OLMAT as a HHF Facility for Testing ITER & DEMO Divertor Armor Materials

2023 SPA Kick-off meeting

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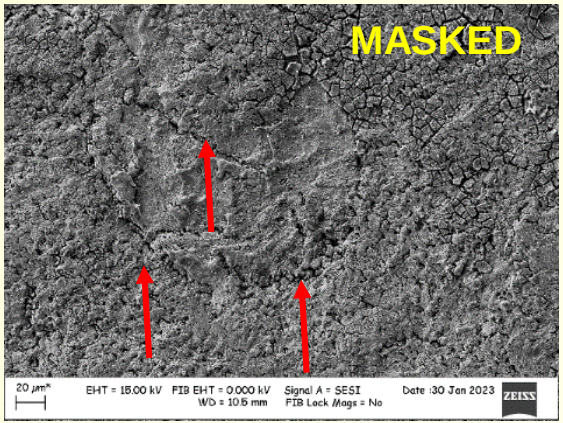
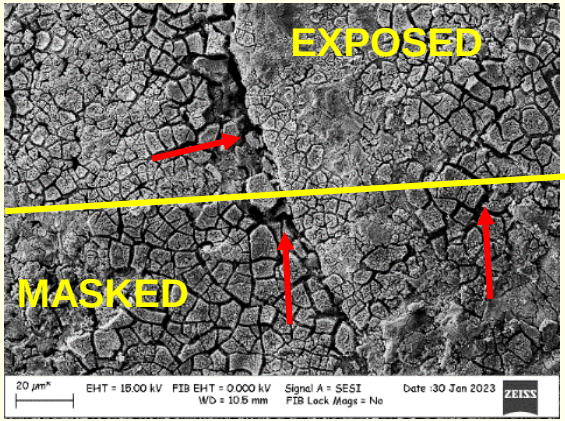
REPEAT: WfW

PoMa- WfW samples at 600-700 ºC with ΔT = 200-350 ºC:

- **934 pulses of 12-15±5 MW/m^2 every 45s: F_{HF} = 3.8-4.7±1.6 MW/m^{2}s$^{0.5}$**
- Particle flux 0.62 ·10^{22} m^{-2}s^{-1}. OLMAT range: 0.28-1.45 ·10^{22} m^{-2}s^{-1}

Complex analysis due to so a high roughness (tens μm)





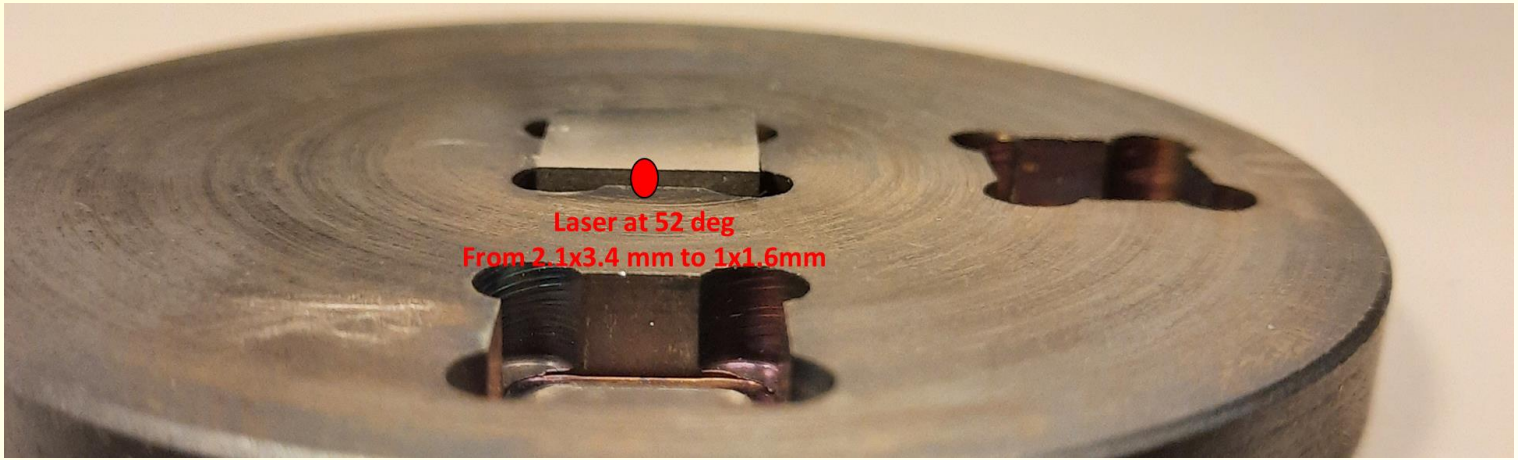
Some cracks appear but difficult to confirm, as they are also in masked part. Fabrication?

