CIEMAT: LMD 2021 review/2022 kick-off

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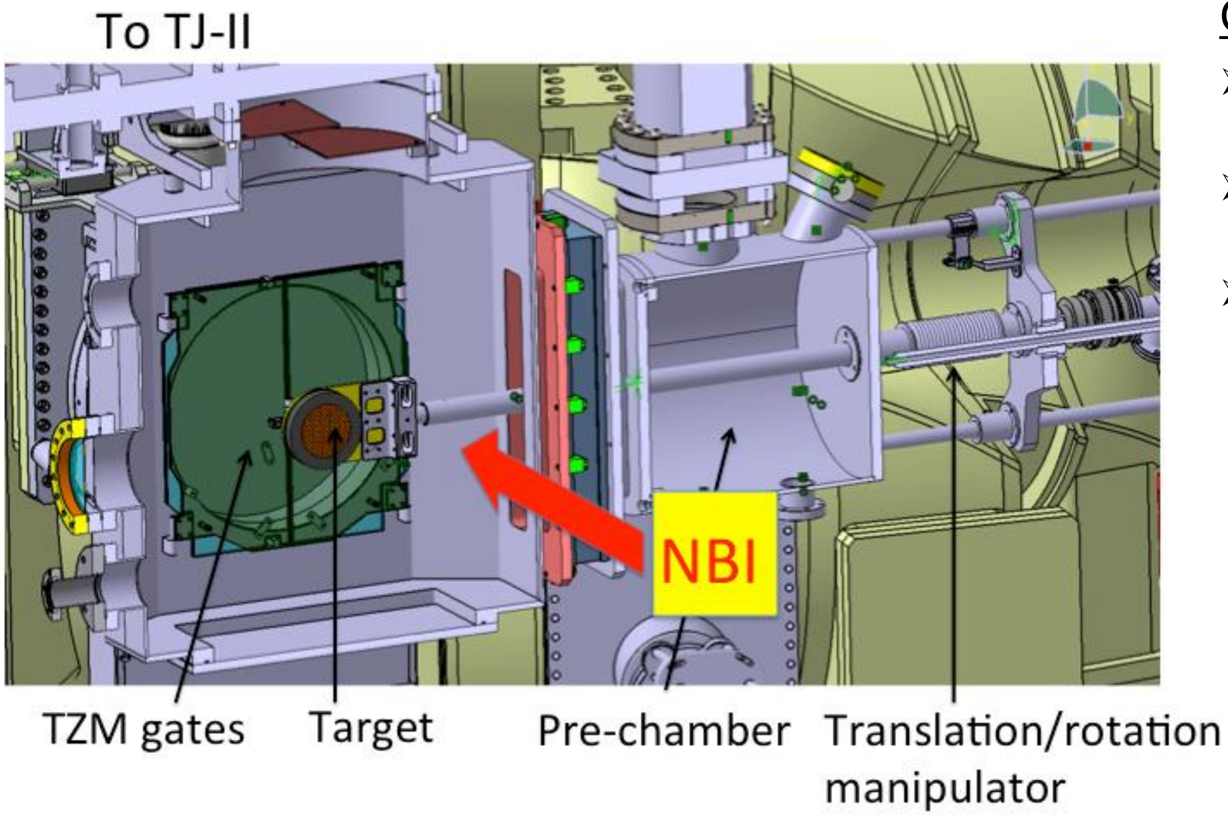
This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

OLMAT



Commissioning:

- Maximum injected power: 705 kW → 50MW/m2
- Maximum pulse length: 150 ms (at medium power)
- Minimum pulse repetition rate: every 30 s.

October campaign
Target: Three 150 μm pore size W meshes on top of the machined TZM plate wetted with Sn.

