



Fusion materials activities at IPP

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OVERVIEW

1. Materials development

Tungsten-based FGMs:

Plasma spraying
Spark plasma sintering

Fine-grained W and composites: Milling + spark plasma sintering

2. Materials testing and plasma-material interaction

Laboratory plasma:

PSI-2 (FZJ)
PF-6 (IPPLM)

COMPASS tokamak:

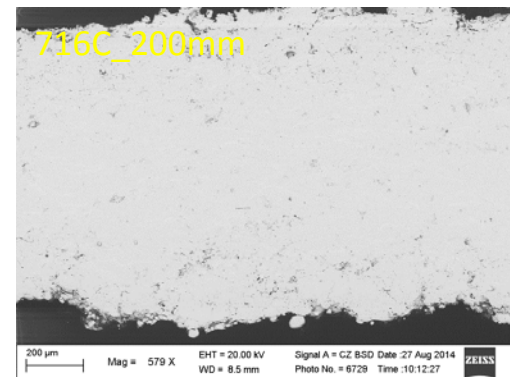
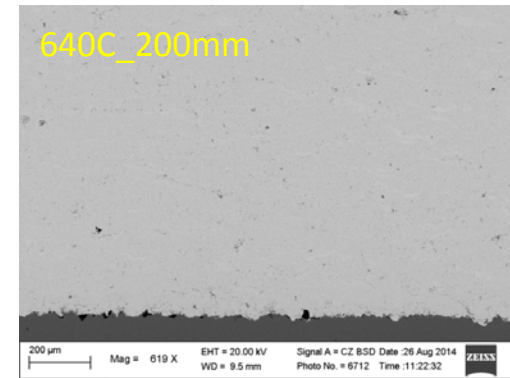
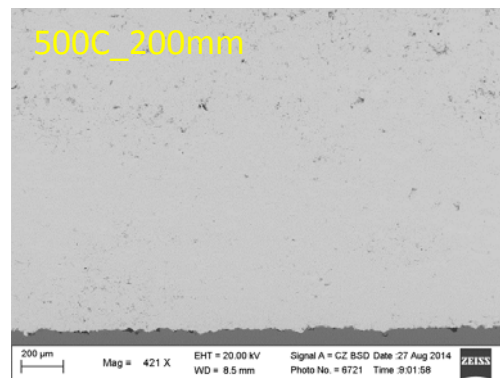
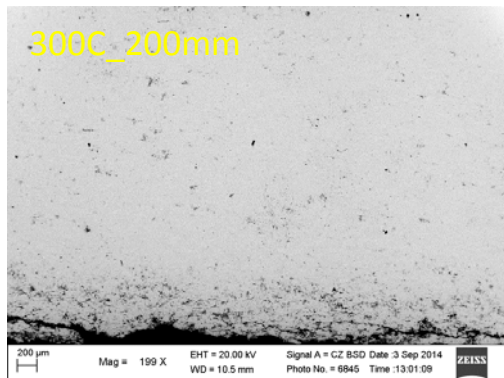
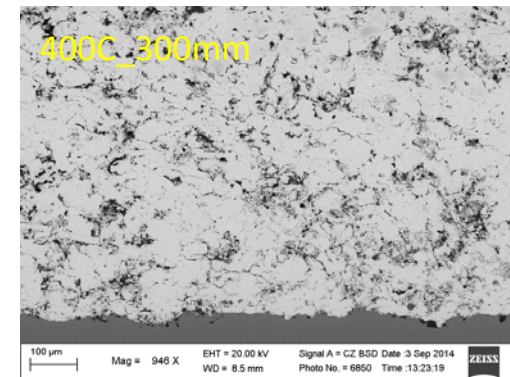
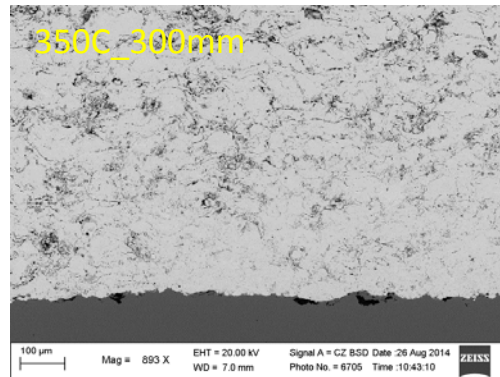
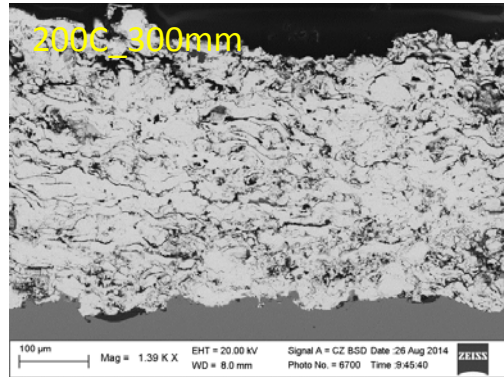
He fuzz and arcing
Dust mobilization

