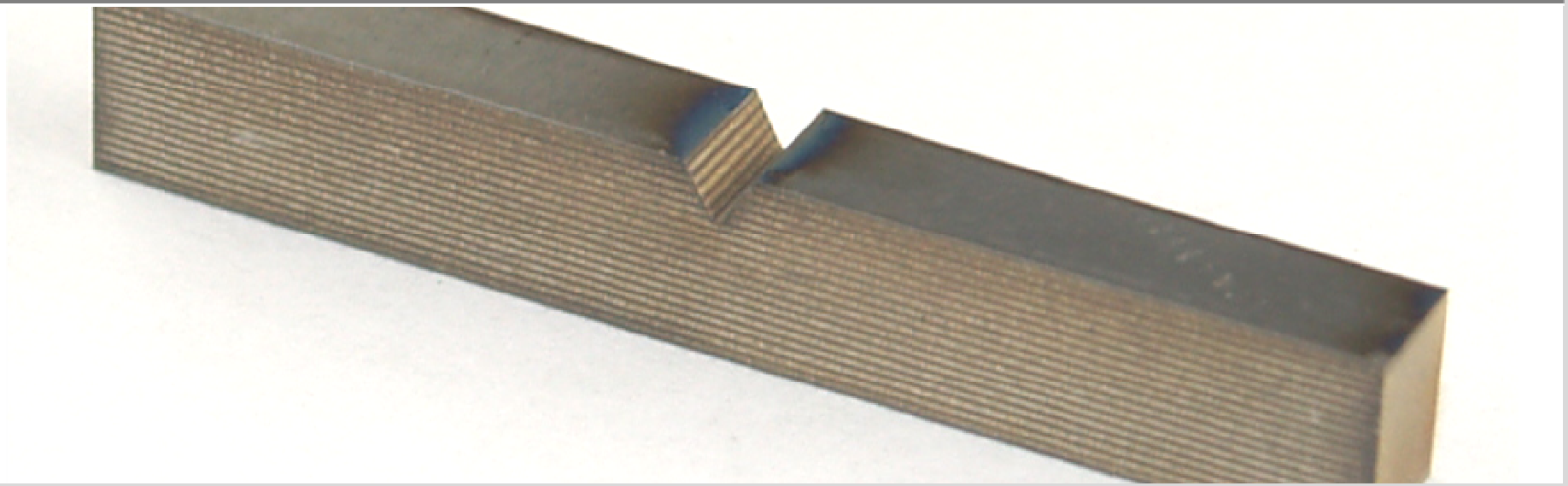
W laminates and their possible use in divertor technology

J. Reiser[1], M. Rieth[1], B. Dafferner[1], A. Hoffmann[2]

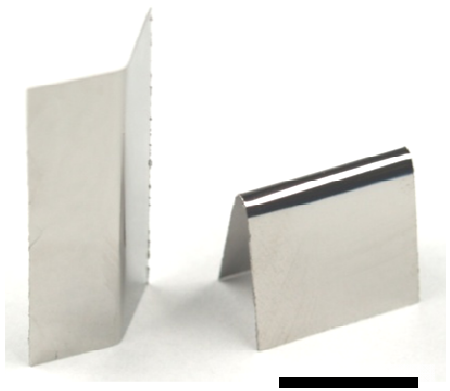
KIT-CCFE Divertor Technology Workshop, Culham, 29.05.12

[1] Karlsruhe Institute of Technology, Institute for Applied Materials, IAM-AWP, 76021 Karlsruhe, Germany
[2] PLANSEE Metall GmbH, 6600 Reutte, Austria

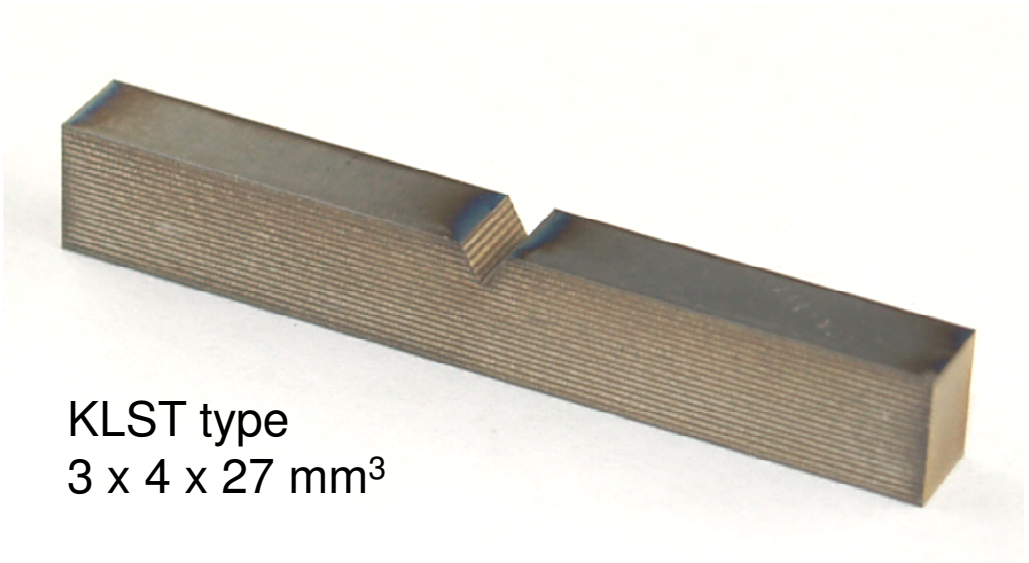
KARLSRUHE INSTITUTE OF TECHNOLOGY, INSTITUTE FOR APPLIED MATERIALS



How to make tungsten ductile?