December campaign:
Target: W felt wetted with Sn (from ENEA)

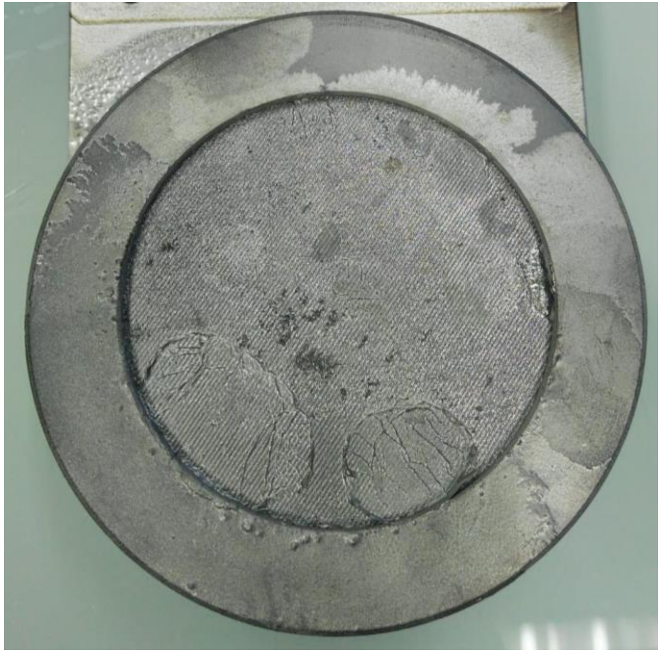
Sn/W mesh target preparation

Wetting process:

- Vacuum oven (200 mTorr) up to 1150 ºC.

Problems:

- Only partial wetting on top, rest spill through a corner.
- Oxidation.
- Bending in the middle of the mesh→ Inhomogeneity problems.