Non-plasma:

Hot He gas
Laser repair



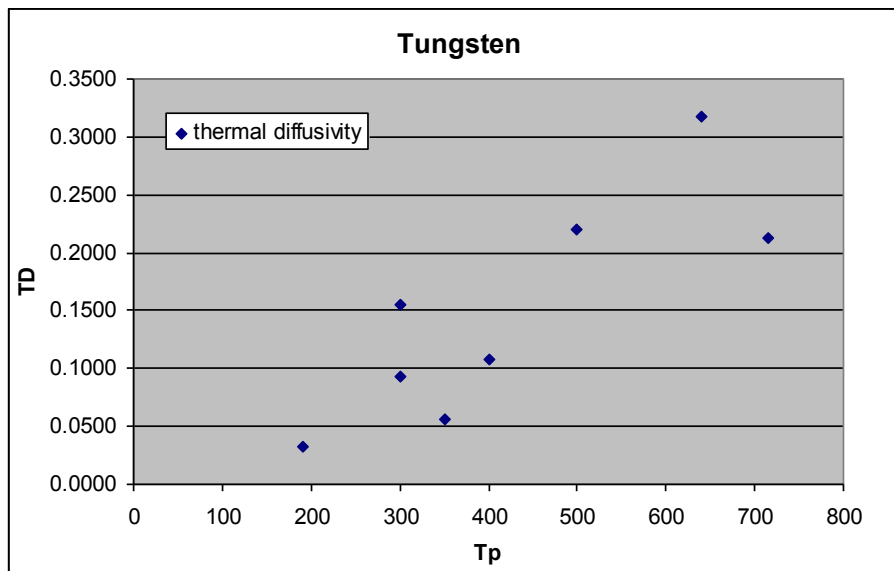
1a) PLASMA SPRAYING



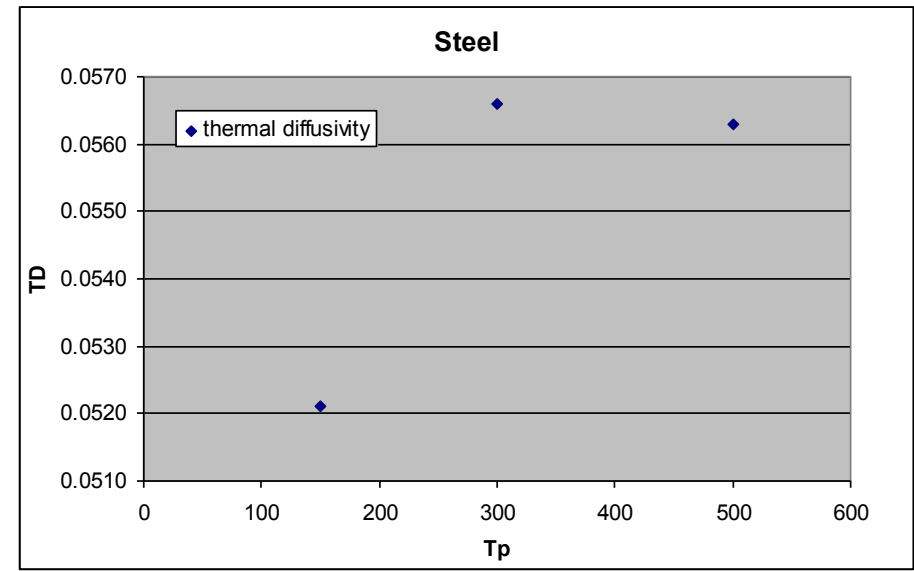


1a) PLASMA SPRAYING

Thermal properties:



~ 6x increase!