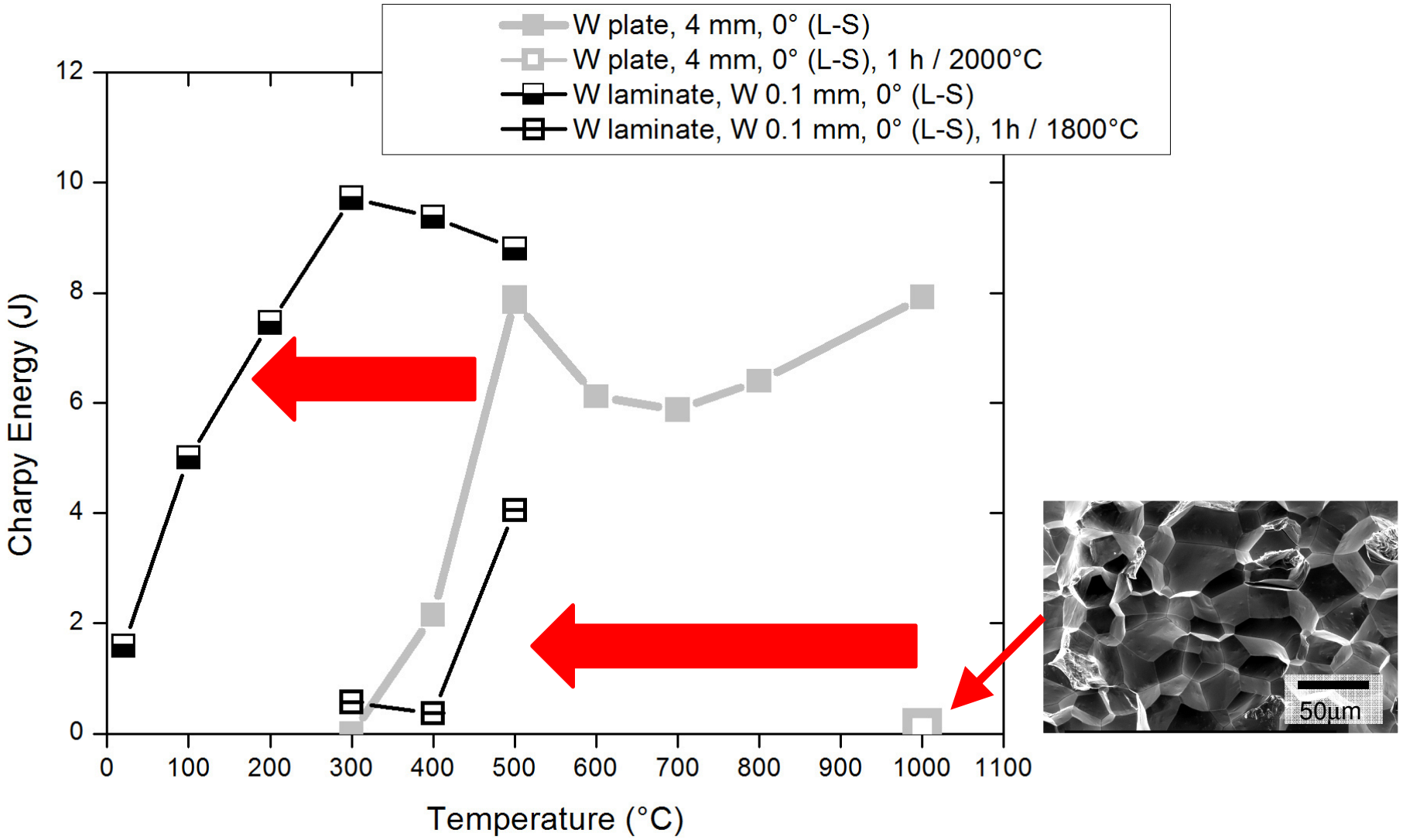


?