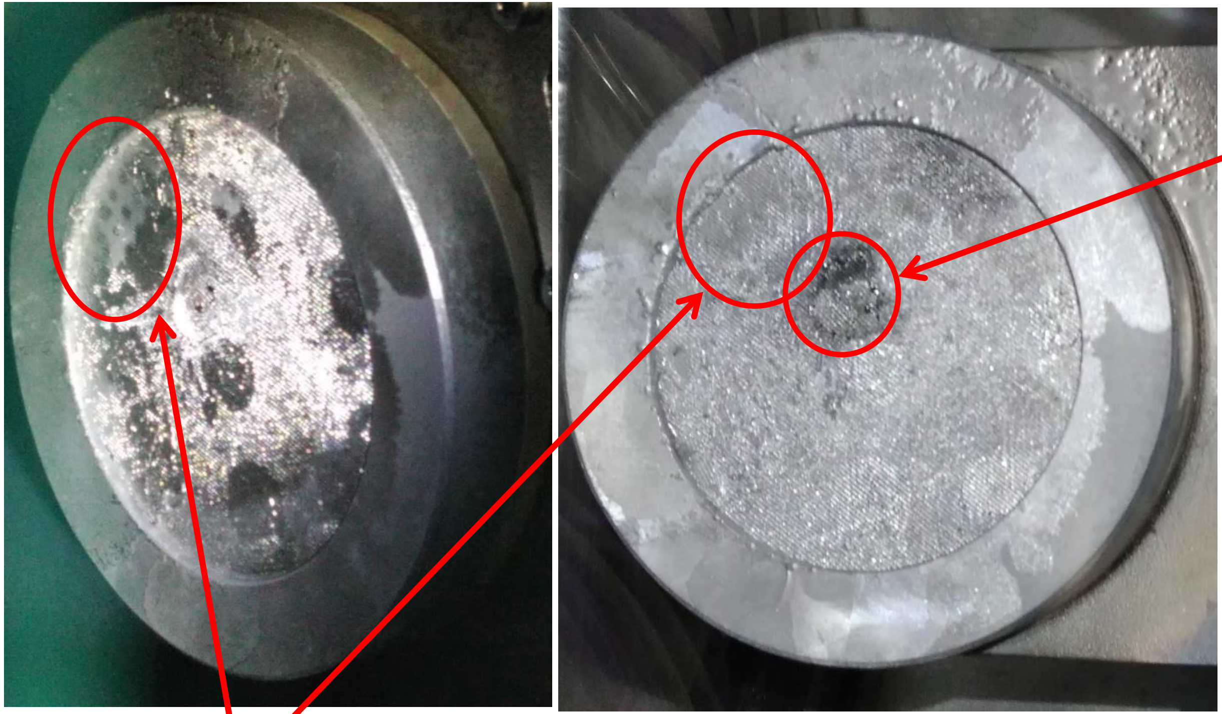


302270 280KW (H_F=15 MW/m^2) 70-110ms Ti=300 ^{0}C

File Info.
FASTCAM SA1.1 model 675K-M1
4000 fps
1/frame sec
640 x 720
Start
3000 frames
0.75 sec

Refilling during cooling and W damage

At 300 ºC　　　　After cooling down

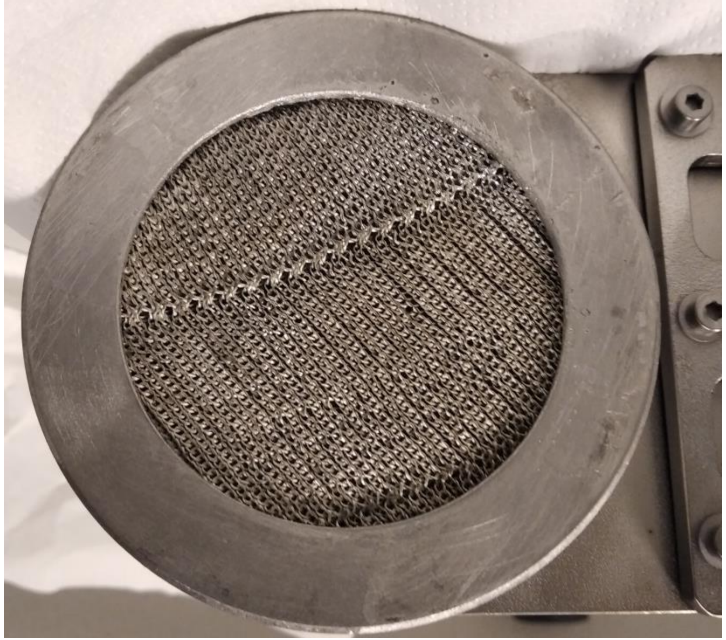


