Tungsten for Structural Divertor Parts

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Bad Herrenalb

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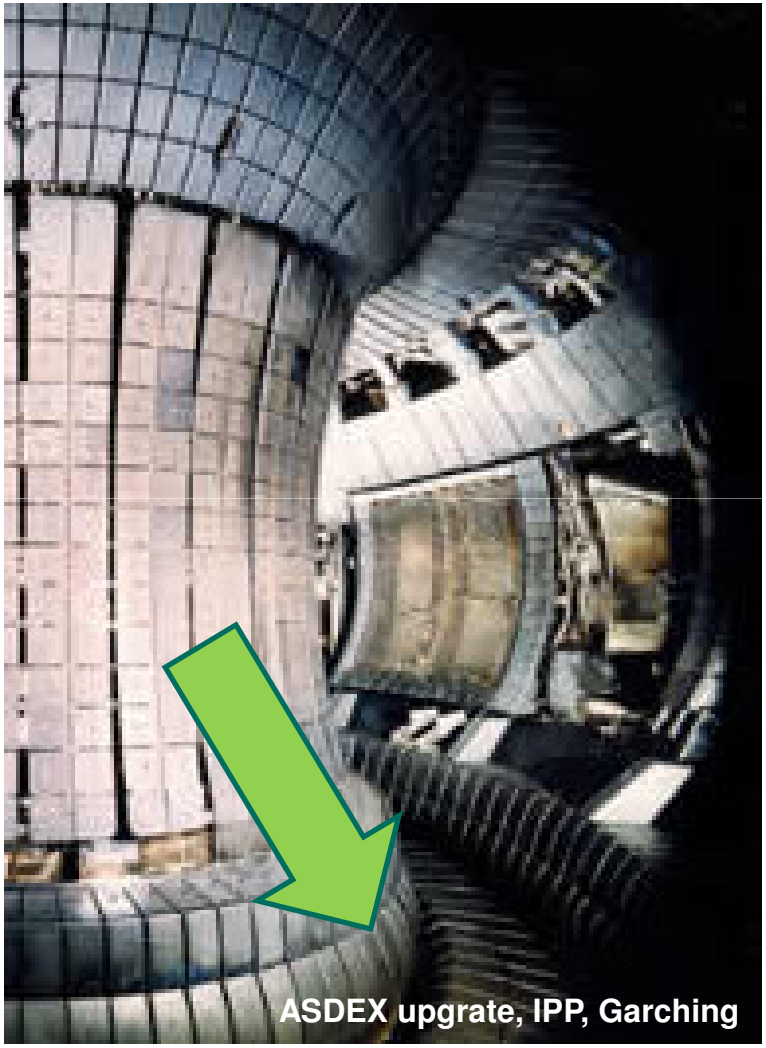
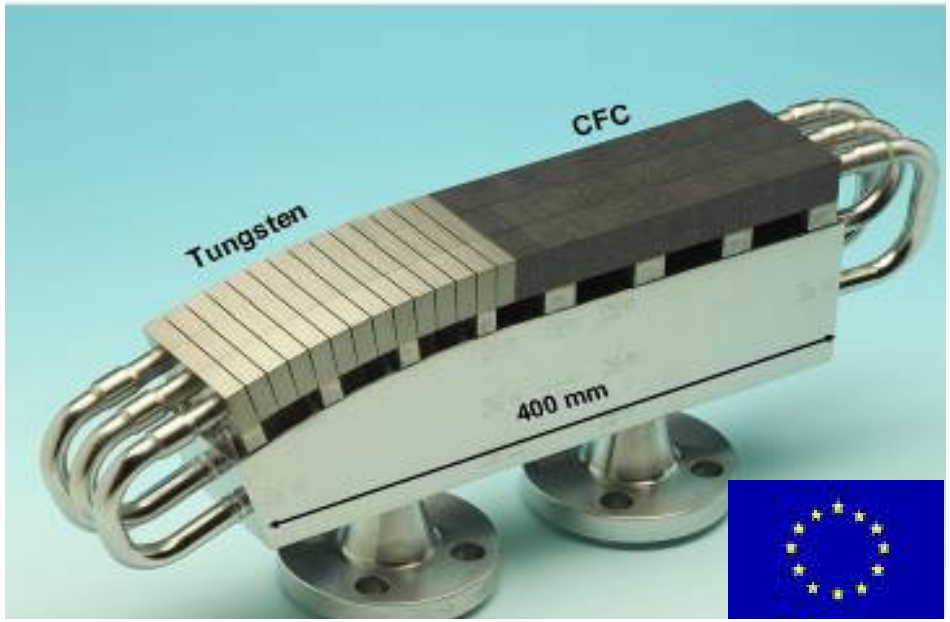
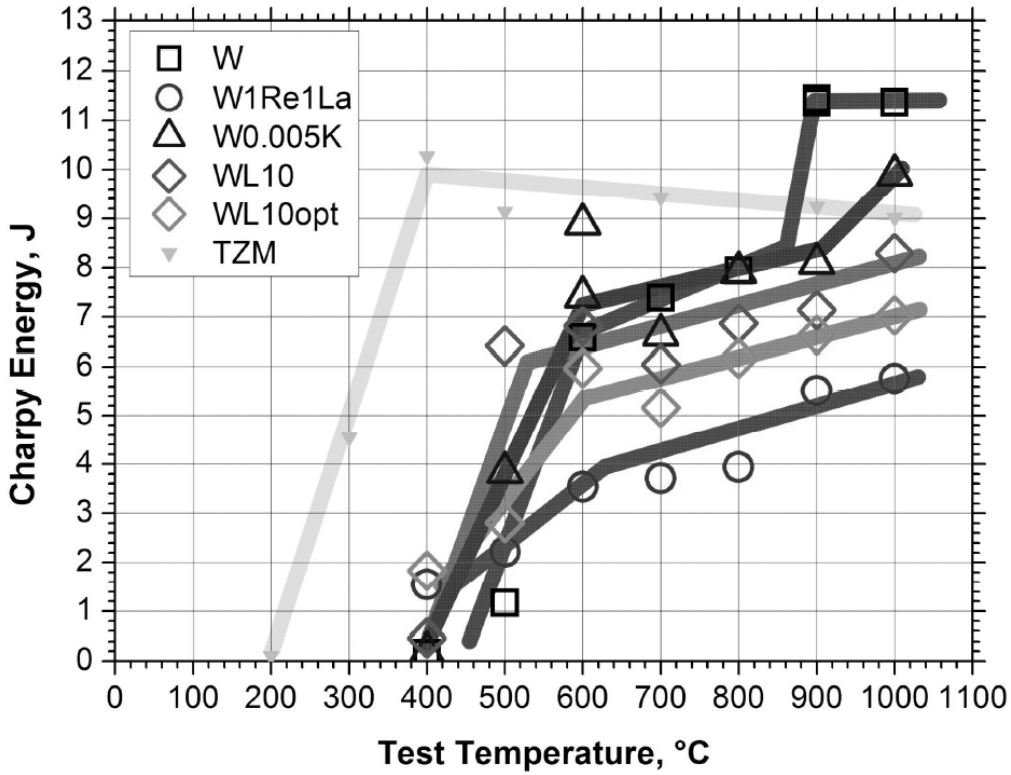
Introduction