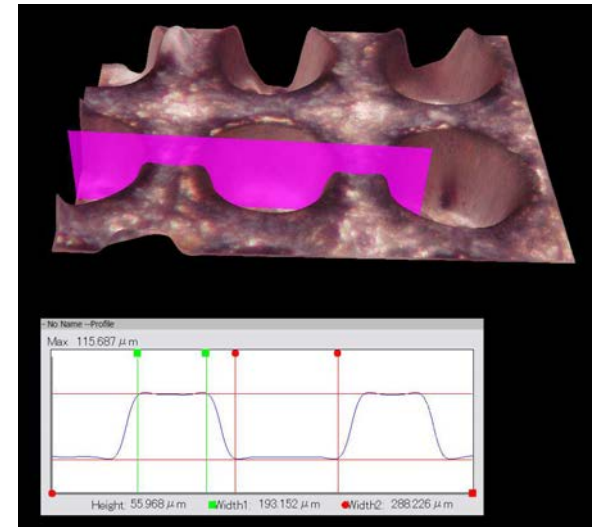
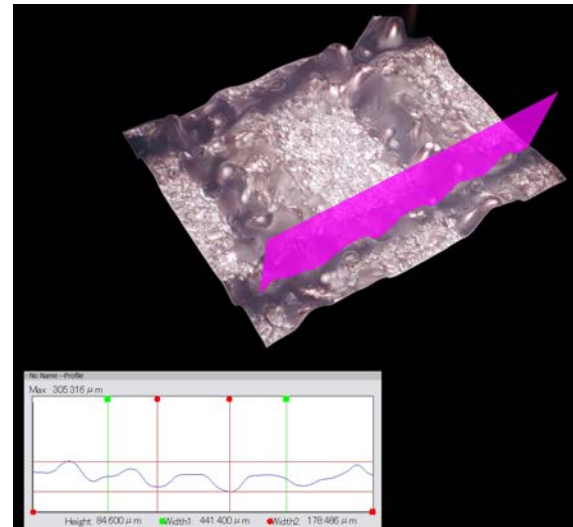
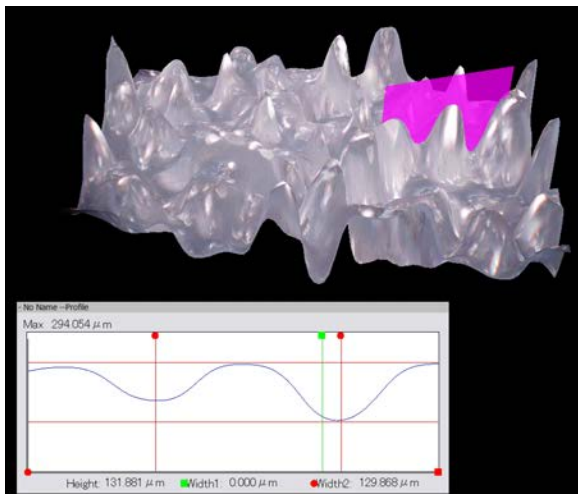
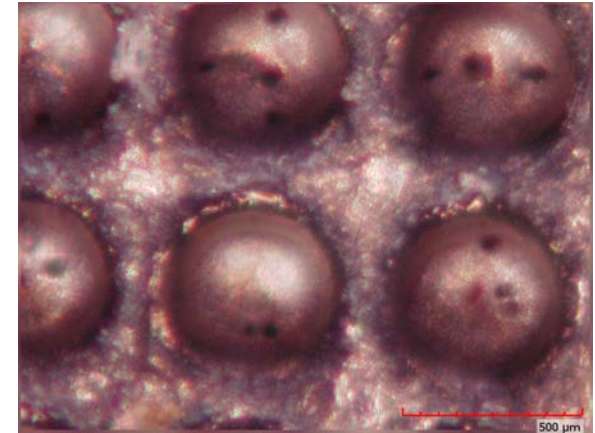
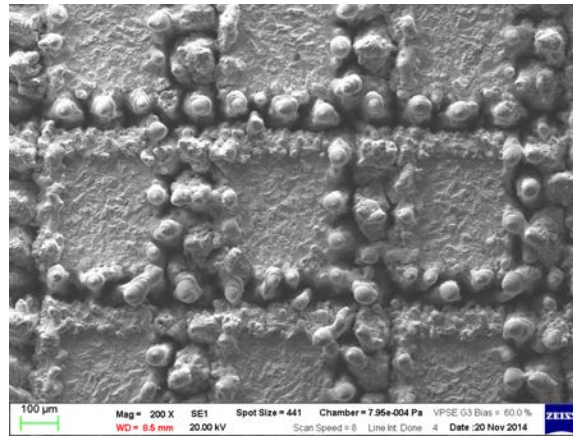
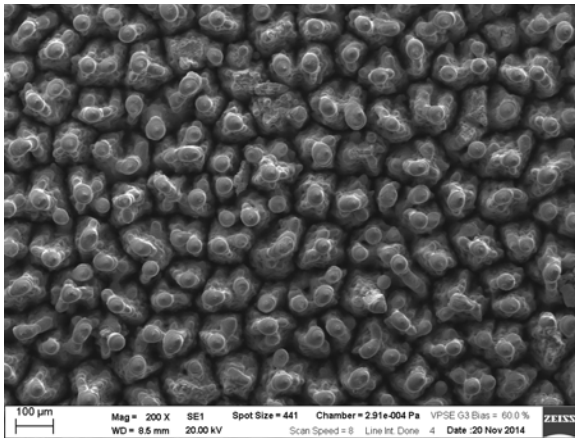