- At 300 ºC the mesh has dry out and the underlying holes can be observed while after the cooling down that part of the mesh is refilled.

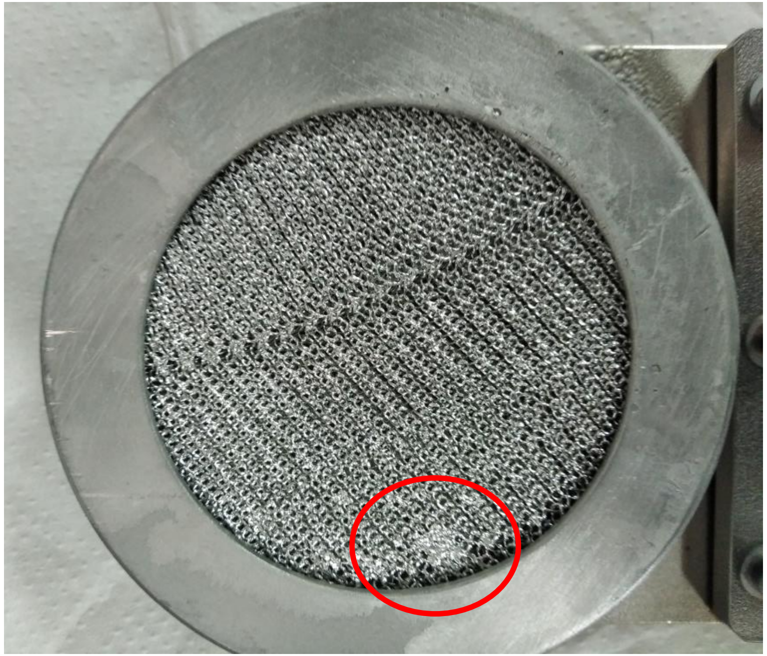
- The central part of the mesh is damaged→ The more external W mesh is gone.
- Máximum H_F=20MW/m^2.
- No refilling during pulse→ Not enough Sn in the target??.

