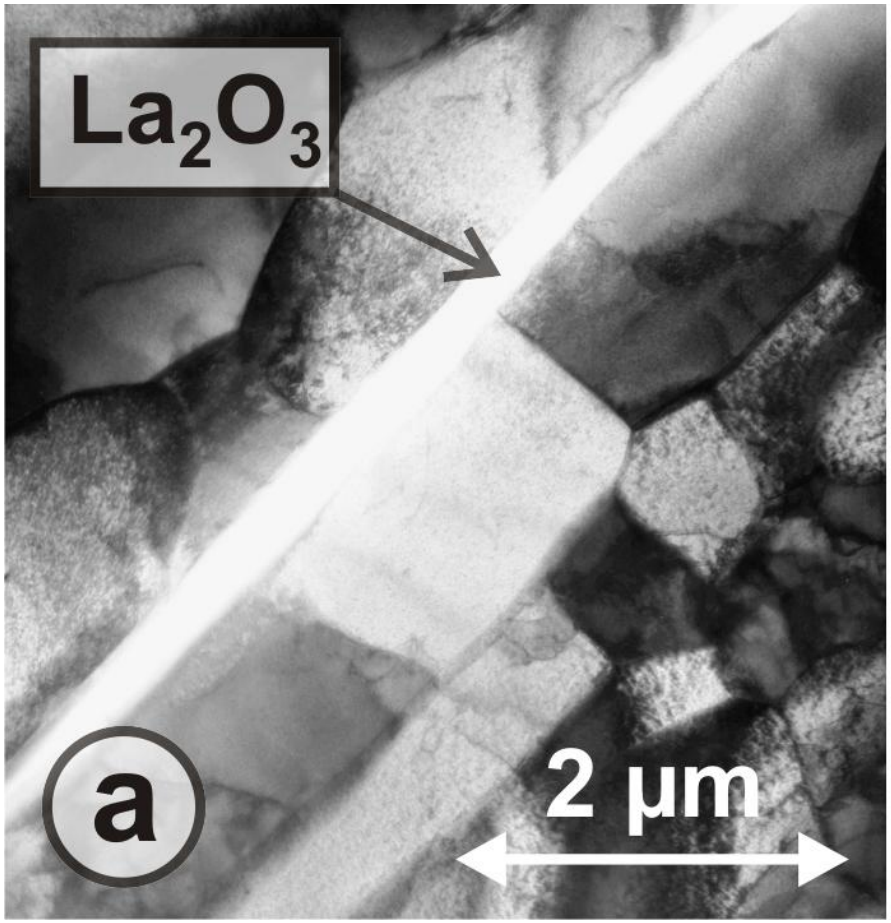
W-1%Re-1%La_2O_3 Rod, Ø10 mm



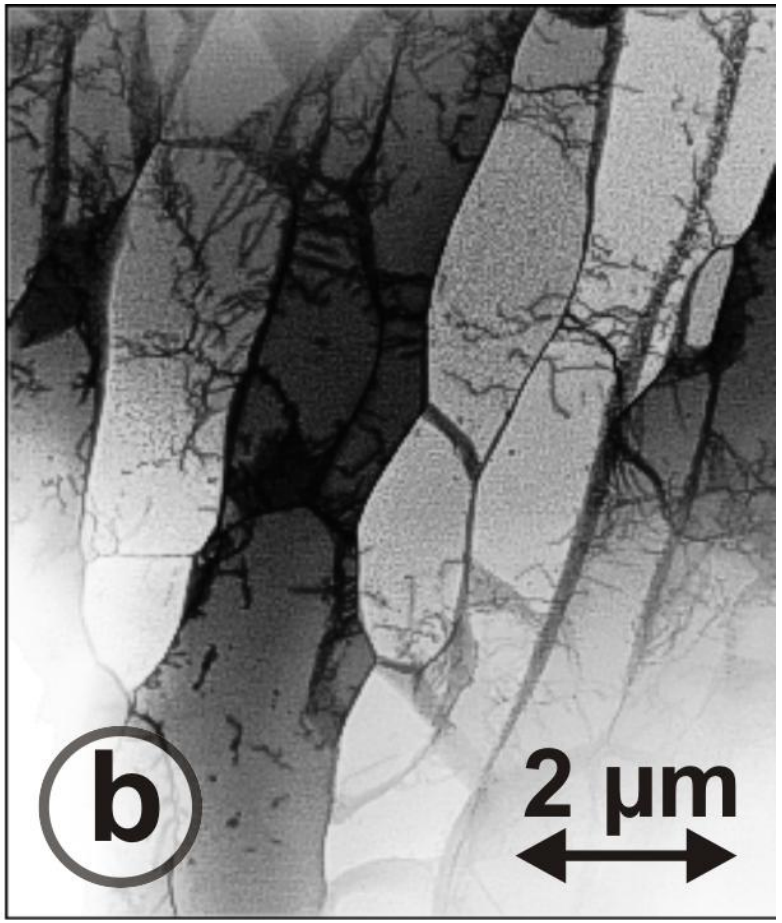


TEM Analysis

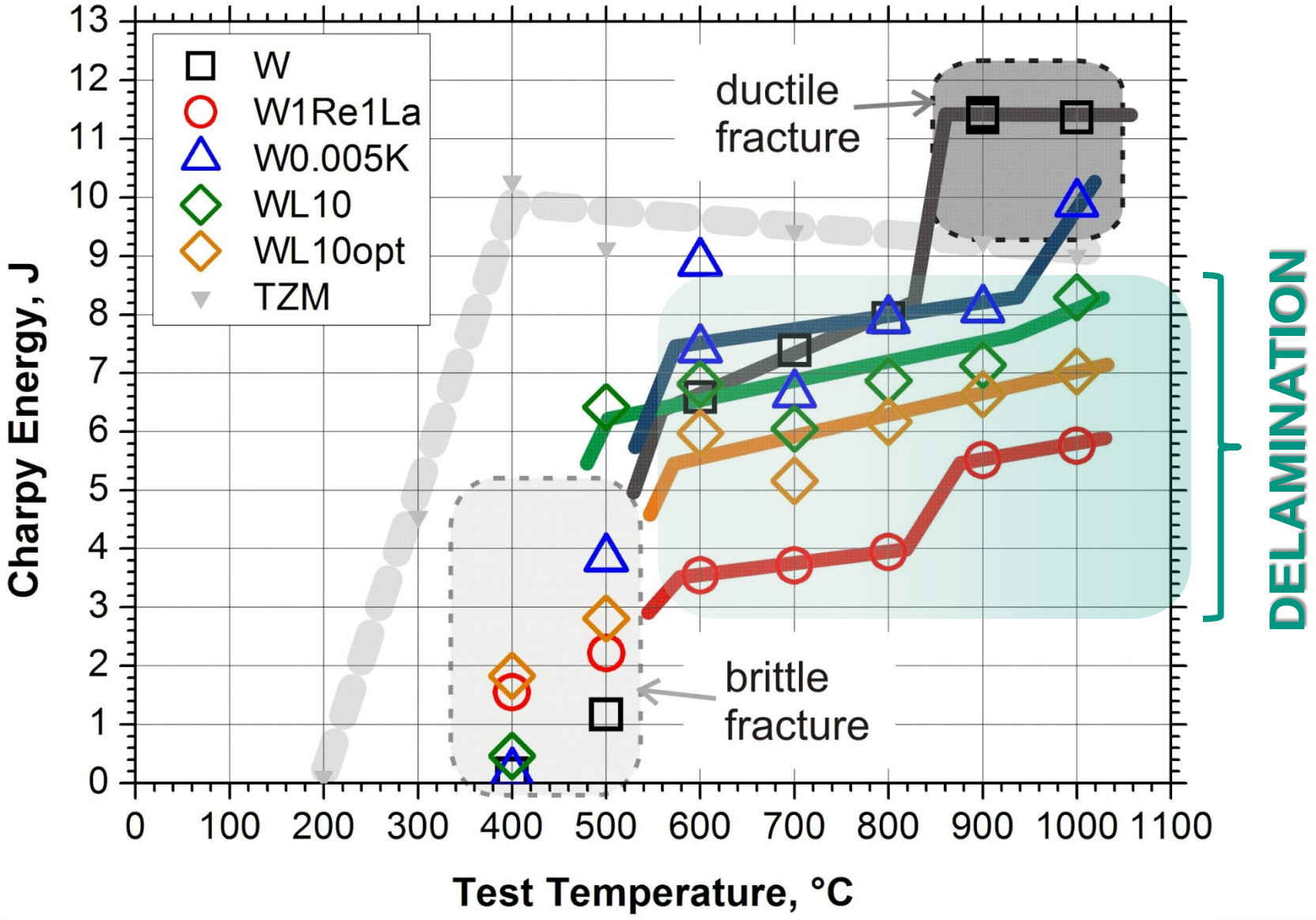
WL10 Rod, Ø7 mm



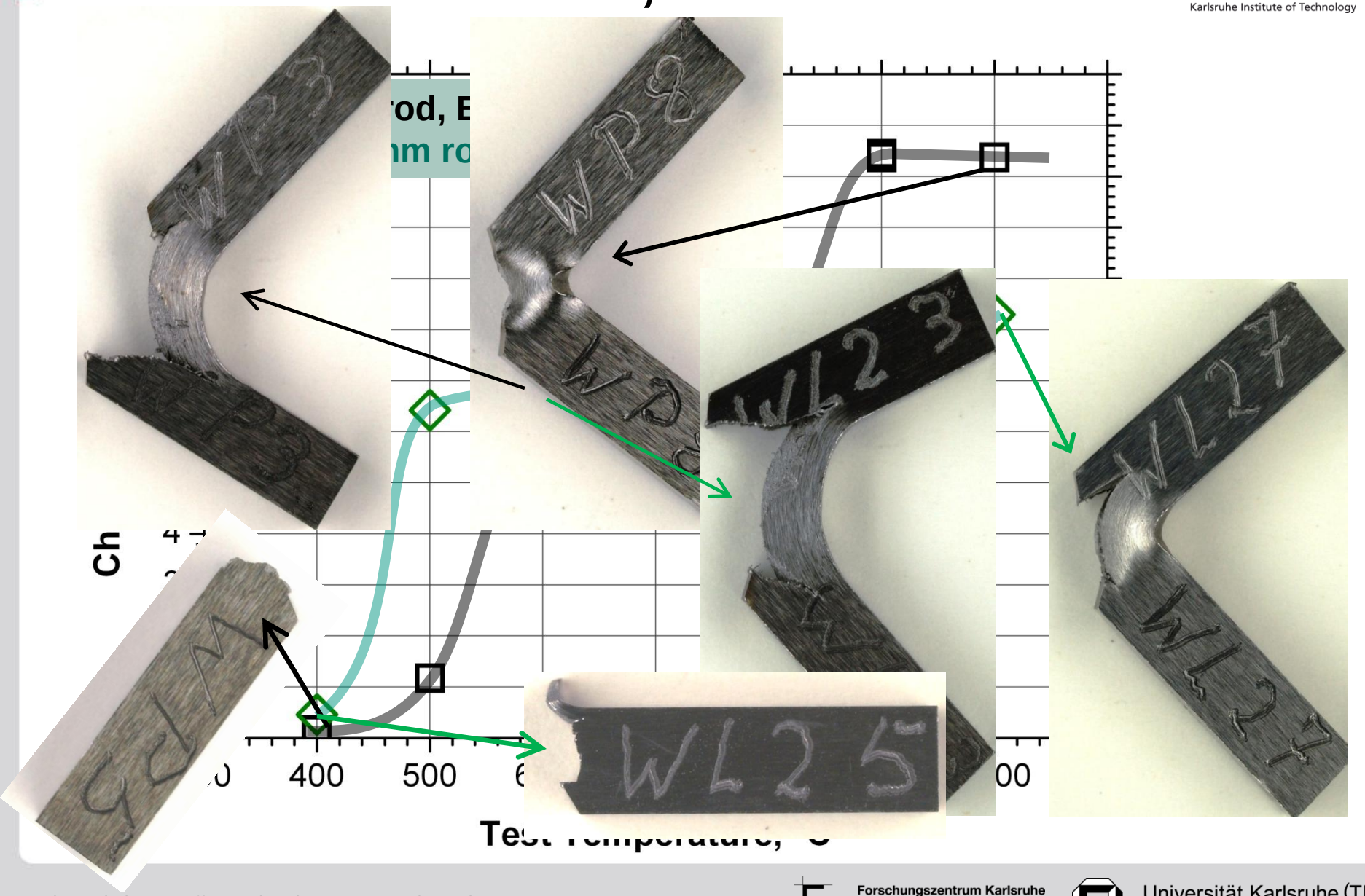
W Rod, Ø7 mm



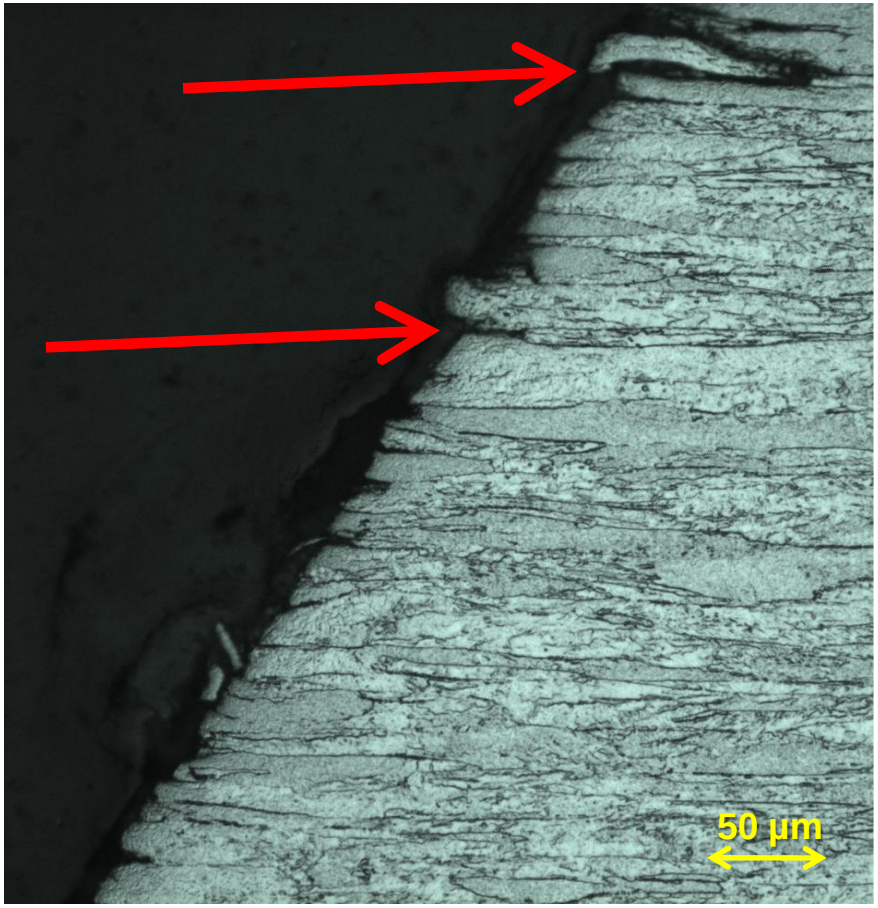