Repeat at higher pulses and polished samples.

EXPERIMENTS: laser

Test WEST disruptions conditions with our CW laser [1-2] Next week

- **Laser irradiation at edges and at 52 deg.**
- **Power 600 MW/m^2 for 2 ms (in DEMO 10-110 GW/m^2 1-4 ms)**



[1] J.P. Gunn et al., *Nucl. Mat. Ener* **27** (2021) 100920
[2] A. Durif, et al., Phys. Scr. 97 (2022) 074004.

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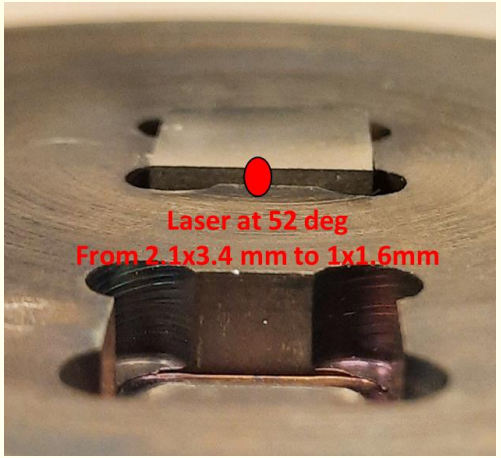
- **Make use of laser flexibility: look for damage threshold**
  - Just 1-2 pulses should cause cracking [6-7]. Test 1, 2, 4, 10...
  - Cracking threshold at different powers: 150, 300, 1000 MW/m^2
  - Heat up samples at 600 ºC: > DBTT



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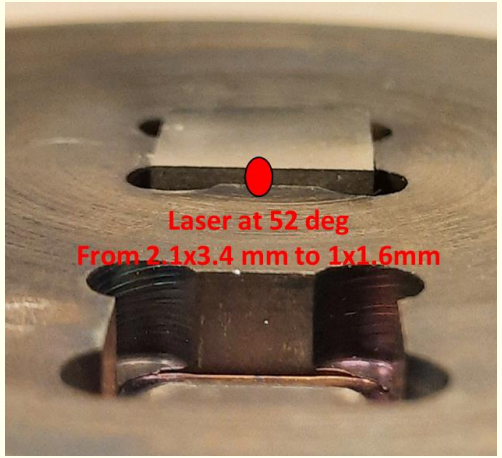
- **Make use of laser flexibility: look for damage threshold**
  - Just 1-2 pulses should cause cracking [6-7]. Test 1, 2, 4, 10...
  - Cracking threshold at different powers: 150, 300, 1000 MW/m²
  - Heat up samples at 600 ºC: > DBTT
- **Mainly ITER-like W, but also PoMa-WfW**
- **In contact with WEST (Alan Durif) to perform simulations and better define experiments.**
- **Future: steady state heat loads in edges for recristallization**



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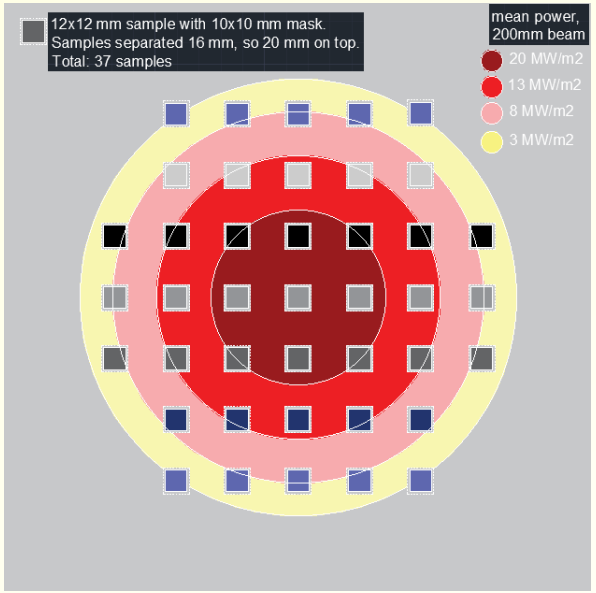
EXPERIMENTS: large holder