Sn/W felt target

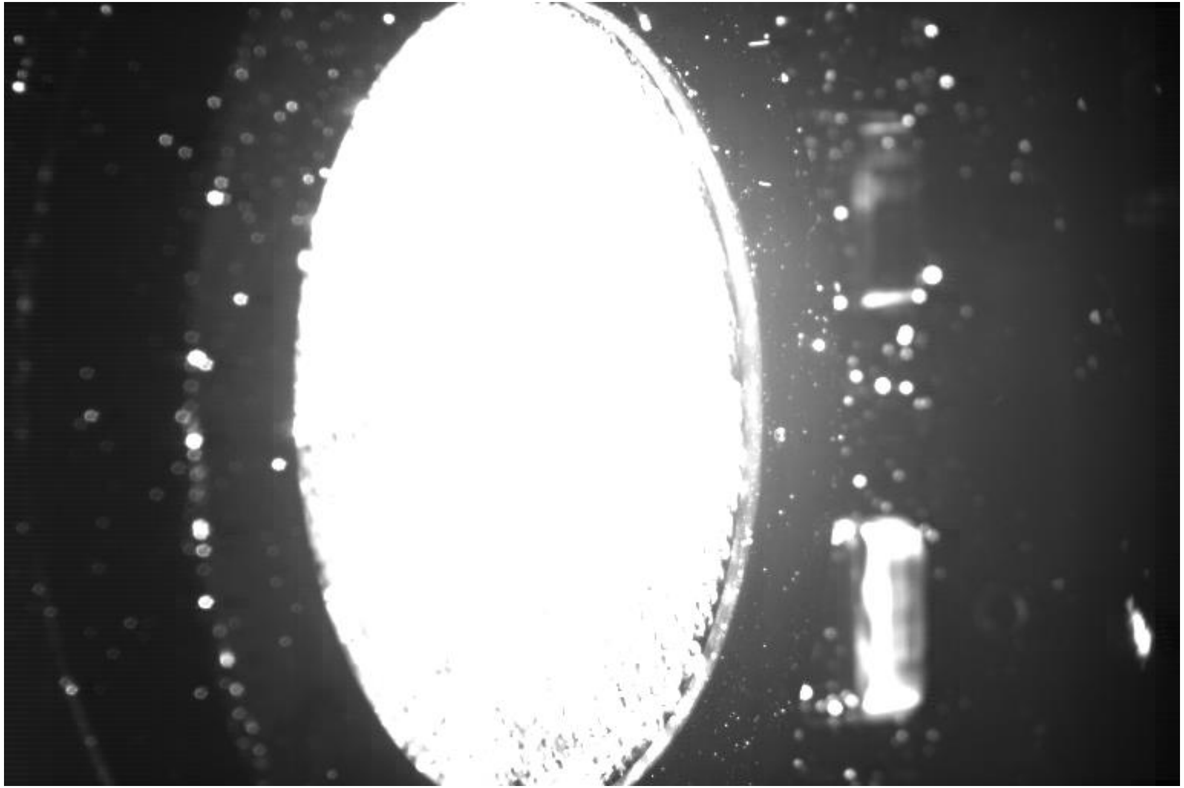
Before exposure



After exposure



302270 280KW (H_F=15 MW/m^2) 70-110ms Ti=300 ^0C



File Info.
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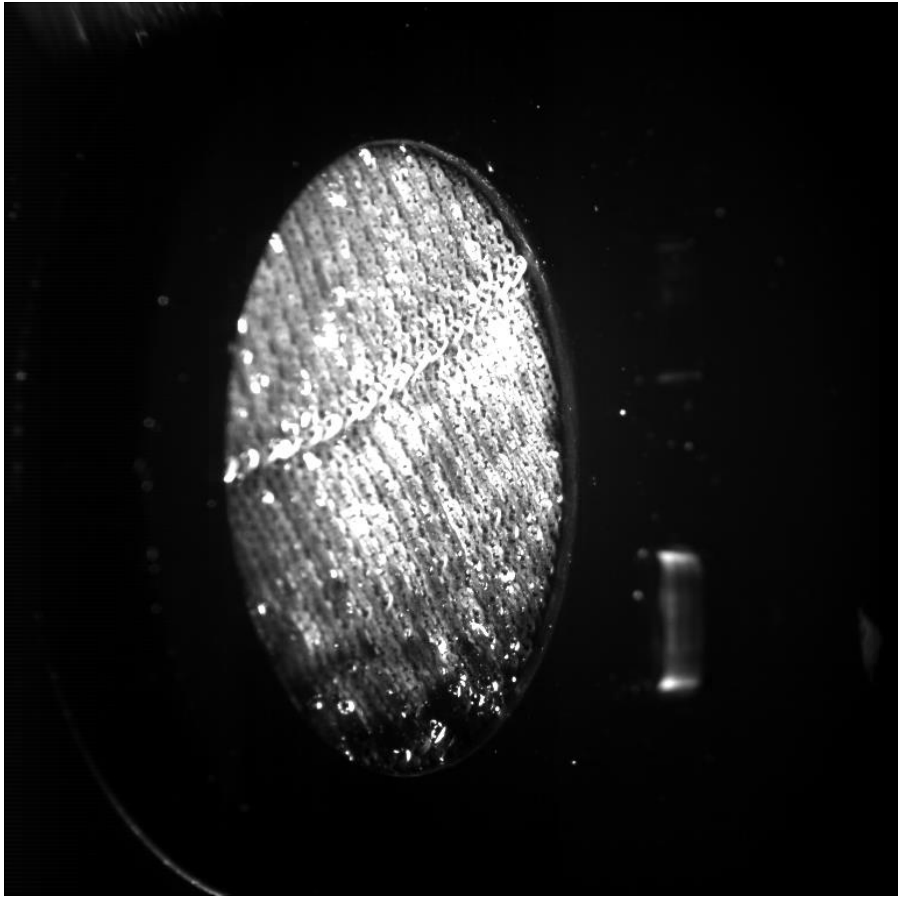
Start
1761 frames
0.1174 sec