~ 10% increase

- similar trends for hardness (cohesion) and deposition efficiency
- adhesion needs improvement (e.g. laser sculpting)



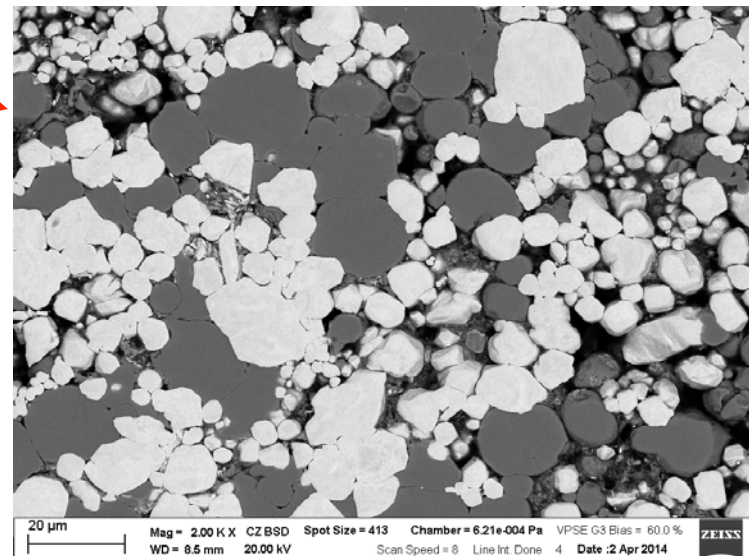
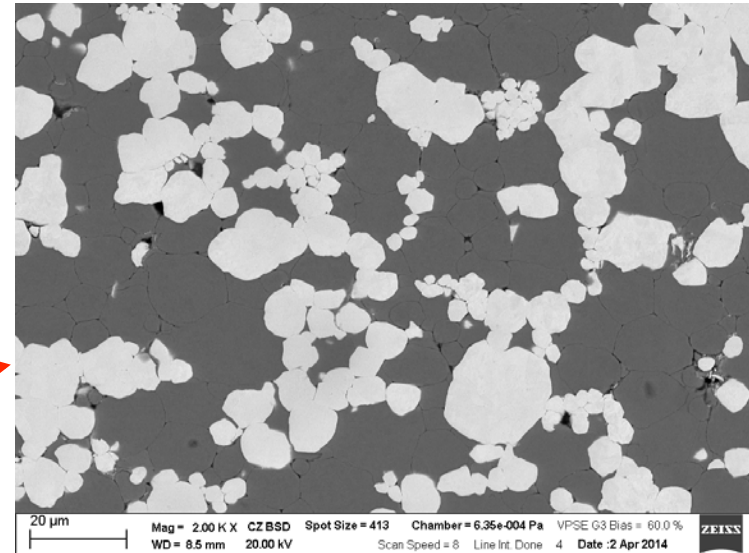
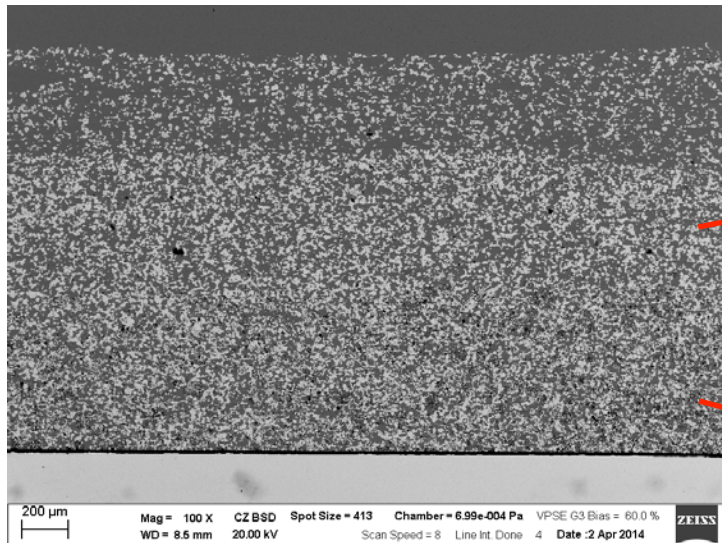
1a) LASER SCULPTING