Results, Rod Materials



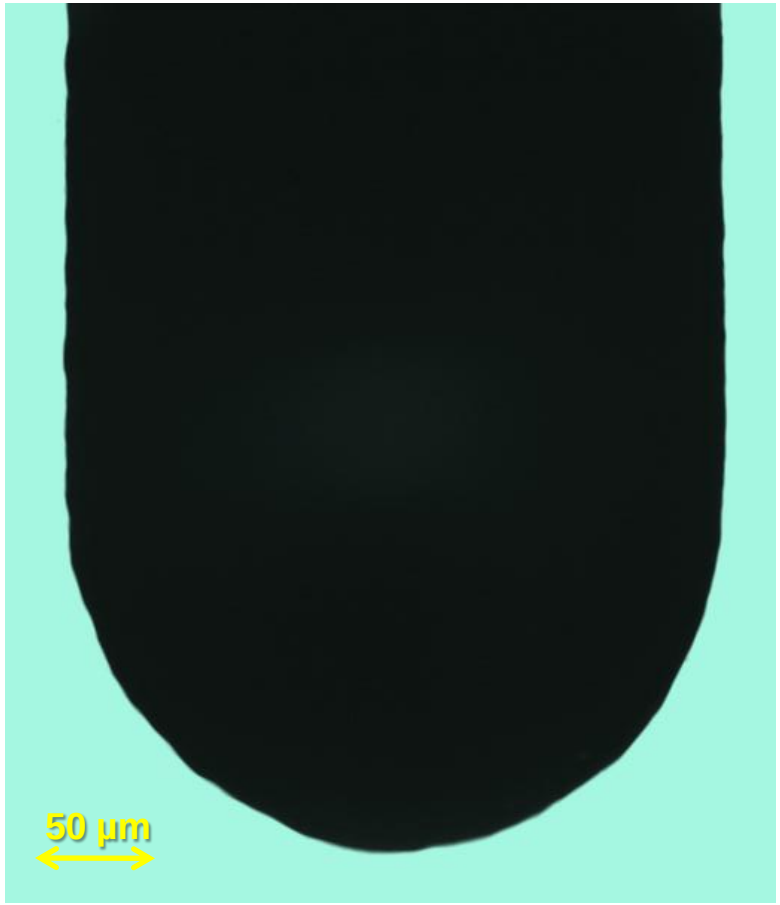
Fracture: W & WL10, 7 mm rods



Surface Fabrication

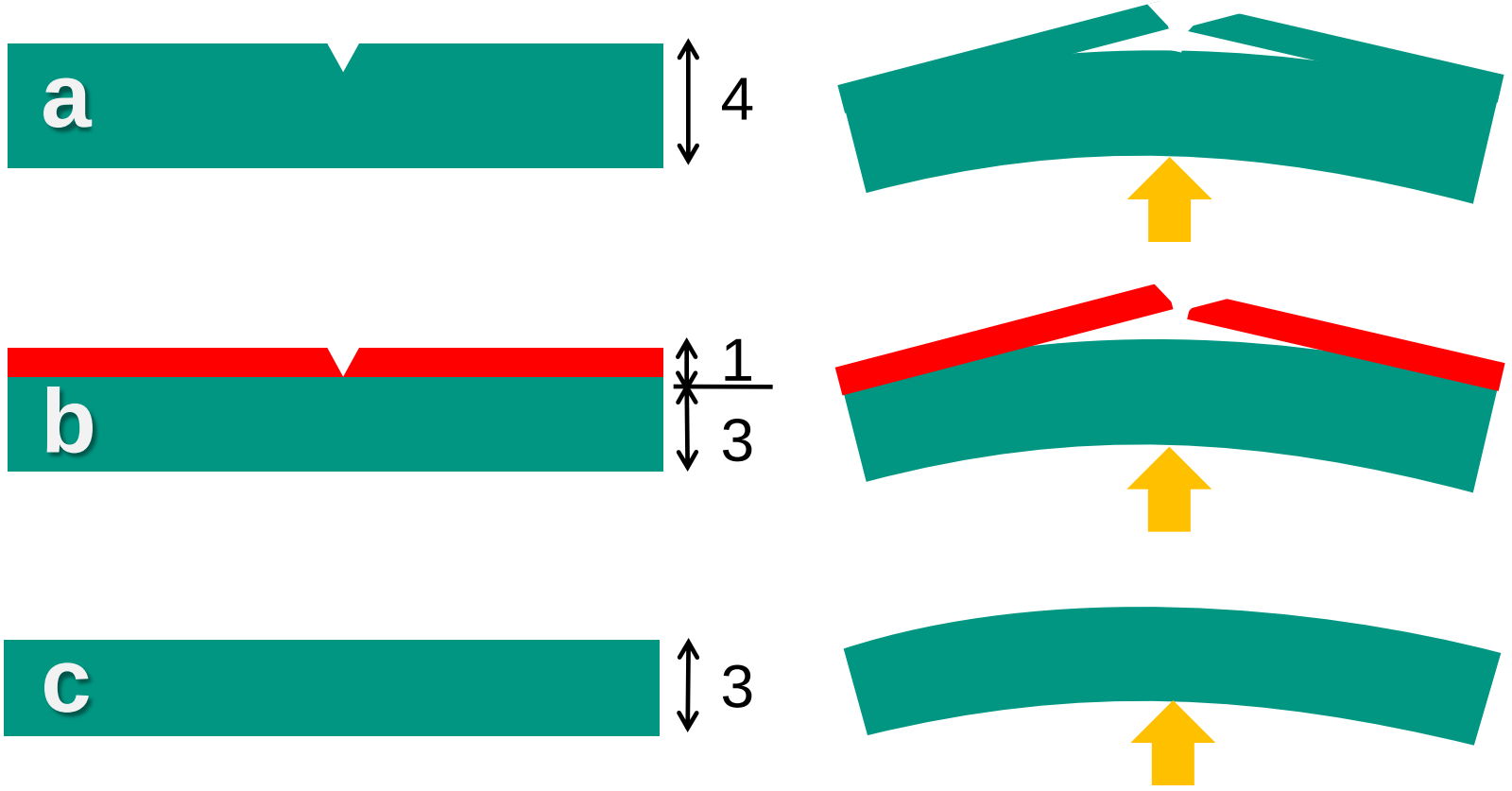


W Rod, EDM

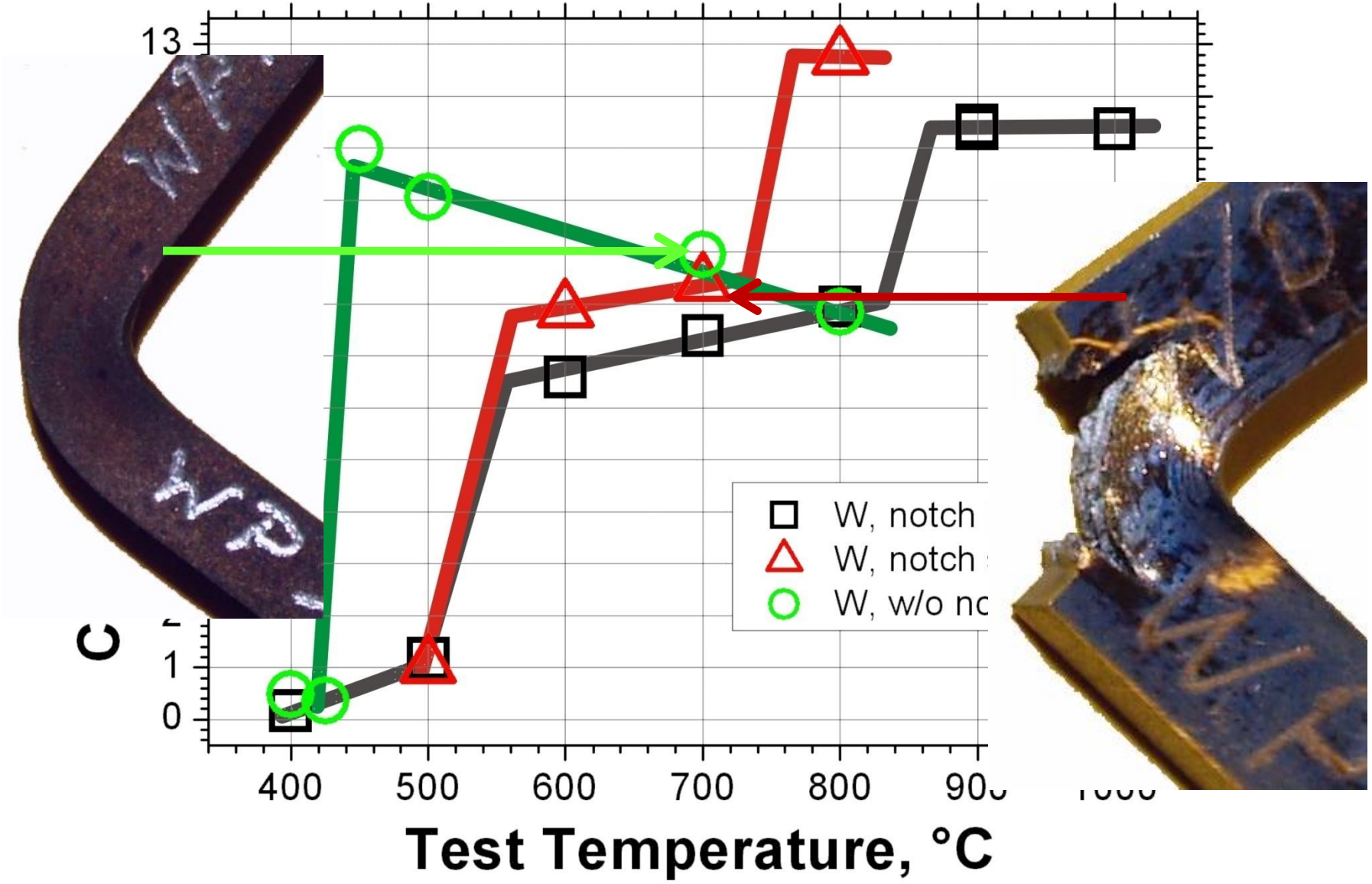


W Rod, Diamond Saw

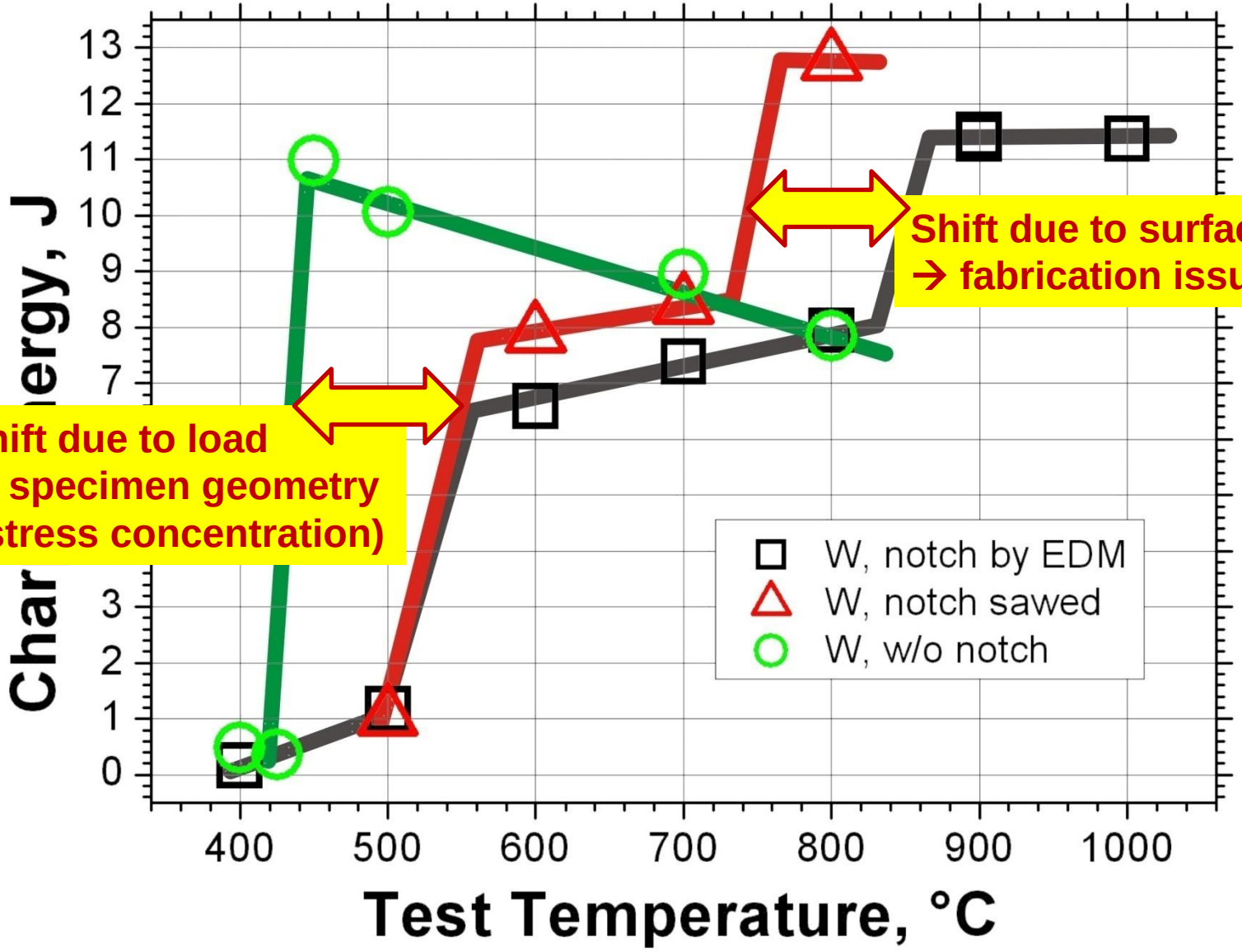