302338 280KW (H_F=15 MW/m^2) 70-110ms Ti=460 ^{0}C



File Info.
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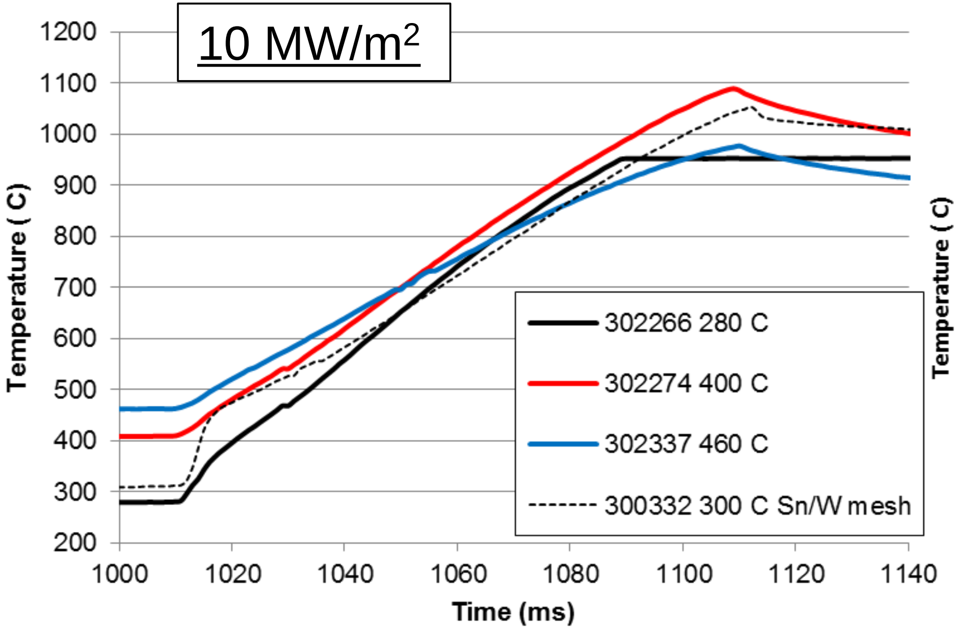
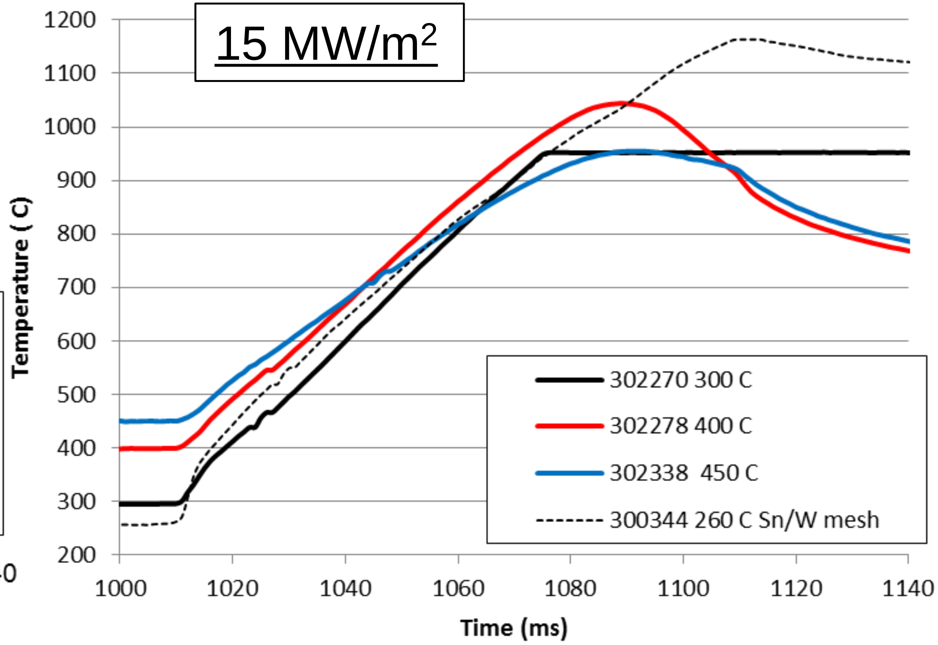
1/frame sec
768 x 768
Start
1409 frames
0.1409 sec

- Droplet ejection clearly decreases with initial temperature.
- Possible effect of CPS conditioning→ repeat in inverse order, from higher initial temperatures to lower initial temperatures.
- Possible effect of window metallization.
- No damage of CPS observed (maximum H_F=15 MW/m^2)

Surface heating comparison





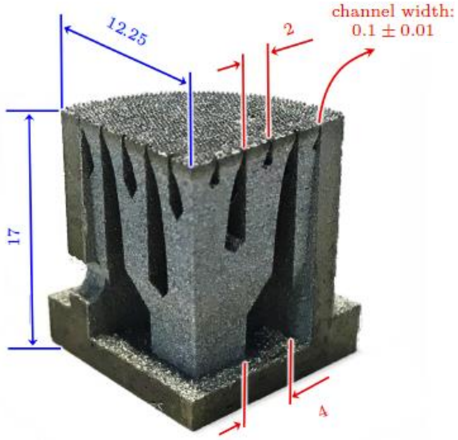
- Similar temperature increase in both CPS.
- Temperature increase decreases with increasing initial temperature→ Improvement of thermal contact with deposit?
- TZM target temperature increase about 200 ^{0}C.