At beam dump: different materials at a power density distribution: late 2023

- **Use the whole OLMAT beam (20 cm) to have a power distribution** (here just an idea)
- **Different samples irradiated at the same time *to compare its fatigue resilience*. Represented by colors in the picture:**
  - **Yet to be defined** the total number of samples
  - **High power, Divertor:** ITER-like W, WfW.
  - **Low power, main wall:** SMART-W+Zr, Eurofer.



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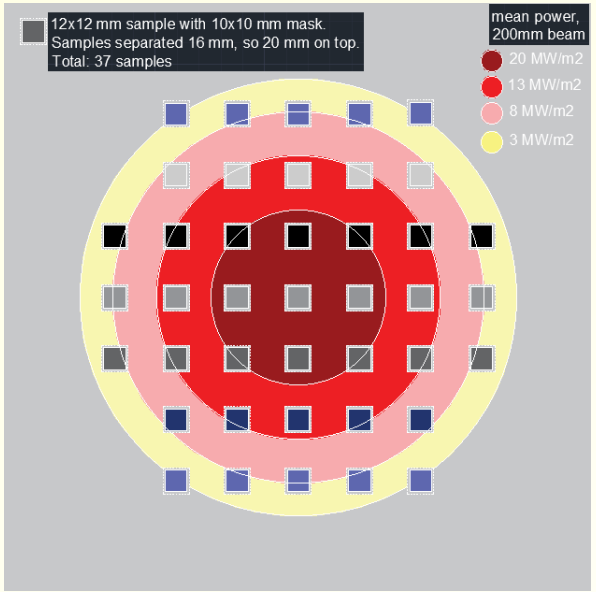
  - **High power, Divertor:** ITER-like W, WfW.
  - **Low power, main wall:** SMART-W+Zr, Eurofer.
- **One sample may be irradiated by the CW laser:**
  - Pulsed: to simulate transients (0.5-10 GW/m^2)
  - Heated continuously to T > DBTT to avoid brittle fatigue.