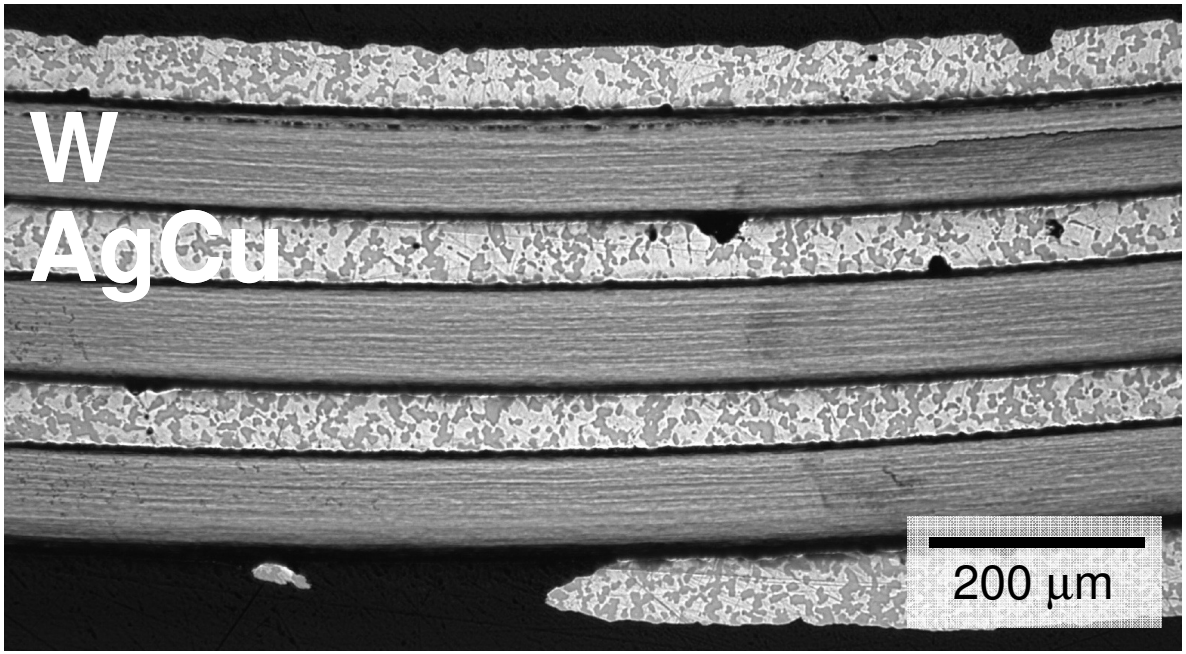


KLST type
3 x 4 x 27 mm^3

How to make tungsten ductile?

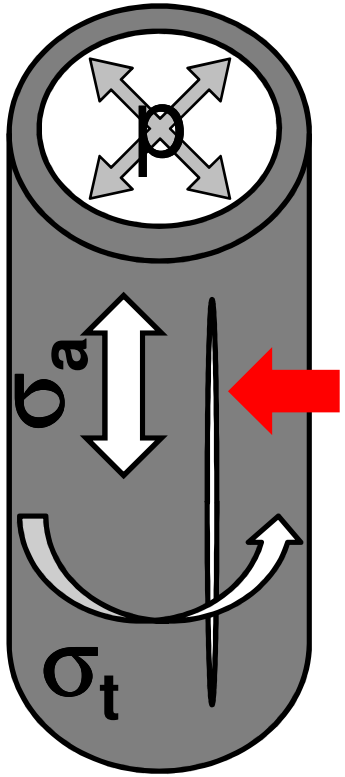


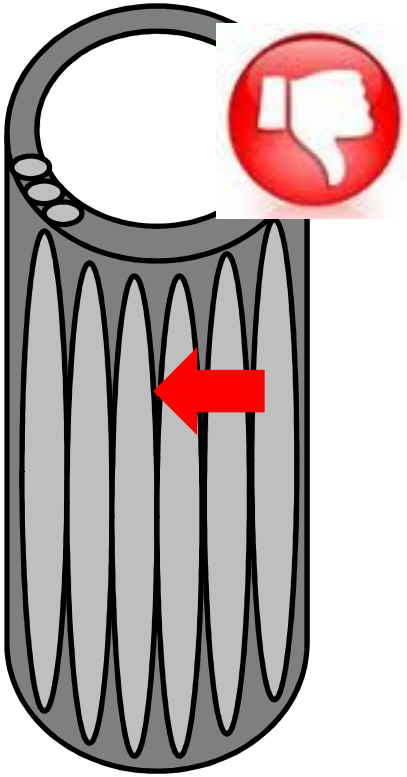
Syntheses of W pipes: 15 x 1 x 27 mm³

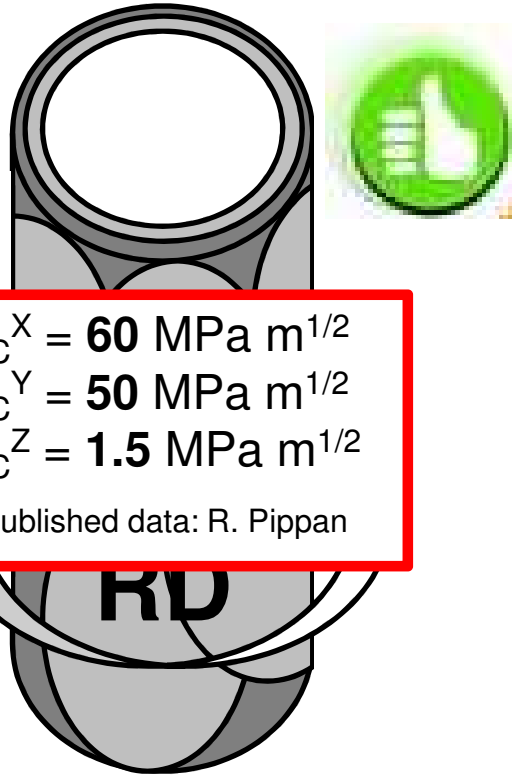


Syntheses of W pipes

rod material	foil







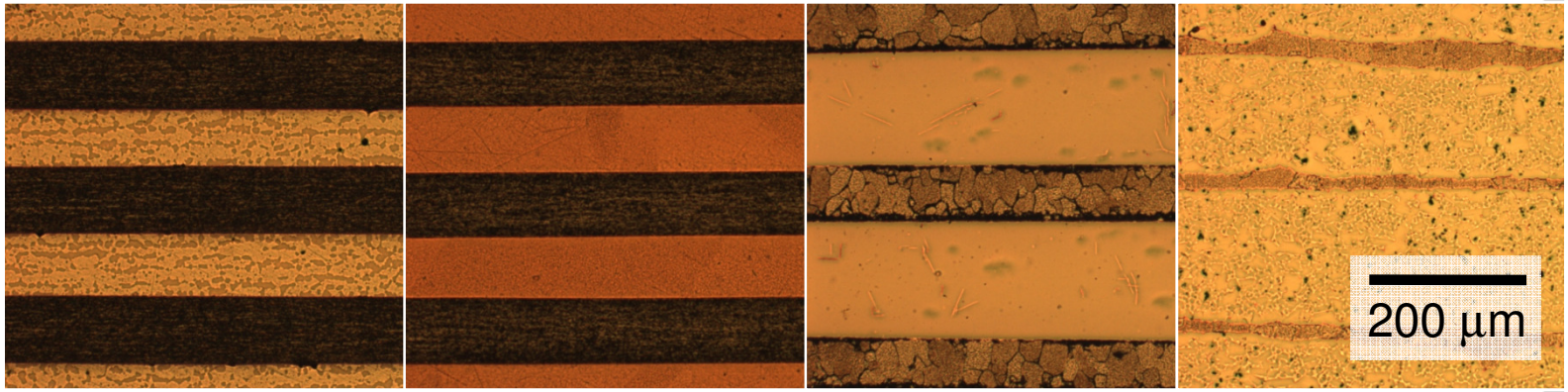
K_{IC}^{X} = **60** MPa $m^{1/2}$
K_{IC}^{Y} = **50** MPa $m^{1/2}$
K_{IC}^{Z} = **1.5** MPa $m^{1/2}$