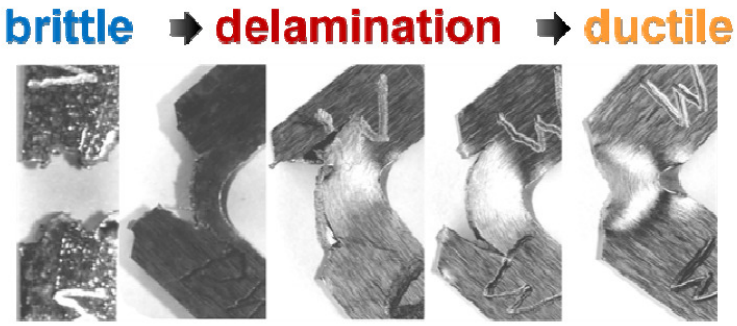




requirement: W for structural parts

The problem: brittle-delamination-ductile





M. Rieth, KIT [1,2]

- Literature:

[1] M. Rieth et al., Adv. Sci. Tec. **73**, 11, (2010).

[2] M. Rieth, A. Hoffmann, Adv. Mater. Res. **59**, 101 (2009).

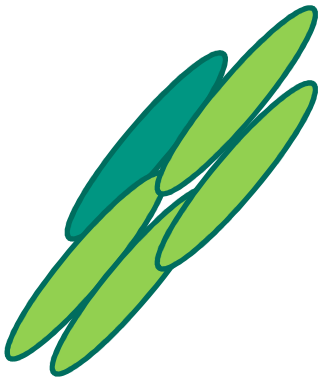
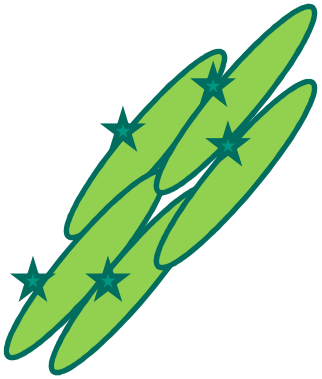
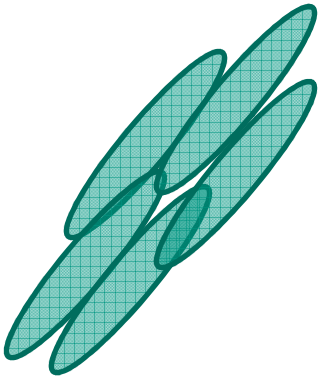
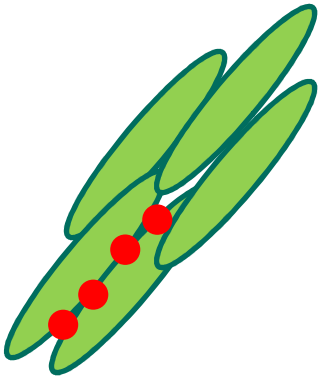
Aims of material development

1. How to make tungsten ductile?
   → decrease DBTT

2. How to increase the grain boundary strength?
   → avoid delamination

3. How to stabilize the grain boundaries?
   → avoid rxx, see ODS tungsten

How to improve tungsten?

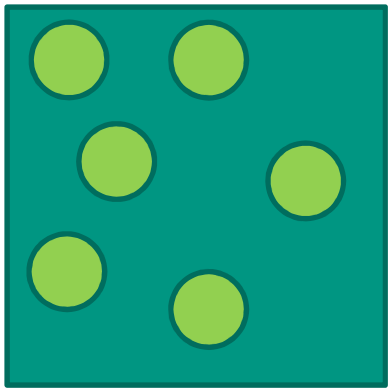





oxides? La2O3 (WL10) Y2O3 TiC (tbd) → NO!	insoluble metals? K (WVM) → NO!	solid solution? WTa, WV WTi (tbd) see *R. Pippan, M. Rieth* → NO!	decrease of impurities? see *B. Gludovatz, R. Pippan* → NO!

→ The best W is pure W

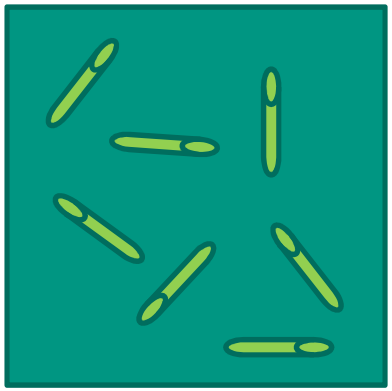
How to improve tungsten?

particle reinforced MMC



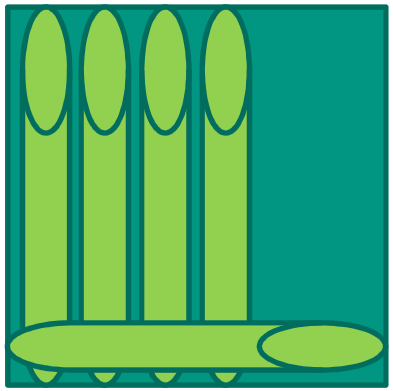
J. Hohe, IWM, Fraunhofer-Institut, Freiburg