Delamination, Simple Analogy



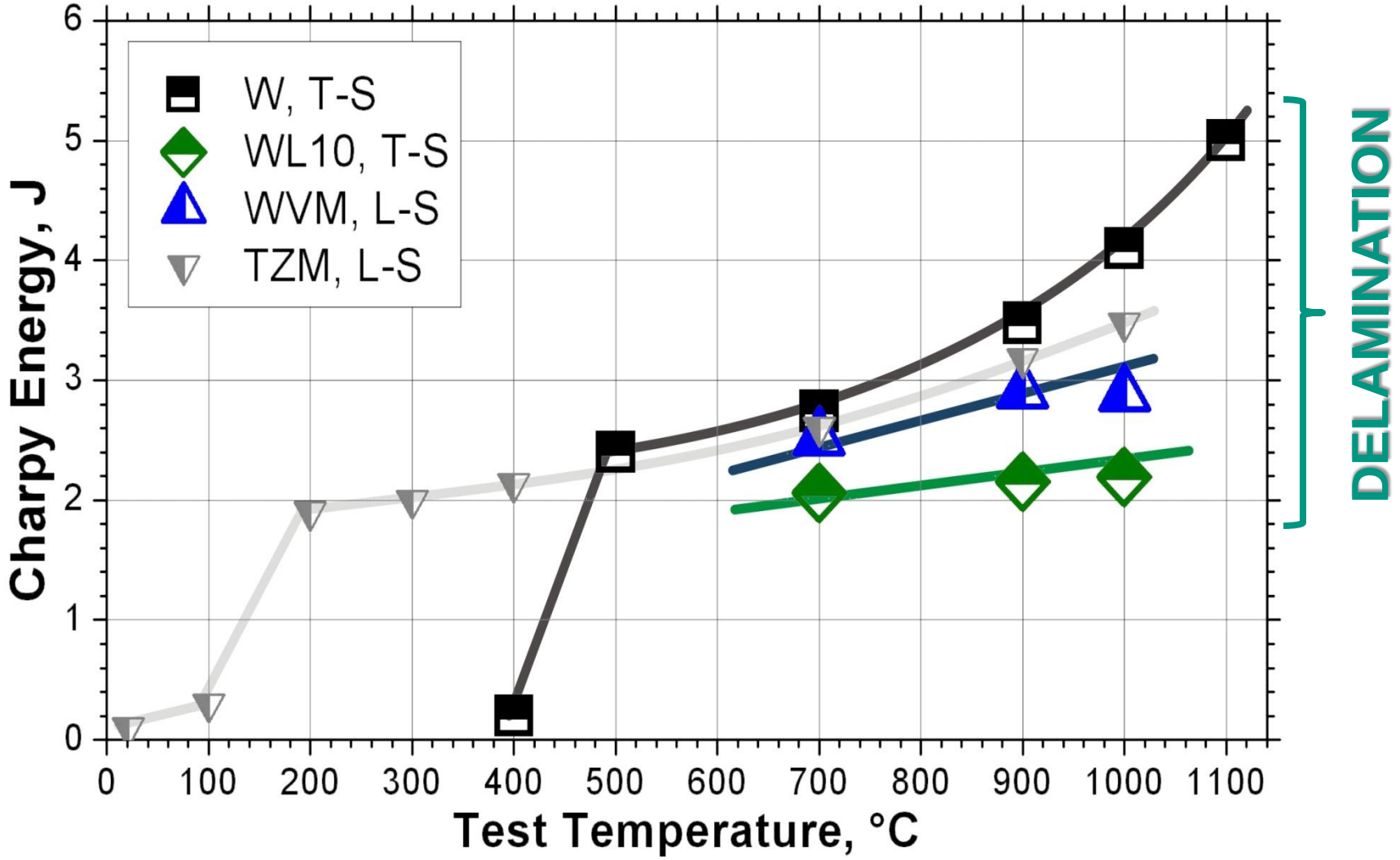
Results, Surface Fabrication



Discussion

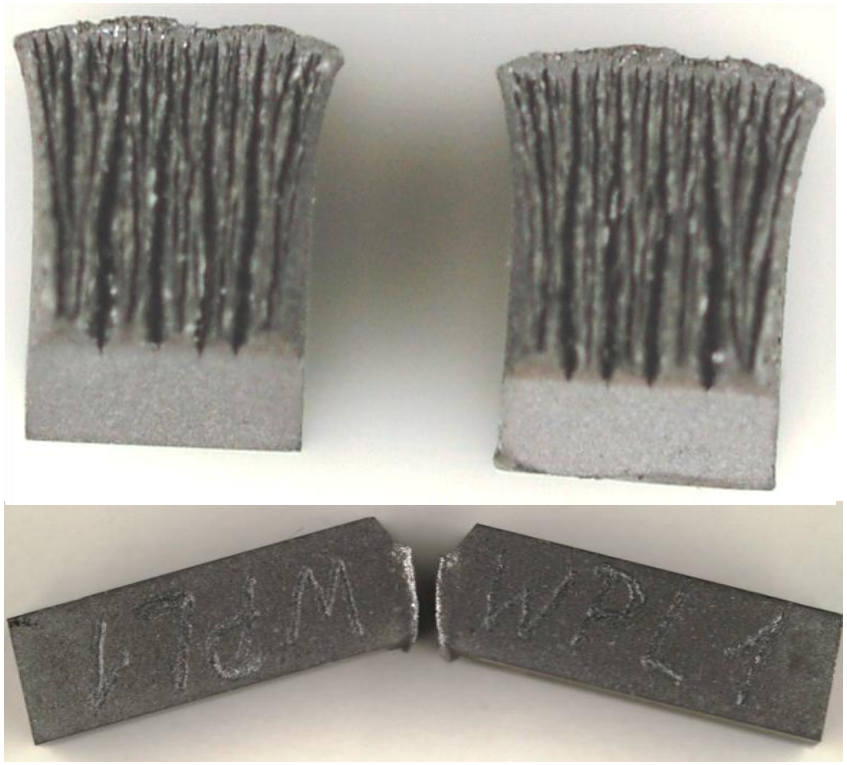


Results, Plate Materials



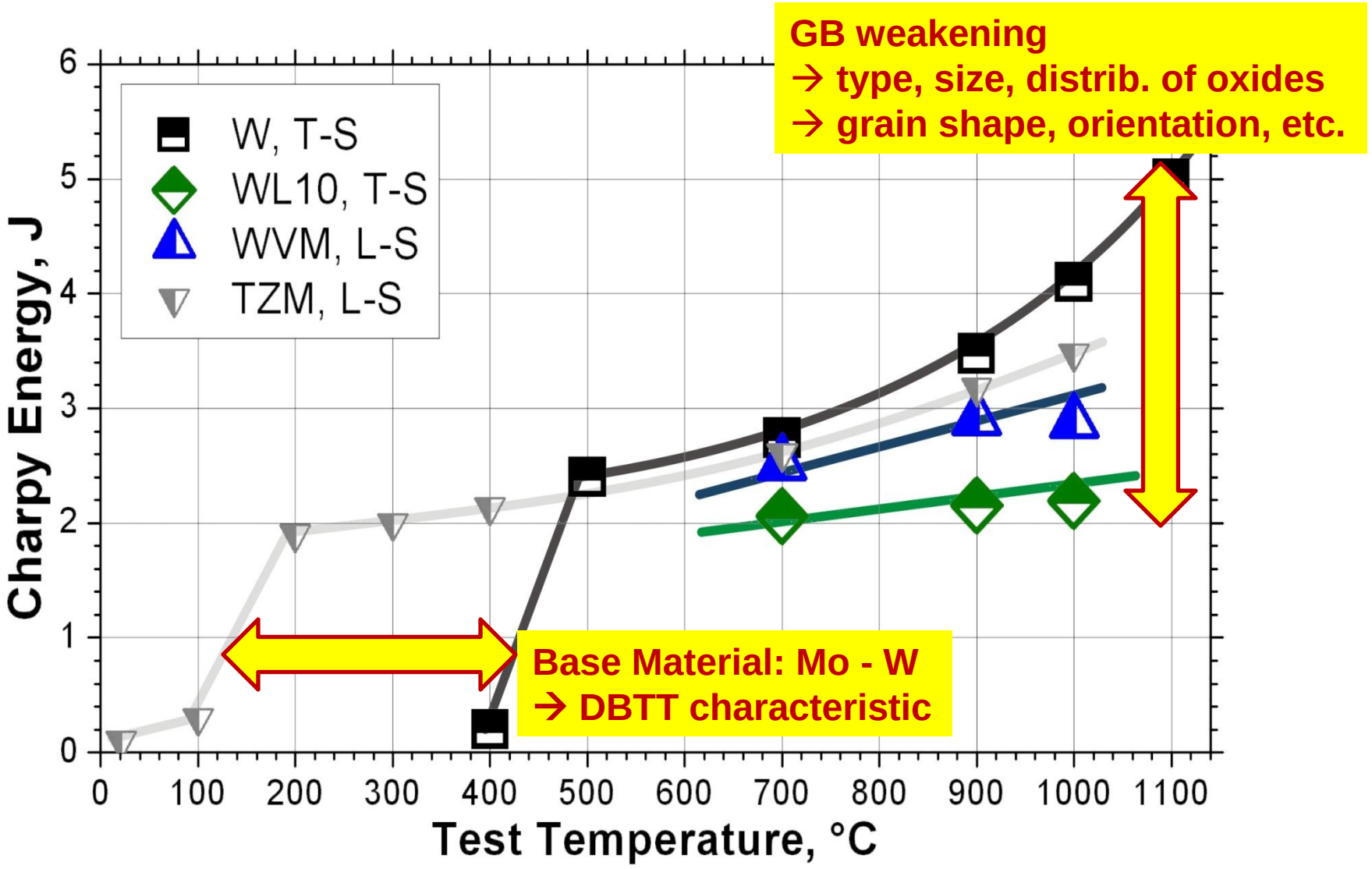
Fracture: W & WL10, plates

W



WL10

