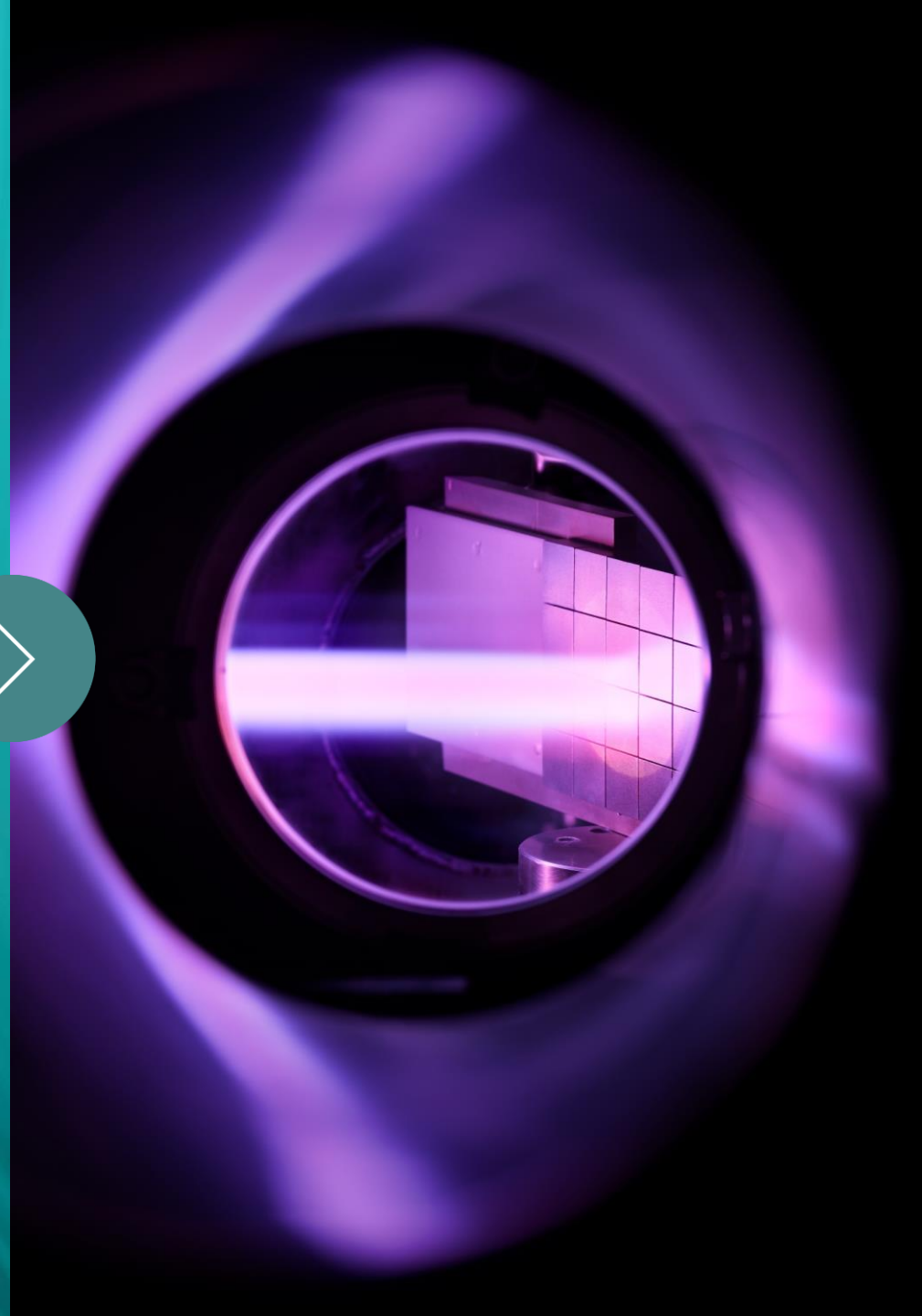
Recrystallization kinetics of different tungsten monoblocks under long term high temperature loading

Thomas Morgan, Giacomo Dose (ENEA), Marius Wirtz (FZJ), Thorsten Loewenhoff (FZJ)



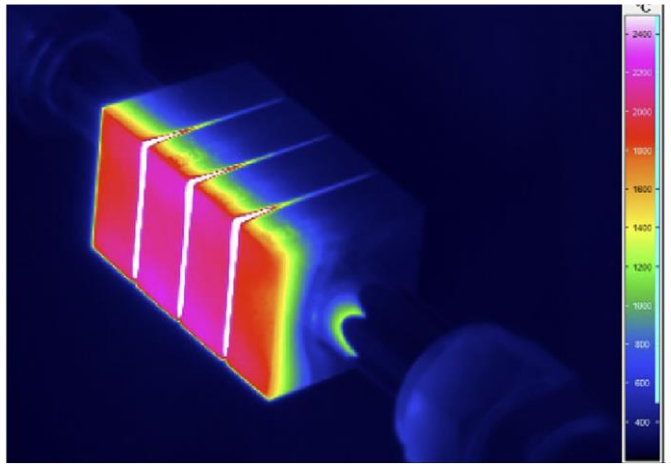
DIFFER

NWO

Background

- Behaviour of W monoblocks undergoing recrystallization important for anticipating performance in ITER
- Expect slow transients to lead to 20 MW m-2 for up to 10 s, leading to temp up to 2100 °C
- Up til now tests mainly carried out with electron beam and neutral beam (GLADIS)
- Recrystallization behaviour particularly important with respect to macro-cracking

