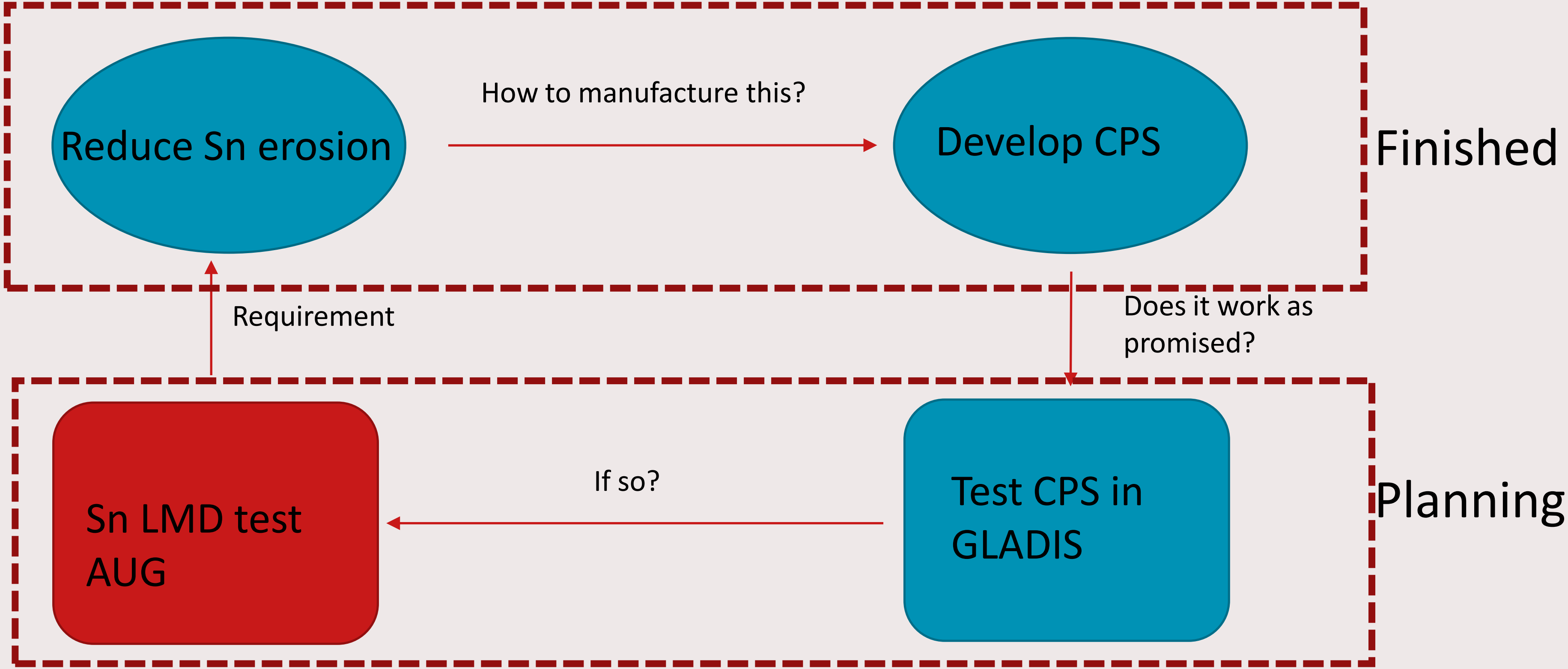
LMD review: DIFFER and TU/e

10-03-2022

Jos Scholte, PhD student

Science and technology of nuclear fusion

Overview



Reduce Sn erosion

How to manufacture this?

Develop CPS

Finished

Requirement

Does it work as promised?