1b) SPARK PLASMA SINTERING

FGM formation:

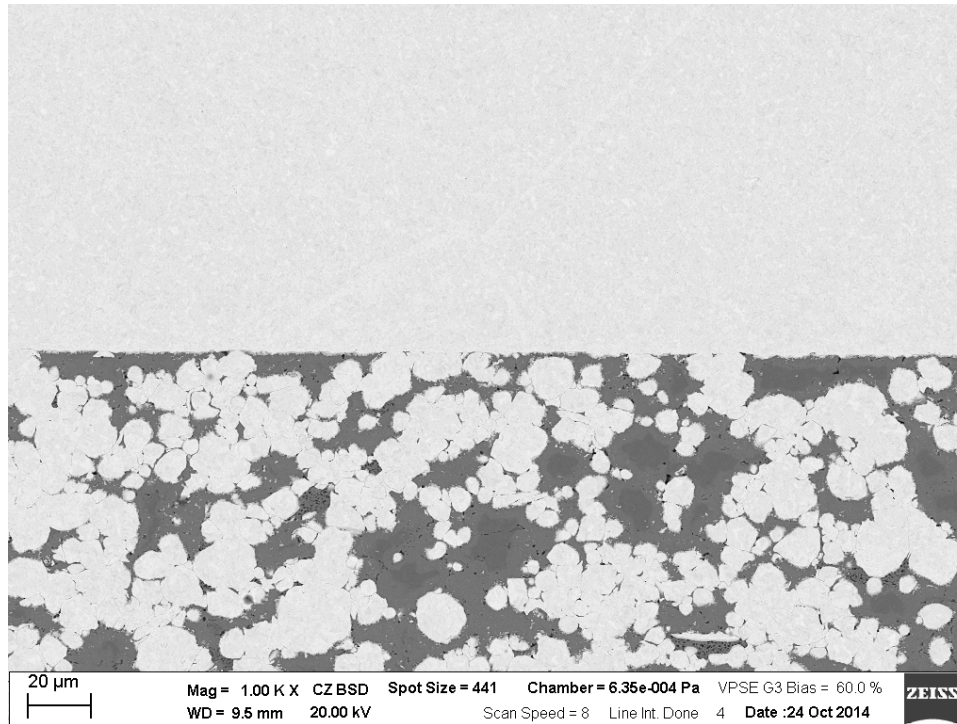


4-layer FGM on W, 1000 C
(W -20 μ m)



1b) SPARK PLASMA SINTERING

FGM formation:



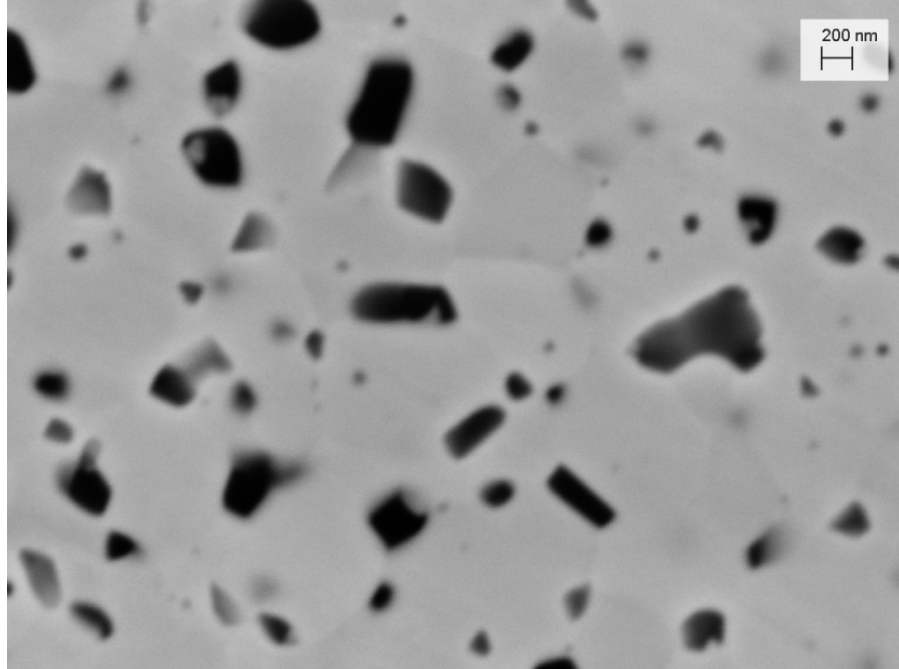
60/40 mixture on W, 1100 C
milled powder mixture, thin layer of steel powder