Plans 2022

April campaign: 3D printed W CPS

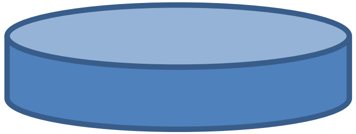
Six operational days with possibility of exposing three different targets:

- ❑ Heat flux increase with different target initial temperatures (surface homogeneity, droplet ejection…)
- ❑ Thermal heating cycles.
- ❑ Change target inclination angle.
- ❑ Witness plate at bottom of target (one witness plate for each target).



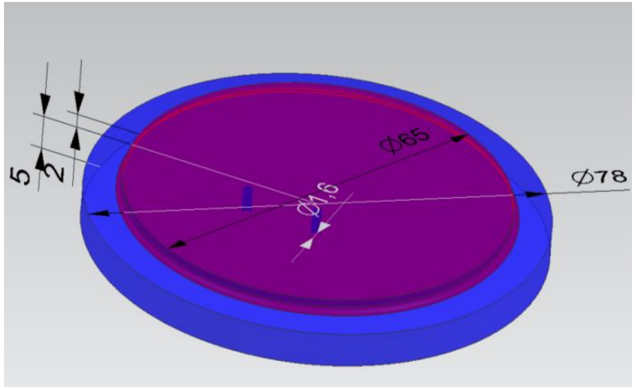
Oven sintered tungsten disc:

- ❑ Material: W, 99,95%
- ❑ Porosity: 50-55%
- ❑ Diameter [mm]: 39±2
- ❑ Thickness [mm]: 3+0,2
- ❑ Smaller pore size.



Tungsten disc sintered with a laser during the printing process:

- ❑ Sintered surface like CPS for AUG (2mm)



CW laser for OLMAT: characteristics

- **Power: <u>930 W continuous; 9300 W pulsed</u>.**
- **Pulses: <u>0.2-10 ms; 90J energy; 10-2000 Hz</u>**

1. Optical characteristics

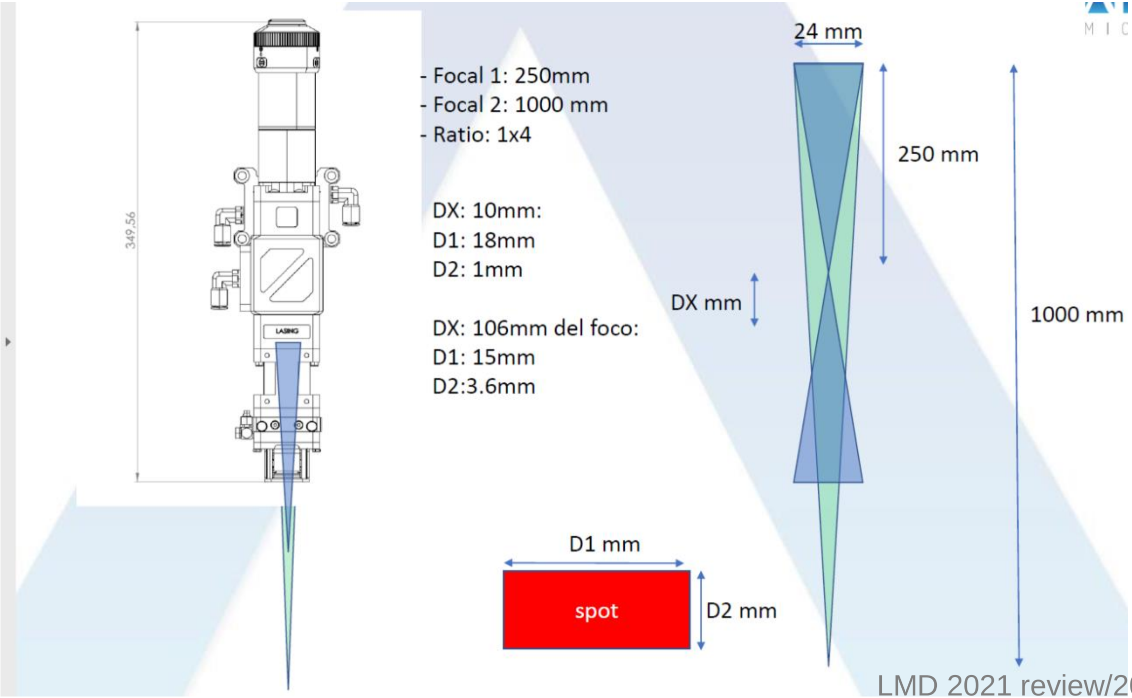
N	Characteristics	Test conditions	Symbol	Min.	Typ.	Max.	Unit
1	Operation Mode			CW / pulsed			
2	Polarization			Random			
3	CW Nominal Power		P_{nom}	900			W
4	Pulsed Nominal Power			9000			W
5	Pulse duration			0.2		10	msec
6	Pulse energy	Duty cycle 10 %, PRR = 10 Hz, Maximum power		90			J
7	Duty Cycle*	Pulsed mode				50*	%
8	Output Power Tuning Range	Pulsed mode		10		105	%
9	Emission Wavelength	Output power: 900 W	λ		1070		nm
10	Emission Linewidth	Output power: 900 W	$\Delta\lambda$		3	6	nm
11	Switching ON/OFF Time	Output power: 900 W			100	150	µs
12	Maximum Modulation Frequency	CW & Pulsed modes Output power: 900 W		2000			Hz
13	Output Power Instability	Output power: 900 W Time interval: 8 hrs (T=Constant)			±1	±2	%
14	Red Guide Laser Power				0.4	0.5	mW