short fiber reinforced (random) MMC



J. B. Correia, IST, Portugal

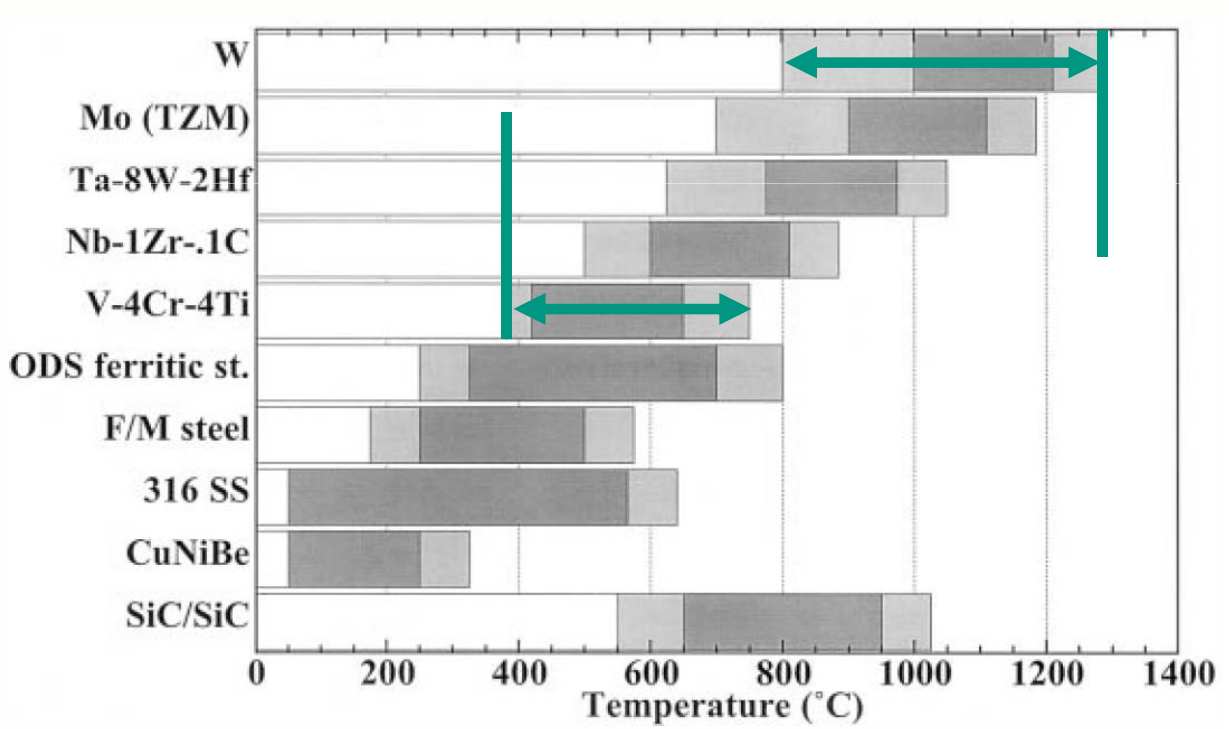
unidirectional fiber reinforced MMC



J.-H.You, IPP, Garching

Particle reinforced MMC

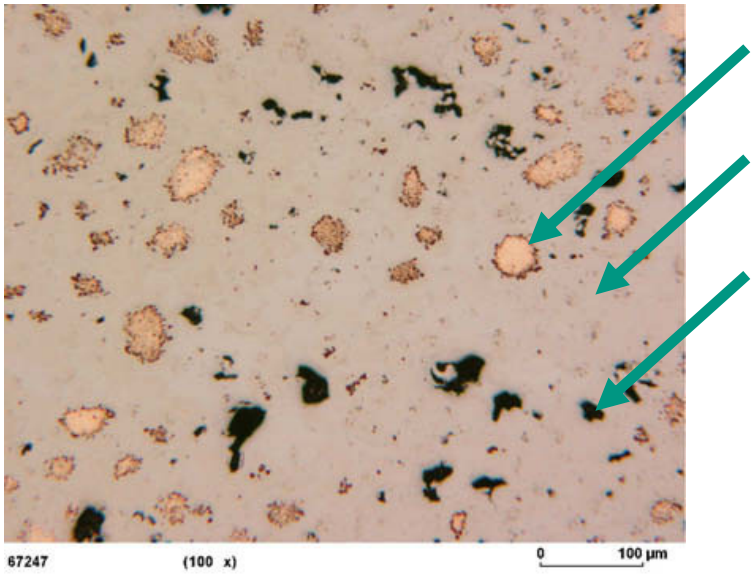
- Idea: enlarge the operation window:
  DBTT from V, creep from W
- Aim: W particle reinforced V matrix



S.J. Zinkle, N.M. Ghoniem, *Fusion Eng. Des.* **51–52**, 55 (2000).