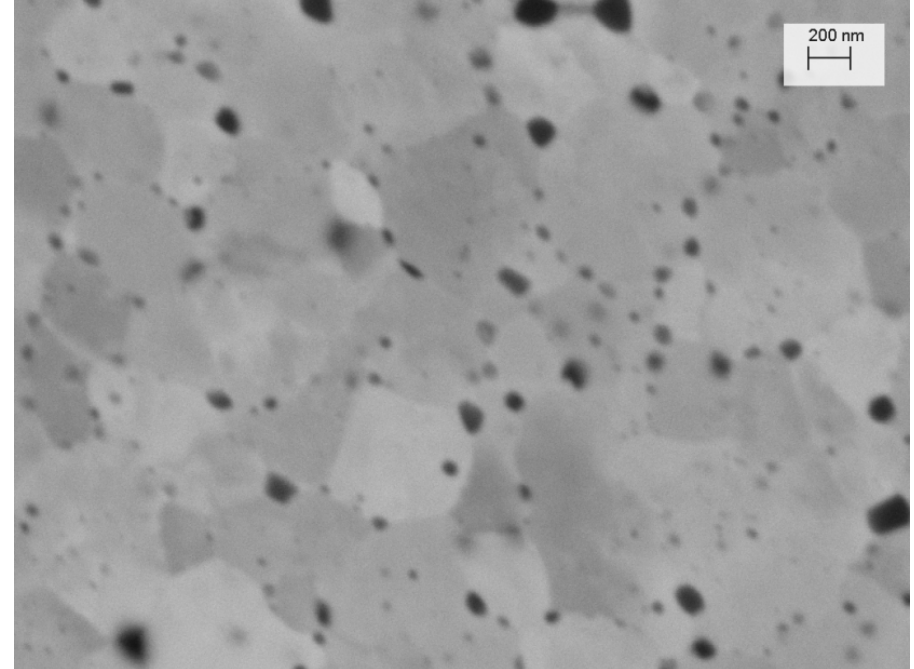
1c) SPARK PLASMA SINTERING

- **Dispersion strengthening:**
- Improved mechanical properties
- Dispersed nanoparticles
 - pinning of dislocations
 - growth inhibitor