Discussion



Conclusions

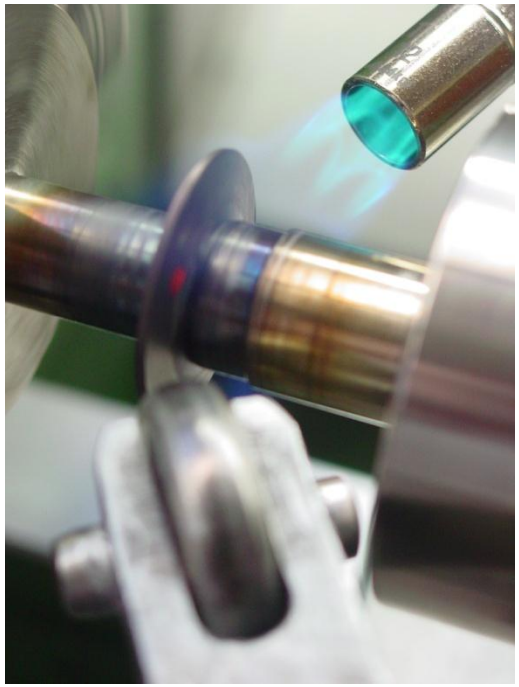
Rod-Material	DBTT	BDTT / delamin.	DDTT / ductile
TZM	300°C	---	--- / **400°C**
W, un-notched	430°C	---	--- / 450°C
W, sawed	---	500°C / ≥600°C	750°C / **800°C**
W	---	500°C / ≥600°C	850°C / **900°C**