Particle reinforced MMC

- Synthesis: 50%W, 50%V → HIP, 1h, 1500°C, 30MPa
- Characterization:



Particle: W surrounded by W68V32 vol.%

Matrix: W12V88 vol.%

voids

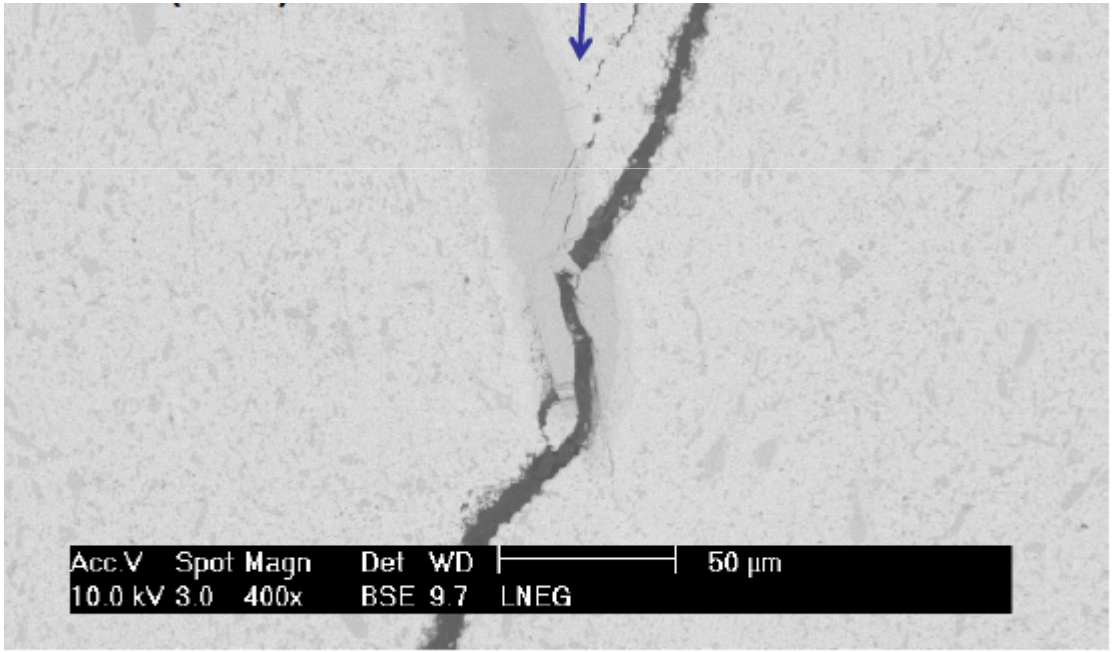
J. Hohe, P. Gumbsch, *J. Nucl. Mater.* **400**, 218 (2010).

- Testing:
  - Fracture toughness like V?

No, like W!

Short fiber reinforced MMC

- Idea: Crack deflection on a Ta fiber
  → increase of fracture toughness?
- Synthesis: W powder, Ta fibers 100 µm, SPS, PPS



Avoid solid solution?

No!

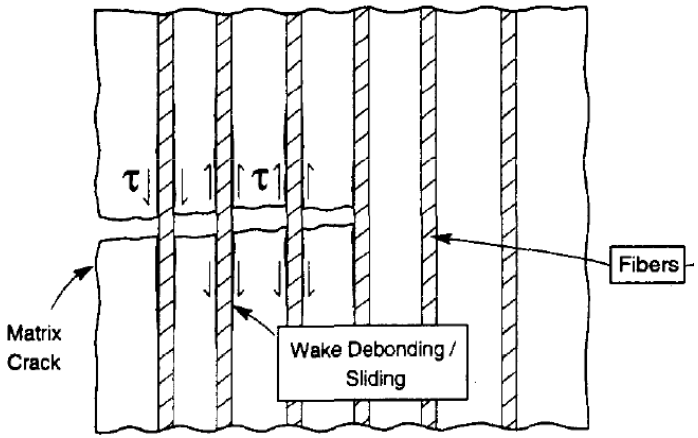
Charpy tests done?

Not yet

J. B. Correia, EFDA Meeting, W&WAlloys, Feb. (2011).

Uniaxial fiber reinforced MMC

- Idea: Copy the energy dissipation method of CMC
  bridge effect
  'non-plastic energy dissipation'