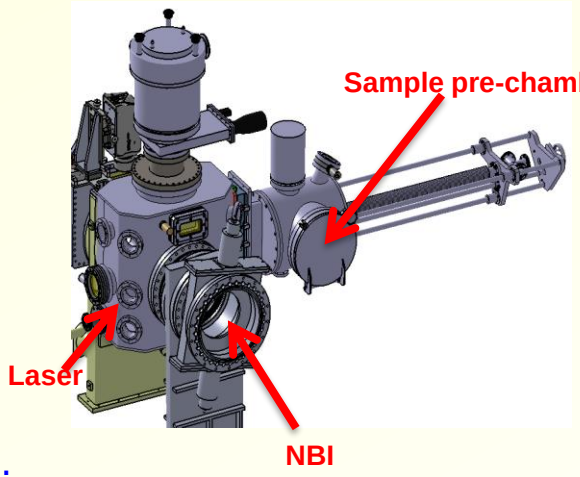


RESERVE SLIDES

OLMAT: NBI BEAM

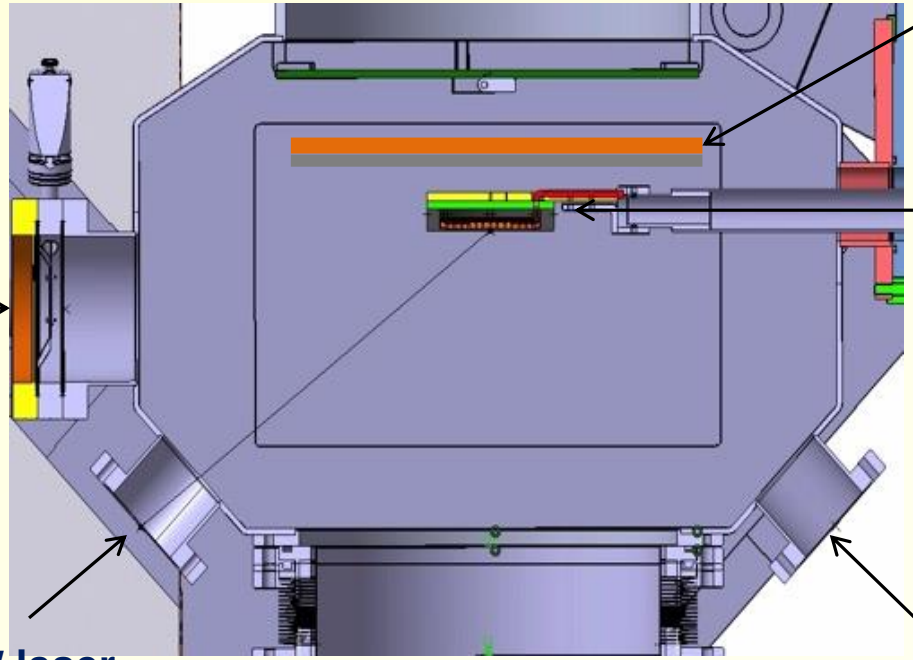
Heating a target with the NBI beam from TJ-II stellarator [2-3]

- **Devoted exposure chamber and pre-chamber with independent vacuum system.**
- **Beam power: 705 kW; H^+ energy: 8-40 keV. H^+ flux : $1.7 \cdot 10^{22}$ 1/m^2s.**
- **Wide beam:** gaussian beam with 1/e width of **20 cm.**
- **Power density between 8±2 to 55±15 MW/m^2.**
- **Pulse duration up to 150 ms.**
- **Repetition rate:** pulse every **30-120 s** depending on power
  - More oriented to **fatigue testing**.
  - 800 pulses per day achievable.
- **Developed plasma: T_e: ~2 eV; n_e: 10^{18} m^{-3}** (OES and probe).
- **Equipped with a large variety of diagnostics.**



[2] D. Alegre,et al. J Fus. Ener. **39** (2020) 411–420.
[3] F.L. Tabarés et al., Fus. Eng. Des. **187** (2023) 113373

OLMAT: CW LASER



Mirror

16-channel photomultiplier
Or
Compact fast camera

CW laser

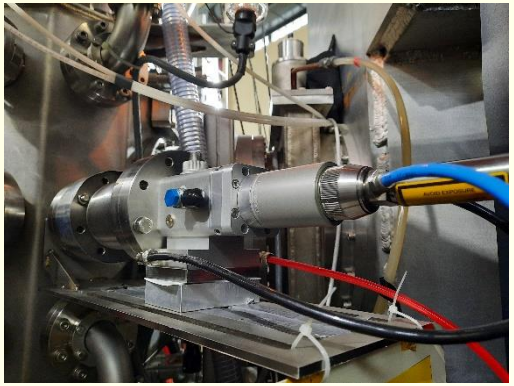
Beam dump
- Lg. sample holder
- 3 thermocouples

Manipulator:
- 2 thermocouples
- Langmuir probe
- V float and I sat

3 of:
- 2 Pyrometers
- IR camera
- OES
- Fast camera

OLMAT: CW LASER

- **Power: 930 W continuous; 9300 W pulsed.**
- **Pulses: 0.2-10 ms; 90 J energy; 10-2000 Hz**
- **NBI 55±15 MW/m^2. Synergies laser+beam**
  - **Ellipsoidal spot due to 52 deg angle irradiation**
  - **Slow installation of a industrial laser in a laboratory**
  - **Bellow to allow laser positioning on sample.**



Continuous mode:

- **ITER (or DEMO) steady state:** 10 MW/m^2 in 33 mm^2 area.
- **Slow transients:** 20-70 MW/m^2 in 17-4 mm^2 area.

Pulsed mode:

- **Mitigated ELMs**:
  - 20 MW/m^2 for 0.5 ms in 130 mm^2 area. 2000 Hz. Quite important fatigue
- **Disruptions**:
  - 1-6.5 GW/m^2 for 2 ms in 3.3-0.5 mm^2 area.

UPGRADES: beam dump

Install actively-cooled copper beam dump.

- Better protection of valves and experimental time increased.
- Place a large (280x280 mm) sample holder.
- Fabrication of copper plate failed (water leaks), so delay until autumn 2023