unpublished data: R. Pippan

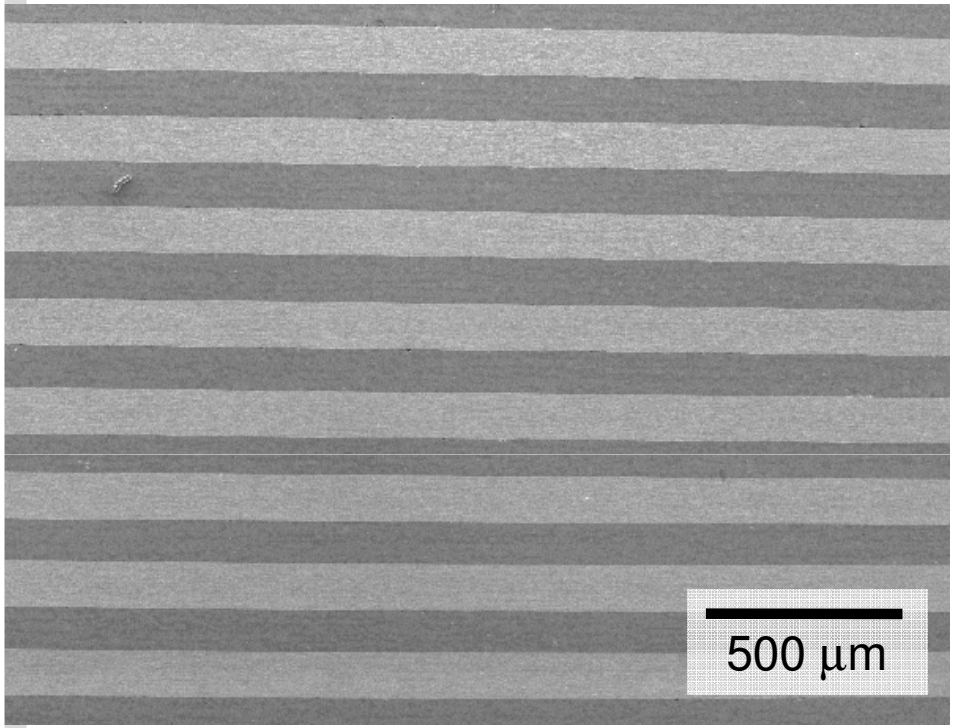
stress distribution	microstructure

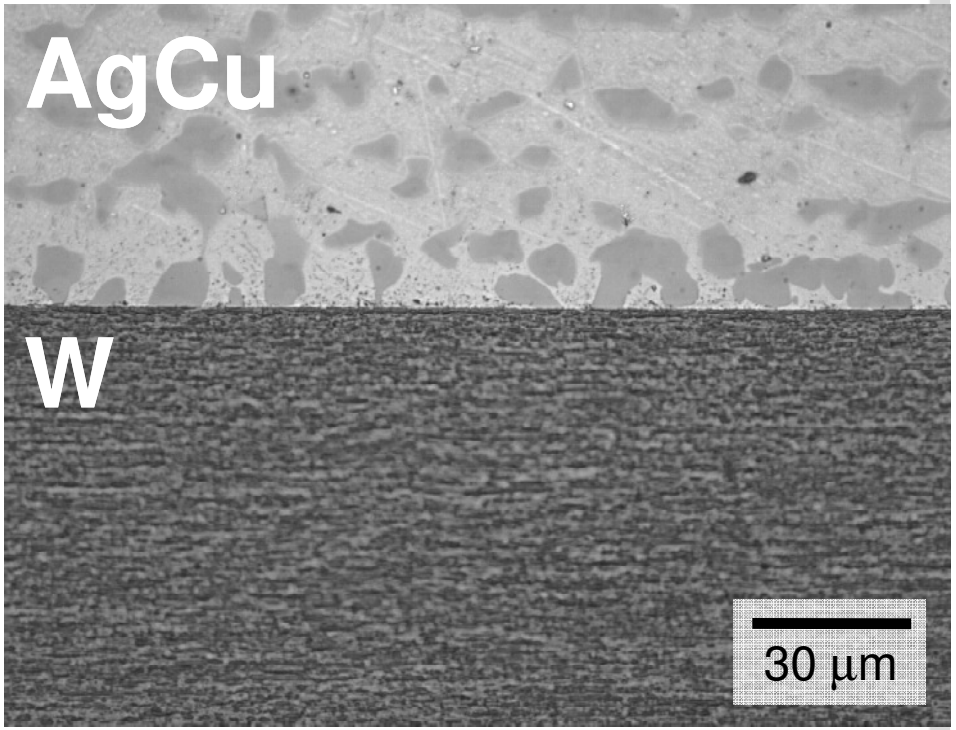
Syntheses of W pipes: 15 x 1 x 27 mm³

rod	AgCu, 780 °C	Cu, 1085 °C	Ti, 1670 °C	Zr, 1855 °C



Brazing

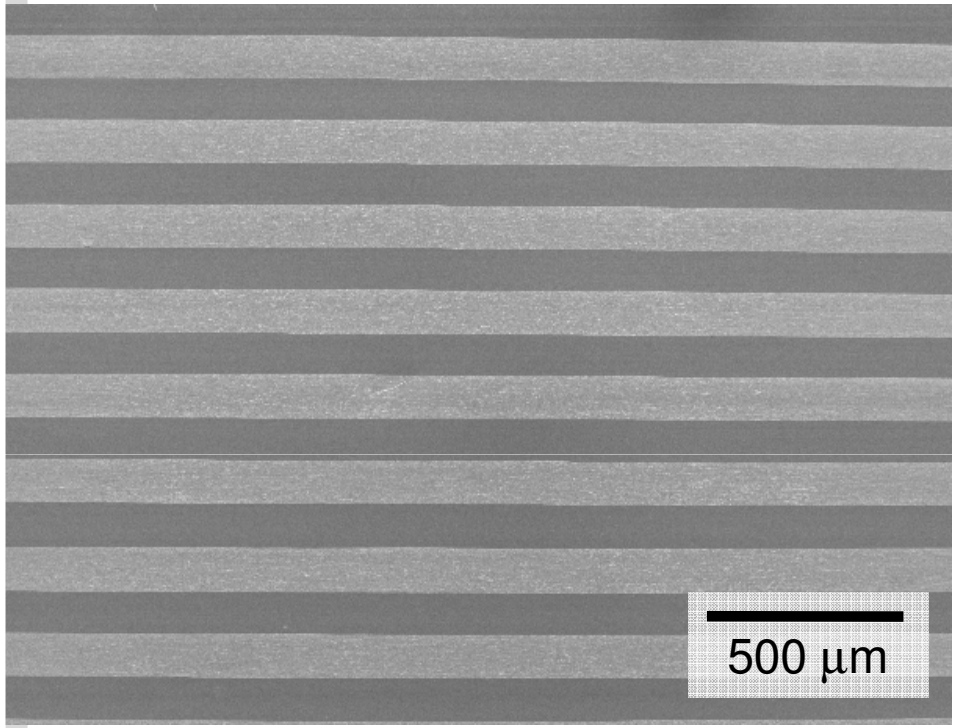


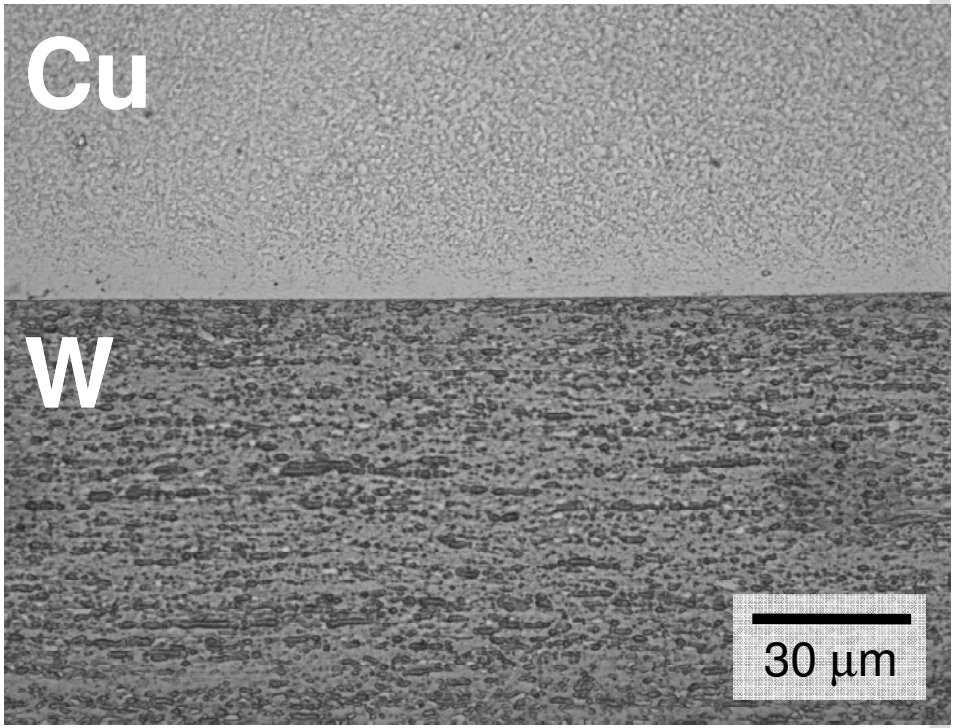


excellent wettability

no diffusion into W

Brazing