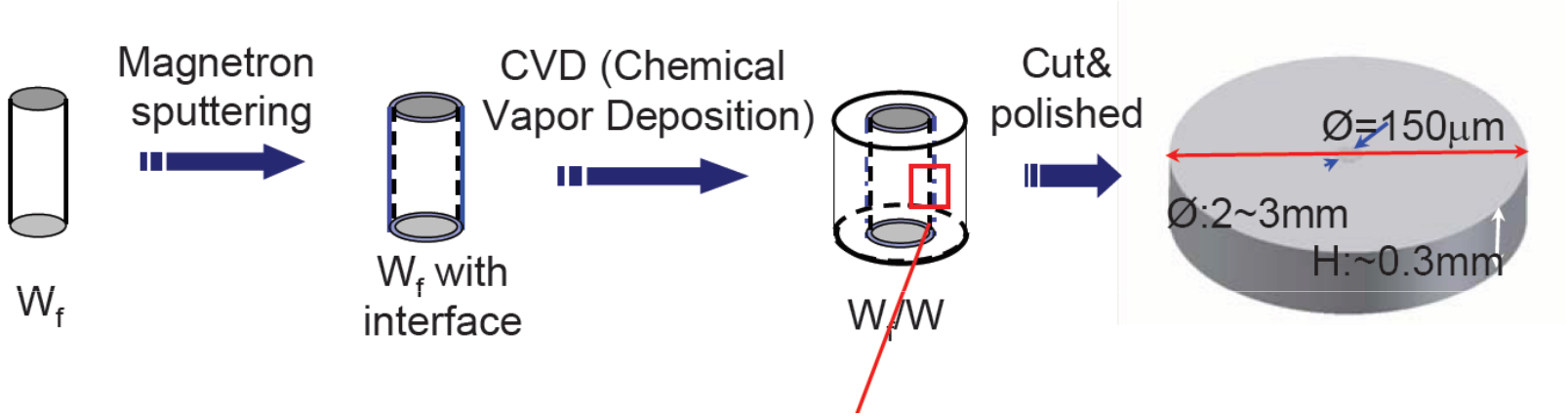
a) Interface Debonding/Friction

Brake made of CMC carbon fibre reinforced silicium carbide (C/SiC)
- One brake = 8000 €
- 30 production steps
- 20 days

A. G. Evans, Acta Mater. **45**, 23 (1997).

Uniaxial fiber reinforced MMC

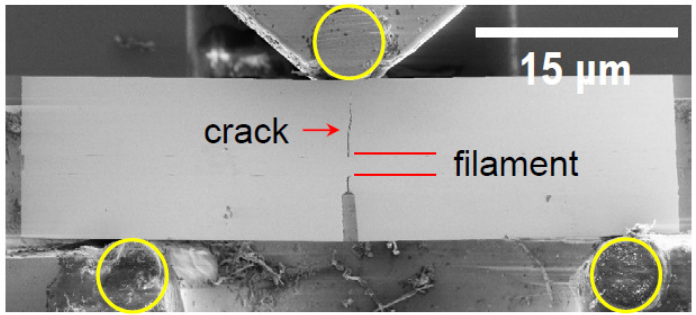
- Synthesis: W fiber (150 μm), Oxide, W by CVD



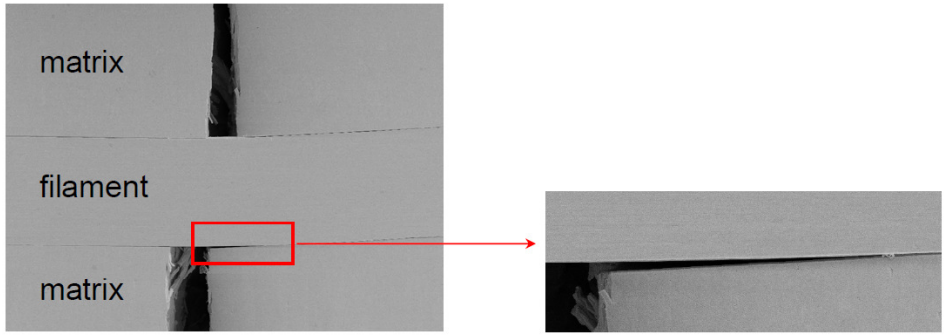
J. Du, T. Höschen, M. Rasinski, J.-H. You, *Mat. Sci. Eng.* **A 527**, 1623 (2010).

Uniaxial fiber reinforced MMC

- Characterization: miniaturized 3-point-bending test



Cf: Wurster's presentation



J. Du, T. Höschen, M. Rasinski, J.-H. You, *Mat. Sci. Eng.* **A 527**, 1623 (2010).

- Avoid solid solution?
- Charpy test?
- Amount of energy dissipation
- 2D or 3D mesh possible?

YES!
Not yet
?
?

Thank you for your attention

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