W2.5TiC 1800 C

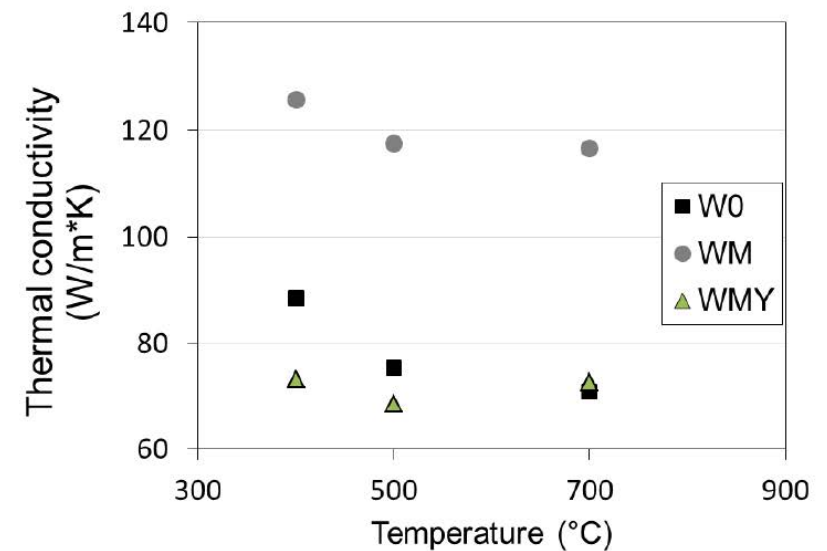
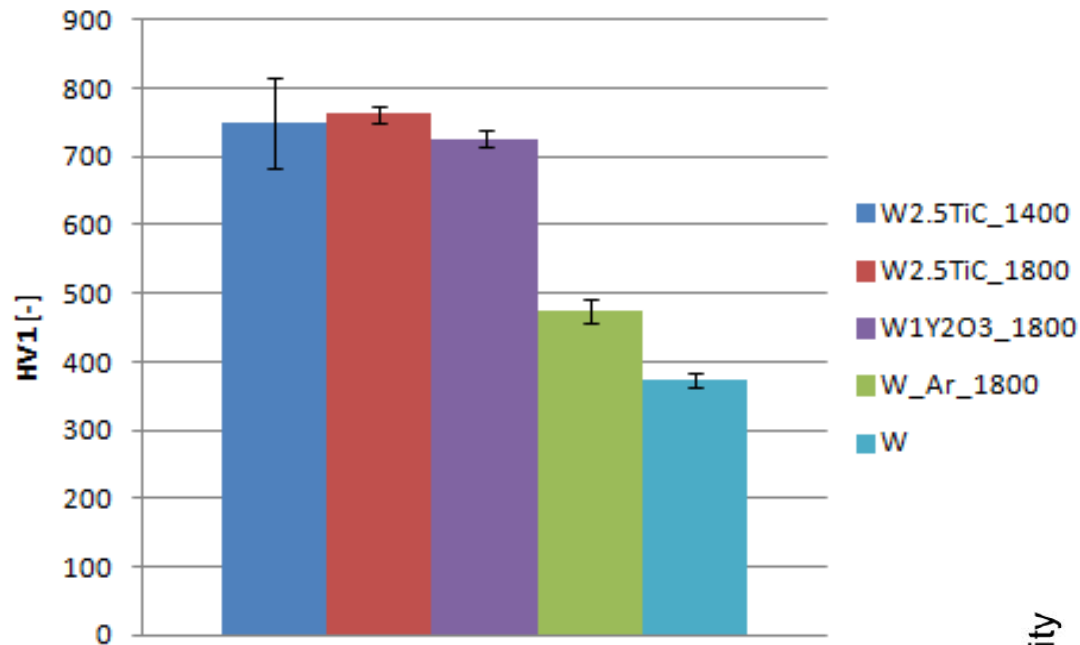