Sn LMD test AUG

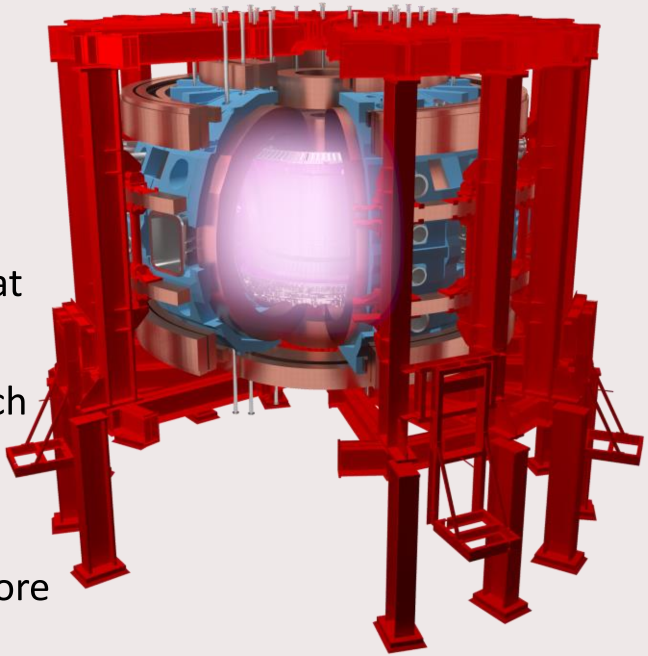
If so?

Test CPS in GLADIS

Planning

ASDEX experiments

- This summer, last day before large maintenance period

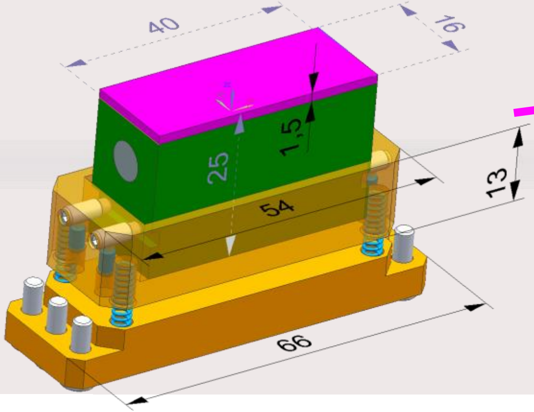


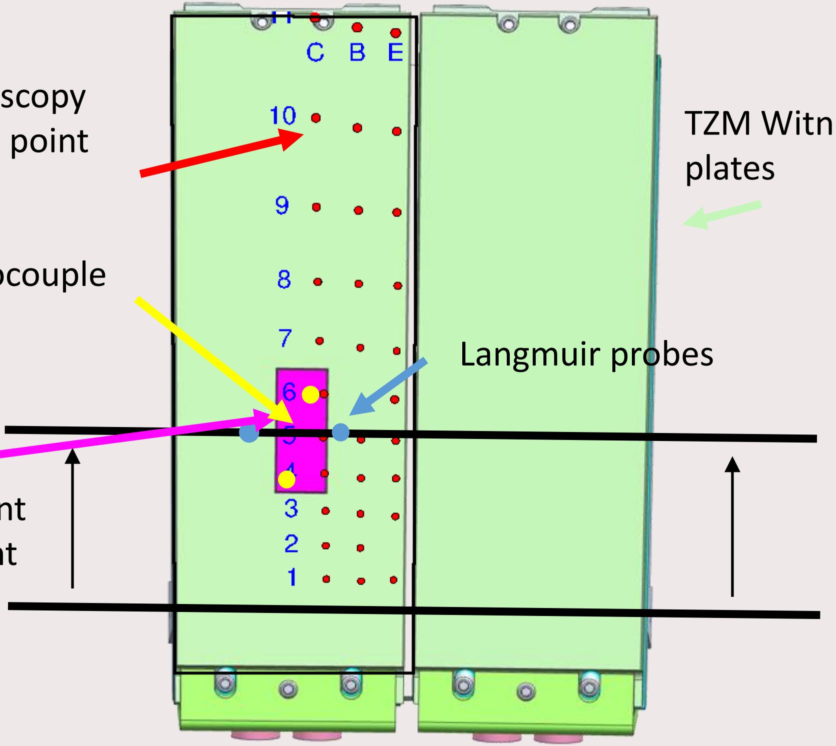
Research questions

1. How does the Sn-filled CPS design perform under high heat flux diverted conditions
2. How much material is promptly redeposited and how much transported elsewhere?
3. Where is eroded material transported?
4. Does the eroded Sn have any measurable impact on the core plasma?
5. How much D is retained in the Sn?