WVM	---	500°C / ≥600°C	950°C / **1000°C**
WL10	---	450°C / ≥500°C ?	>1000°C / ???
WL10opt	---	500°C / ≥600°C	>1000°C / ???
W-1Re-1La_2O_3	---	500°C / ≥600°C	>1000°C / ???
Plate-Material			
TZM	---	150°C / 200°C	>1000°C / ???
W	---	450°C / 500°C	>1100°C / ???

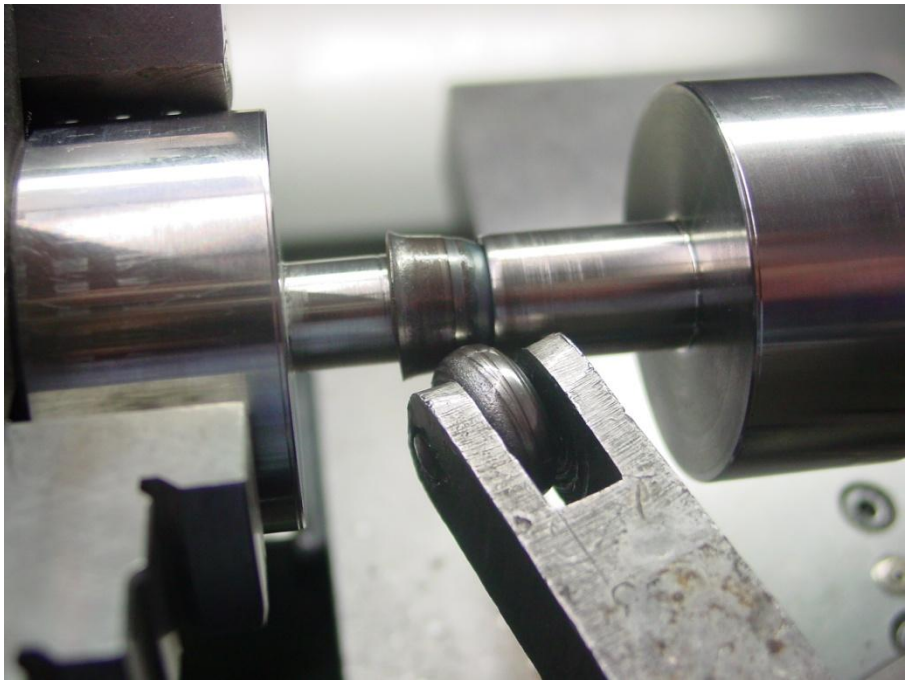