W1Y₂O₃ 1800 C



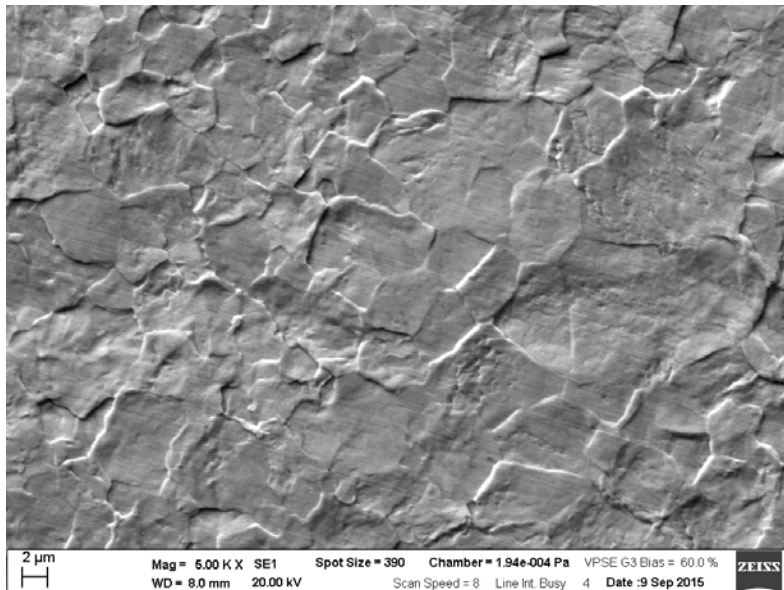


1c) SPARK PLASMA SINTERING

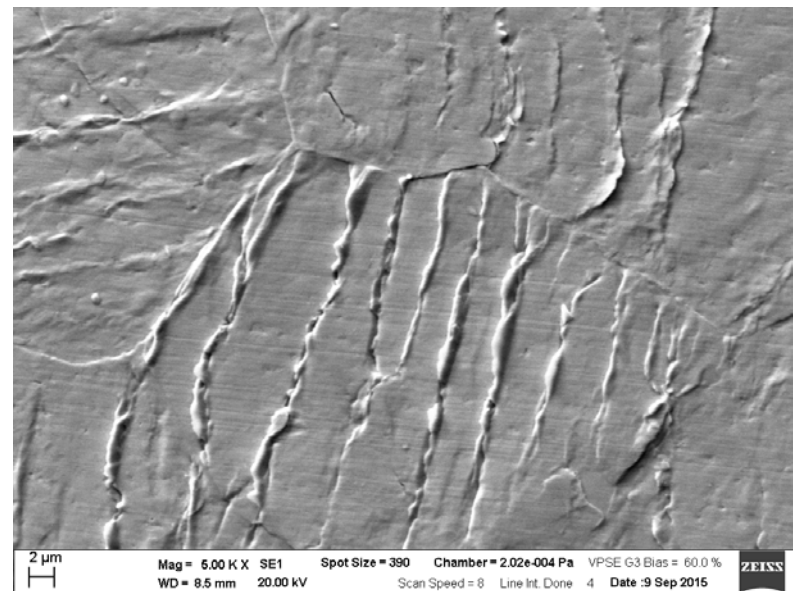


2a) Plasma-material interaction

PSI-2: ELM simulation by combined D plasma+laser loading
SPS W with varying grain size



Fine grains:
 only surface roughening
 no cracks



Coarse grains:
 moderate surface roughening
 occasional microcracks
 minor material ejection

2a) Plasma-material interaction

comparison with 'standard' W tungsten:

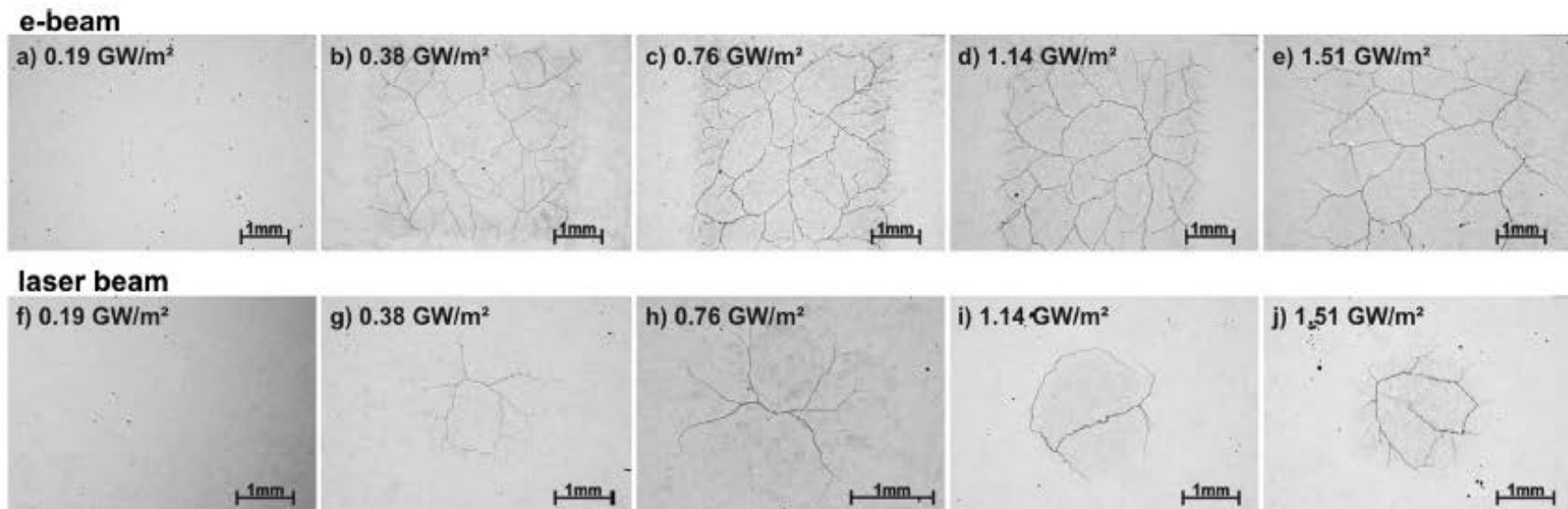


Fig. 1. SEM images of the loaded surfaces after exposure to ELM-like thermal shock events ($\Delta t = 1$ ms) simulated with an electron (top row) and a laser beam (bottom row).

↑
current loading

[Wirtz13]



Plasma-material interaction

More activities:

Pulsed plasma loading up to melting (PF6)

>> poster 2-48 M. Vilemova

Arcing on He fuzz in Compass

Exposure of various W grades to hot He gas

>> poster 4-32 J. Matejicek

Laser repair of cracked W

>> talk O26 T. Loewenhoff