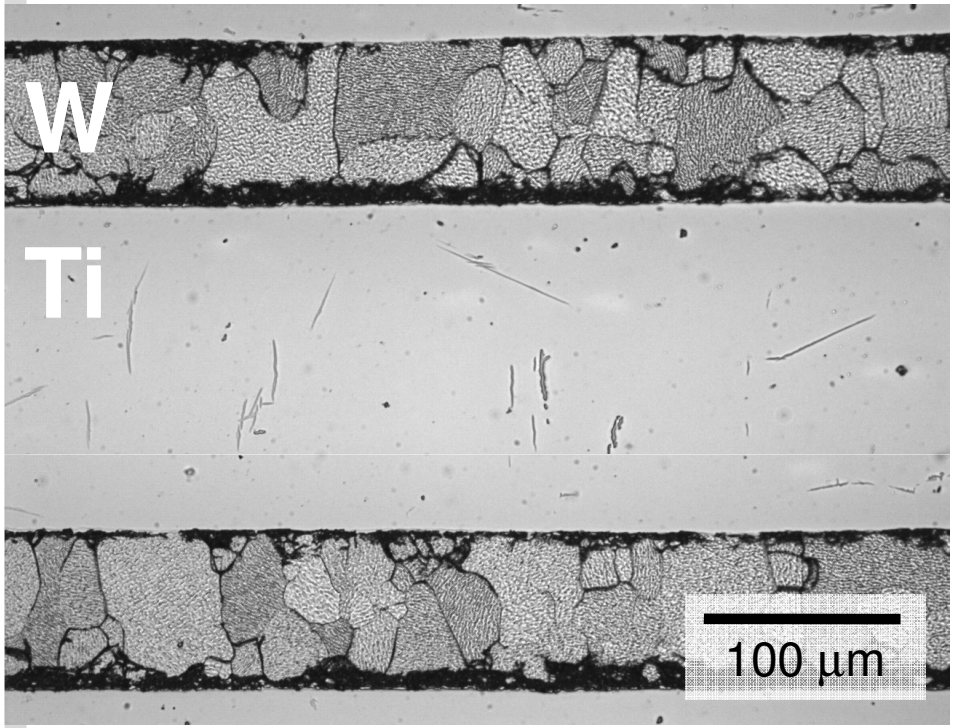


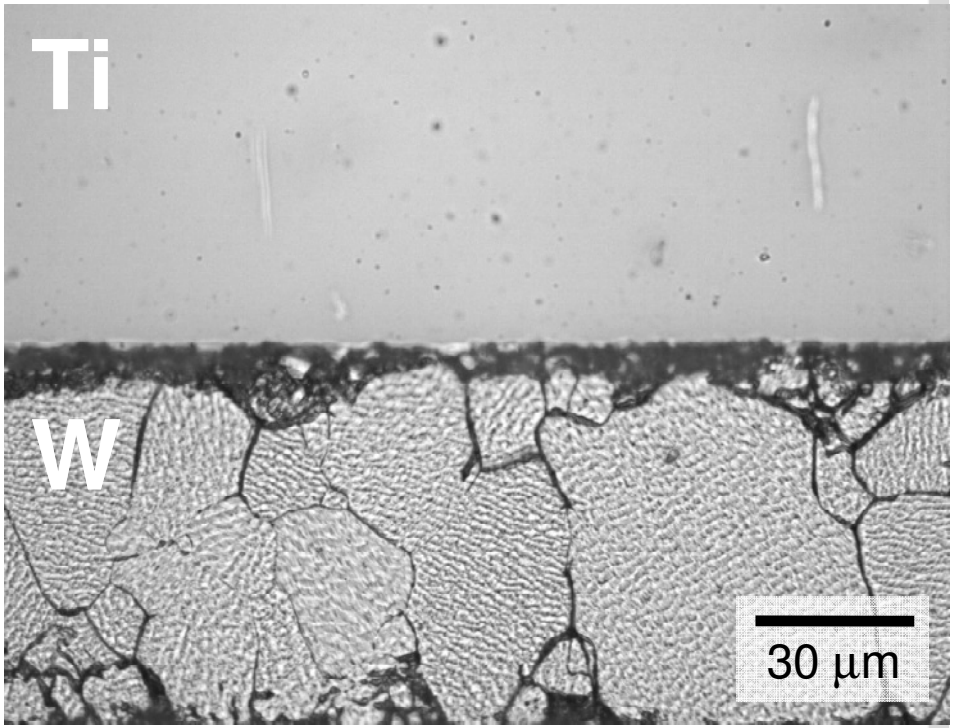


excellent wettability

no diffusion into W

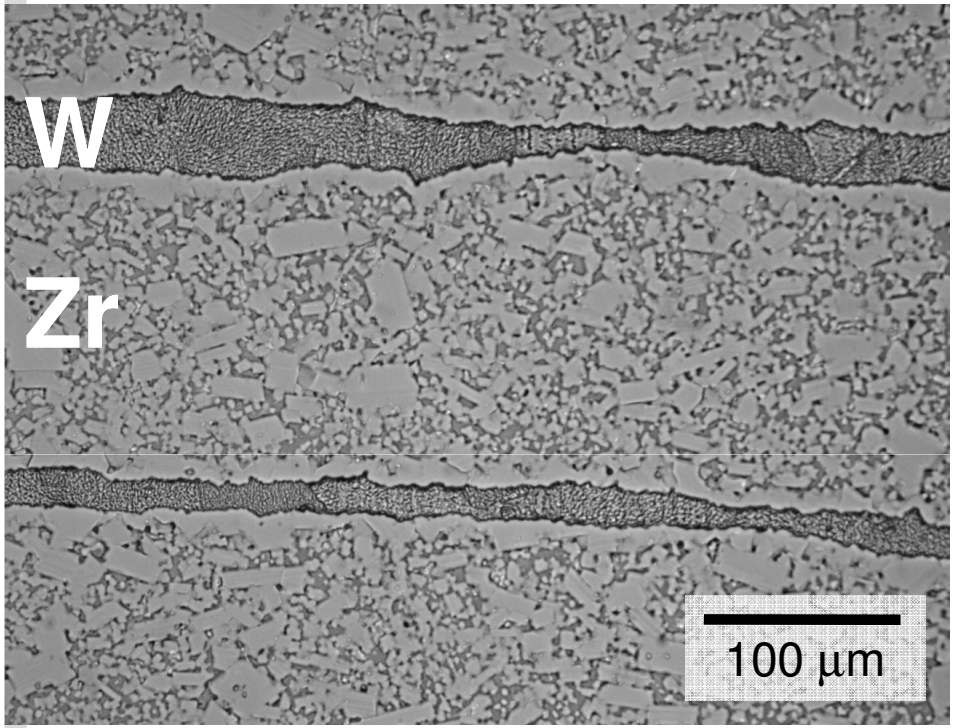
Brazing

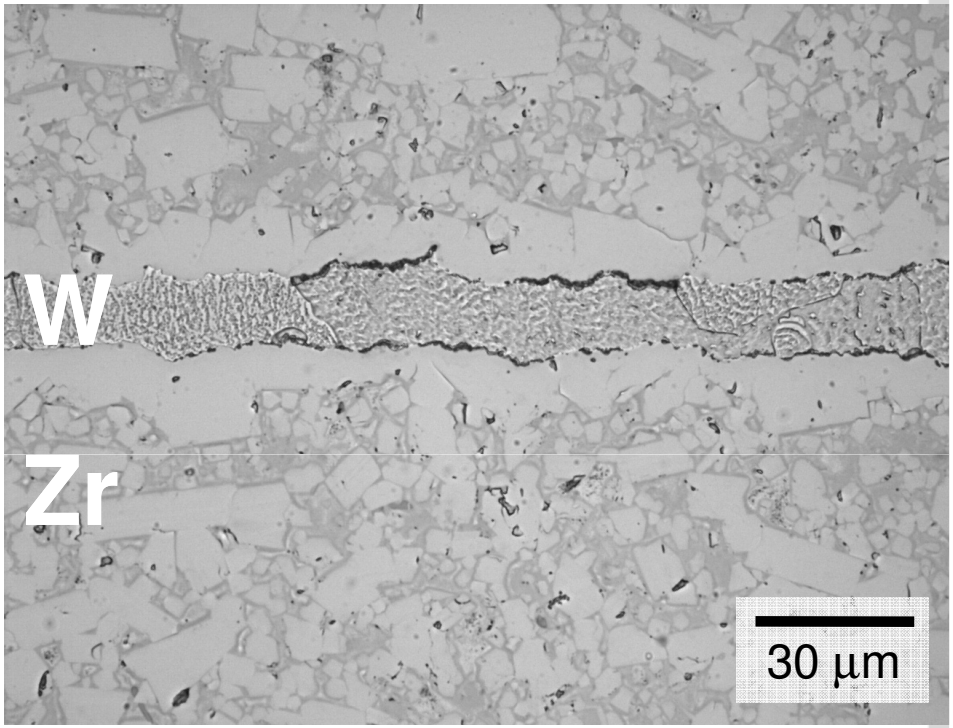




foil recrystallized
W solid solution

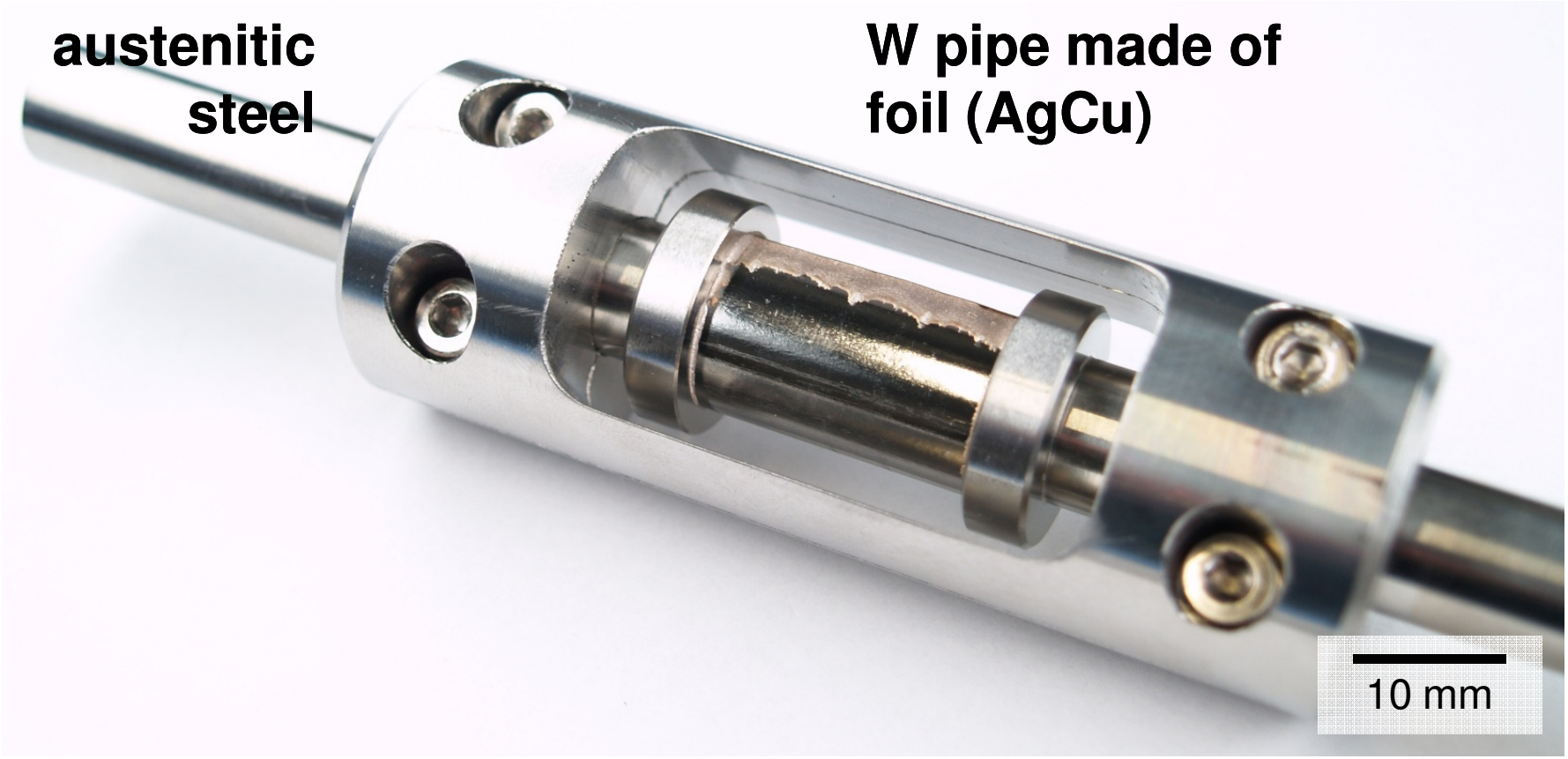
Brazing





foil recrystallized
intermetallics

Burst test: performed at PLANSEE SE



in cooperation with