DBTT: ductile-to-brittle transition temperature
BDTT: brittle-to-delamination transition temperature
DDTT: delamination-to-ductile transition temperature

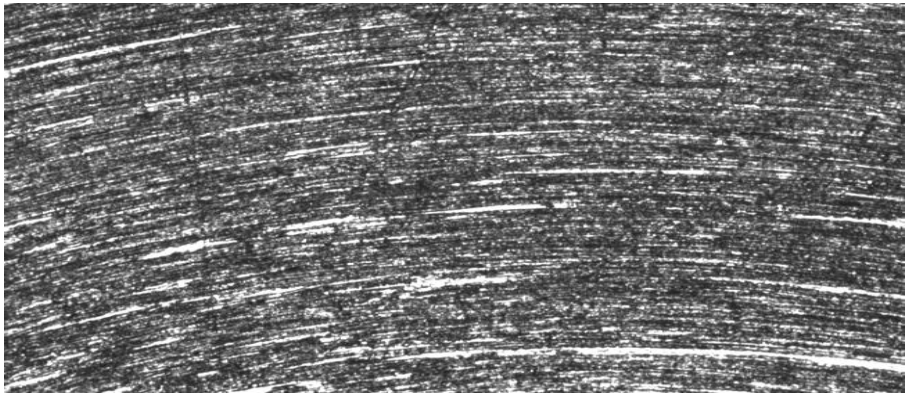
Conclusions

- Microstructure significantly defines transition temperatures (rod texture more favorable than that of plates)
- Oxide particles (and also potassium doping) promote delamination (but they are necessary for stabilizing GB → suppr. re-crystallization)
- Tungsten materials have a DBTT limit of ≥400°C (when produced by sintering & deformation, tested according to DIN EN ISO 148-1, …)
- Notches/edges have to be avoided in structural parts
- Optimum fabrication probably only by aligning grains along the contour of the according part → deep drawing, twisting, pressing, …

Outlook







→ J. Reiser, this conference