**Maximum duty cycle limit is inversely proportional to peak power: 10% for 9000W, 15% for 6000 W,......., 50% for 1800W and lower*

CW laser for OLMAT: optic head

- Power: <u>930 W continuous; 9300 W pulsed</u>.
- Pulses: <u>0.2-10 ms; 90J energy; 10-2000 Hz</u>

We still do not have optic head, so different possibilities:



Circular:
Ø = 14 mm

variable

Elongated:
0.5-5x18 mm

CW laser for OLMAT: continuous mode

- **Power: 930 W continuous**
- **Operation for hours, independent/triggered with OLMAT:**
  - **DEMO-like pulses (attached o detached mode):**
    - 10-100 MW/m^2 in 0.93-0,093 cm^2 area. 400s pulses, or when reached steady state.
    - Combined with OLMAT beam 50 MW/m^2. Synergies laser+beam
    - Allow for fatigue studies of full CPS structure
  - **Vapor shielding:**
    - 1 MW/m^2 in 9.3 cm^2 area for a few seconds just before OLMAT pulse.
    - Heating LM until vapor shield temperature (e.g. 1200 ºC for tin).
    - Allows longer development and studies of vapor shielding.

CW laser for OLMAT: pulsed mode

- **Pulses: 9300W, 0.2-10 ms; 90J energy; 10-2000 Hz**
- **Operation for hours, independent/triggered with OLMAT:**
  - **Mitigated (or type III) ELMs**:
    - 10 MW/m^2 in 9.3 cm^2 area. 2000 Hz.
    - Quite large area allows fatigue studies of relevant CPS samples.
  - **Disruptions or Type I ELMs:**
    - 0.5-30 GW/m^2 in 18-0.3 mm^2 area (0.6mm spot).
    - CPS resilience against disruptions damage.
    - Studies of fatigue caused by mitigated disruptions or Type I ELMs

Future plans

Ongoing laboratory experiments:

- Test of Sn refilling time of different targets by LIBS.
- Estannane production experiments: RGA and surface analysis techniques during/after H-Sn GD-plasma exposure. Using cryotrap and optical spectroscopy.
- H_2 GD assisted wetting.

OLMAT:

- April campaign (AUG targets exposure)
- October-December campaign:
  - Commissioning and exposure of targets to laser + NBI pulses.
  - Refrigeration of target and beam dump.
  - Installation of heated windows to avoid metallization.
  - Open to the possibility of exposure of larger prototypes inserted at bottom: 300x300mm

End