T. Huber, A. Zabernig; Plansee SE

Burst test: performed at PLANSEE SE

- 1st result: **1000 bar, no damage**

  W0.1 AgCu0.1, 15 x 1 x 27 mm^3, RT, water
- 2nd result: **AgCu is only sealing**

  $\sigma_t = p * r / t$

  = (100 MPa * 7.5 mm) / 1 mm

  = 750 MPa

  R_m^{AgCu} = 350 MPa
- 3rd result: **transition W laminate - steel (fcc) works**

Impact on the divertor design

- water cooled divertor
- helium cooled divertor

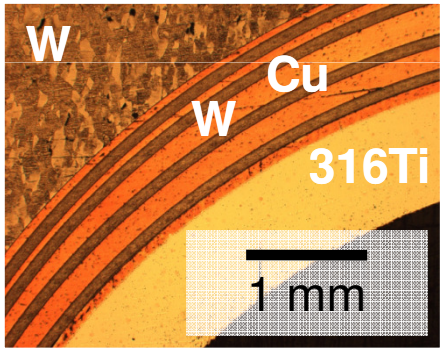
W laminate for divertors

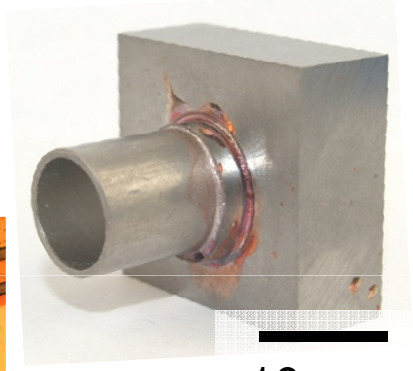
	water	water	helium
	100 °C – 120 °C, 40 bar	275 °C – 325 °C, 160 bar (PWR)	400 °C – 600 °C, 100 bar
Cu RT – 250 °C	**20 MW/m²** see ITER	✗	✗
austenitic steel RT – 550 °C	**W-laminate: used as a transition piece between W and steel**		
RAFM steel 350 °C – 550 °C/ 650 °C			