Pintsuk International Journal of Refractory Metals & Hard Materials (2018)



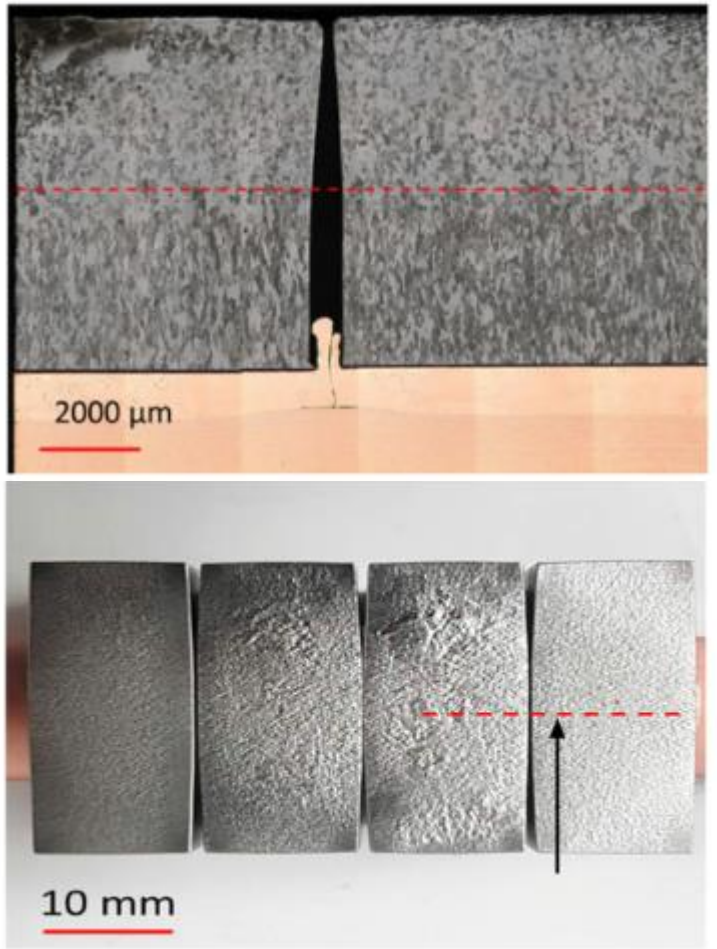
Visca FED 2018

Goals of experiment

GOALS: investigate the impact of the nature of loading (e-beam vs plasma beam) on the rescrystallization on two different grades of tungsten (ALMT vs AT&M), while expanding the literature database from previous experiements on tungsten recrystallization. Explore temperatures expected in DEMO during slow transients (plasma reattachment) Tmax~2100 °C (qaverage=~ 20 MW/m2 for tens of seconds).

Open questions

1. Does the tungsten grade have an impact on recrystallization?
2. Can we confirm the previous results of the comparison e-beam/plasma beam induced recryst.?
3. Does one observe the secondary (runaway) grain growth observed in GLADIS with cyclic loading when steady state load is applied? In other words, can we exclude the impact of accumulated plastic strain/periodic stress on this phenomenon)
4. Does one observe the surface roughness increase observed in GLADIS with cyclic loading when steady state load is applied?



Greuner SOFT 2018

Experimental approach

- Identical loading conditions to be applied JUDITH and Magnum-PSI
- 2x 4 block chains (2 grades)

- **Steady state loading** at JUDITH-2 / Magnum-PSI at constant temperature, but **different time of exposure for each block**.
- ▪ Coolant: water @ **RT, 20 bar, 30 l/min** (v = ~4.8 m/s with d = 12 mm + swirled tape tt = 0.8 mm, y = 2)
- ▪ **Gaussian beam** shape at center of blocks, **FWHM ~ 10 mm**
- ▪ **Tmax ~ 2100 °C**

Loading conditions

- **First block: 20 sec (~ 1-2 reattachment events)**
- **Second block: 3 min = 180 sec [+1 orders of magnitude]**
- **Third block: 30 min = 1800 sec (~GLADIS) [+2 orders of magnitude]**
- **Fourth block: 5 h = 18000 sec [+3 orders of magnitude]**

- H plasma, floating conditions, T_{base} ~2100 C
- Key diagnostics: **pyro**, IR-cam, TS, calorimetry

Post-mortem analysis

- **HV map** on the loading surface, Vickers (HV10?)
- ▪ **Comparison with hardness annealed samples (as received)**
- ▪ Possible **axial cross section if needed** to increase hardness measurements. (Expected recrystallized thickness ~4 mm)

Status

First round of experiments complete Feb 2021

One exposure on AT&M chain not completed due to source failure (2500 instead of 18000 s)

Visual observation shows clear recrystallized region with strong surface modification: roughening and cracking?

Currently undergoing more detailed analysis at FZJ