W-laminate Cu: 400 °C – 800 °C	**W-laminate: used as structural material**		

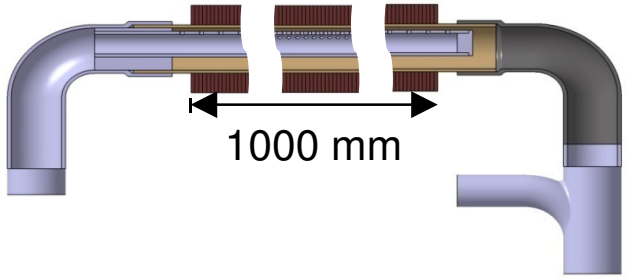
W laminate for divertors

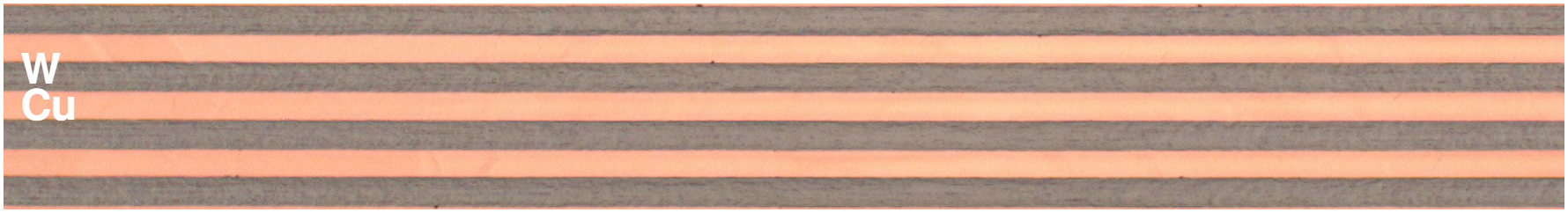
1 Transition piece between W and steel

2 Structural W material









Thank you for your attention

The authors are grateful to:

Plansee Metall GmbH
University of Oxford
our colleagues from IAM (KIT)