Target manipulator set-up

Operational mode
L-mode
H-mode, type-III ELMs
H-mode, type-I ELMs





Spectroscopy viewing point

Thermocouple

CPS

Strike point movement

Langmuir probes

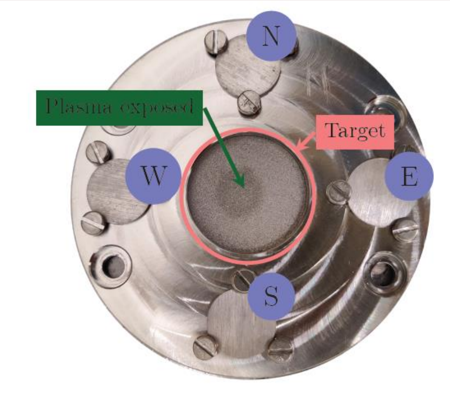
TZM Witness plates

Early experiment show significant tin droplets when exposed to a hydrogen plasma

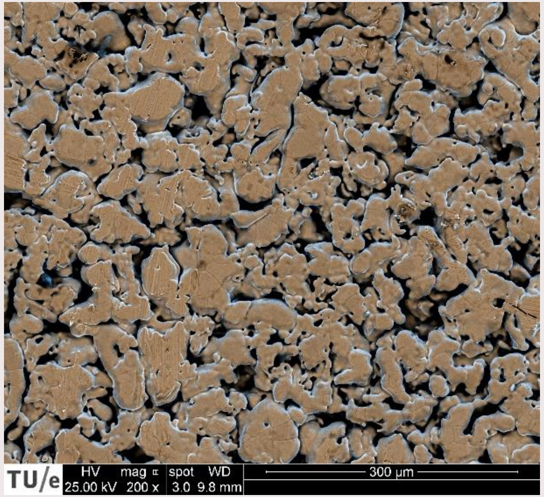
- Supersaturation of gas
- How can Sn droplet ejections be reduced?
  - Pore size reduction
  - Manufacturing procedure

Ou,2021, Supplementary video 4,6

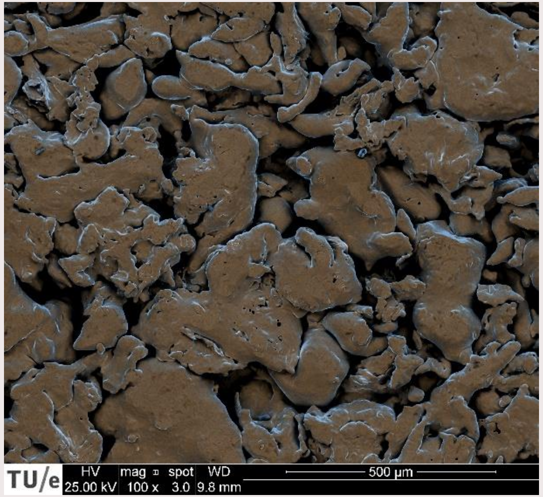
Effect pore size tested with discs



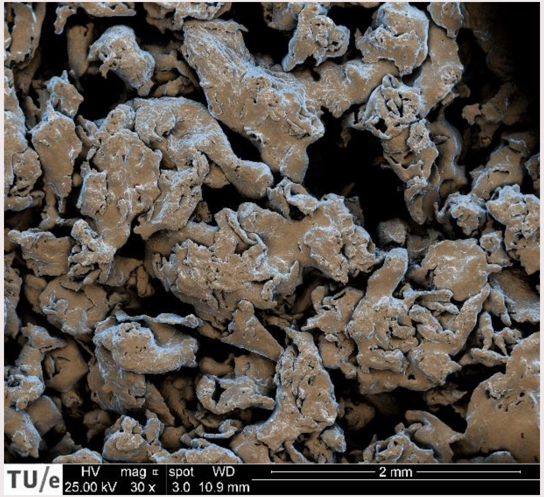
- Sintered stainless-steel
- Pore size: 0,5µm-100µm



Grade 0,5, mag=200X



Grade 10 , mag=100X



Grade 40, , mag=30X

Tungsten Targets


Sintered

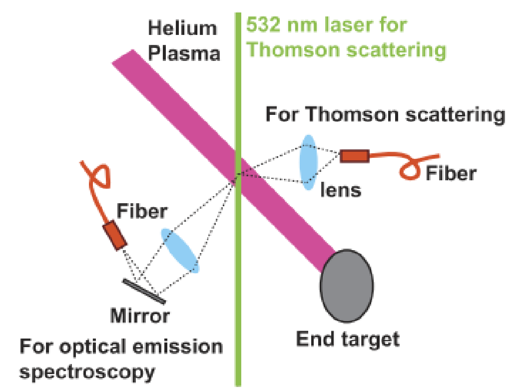

3D Printed


Felt

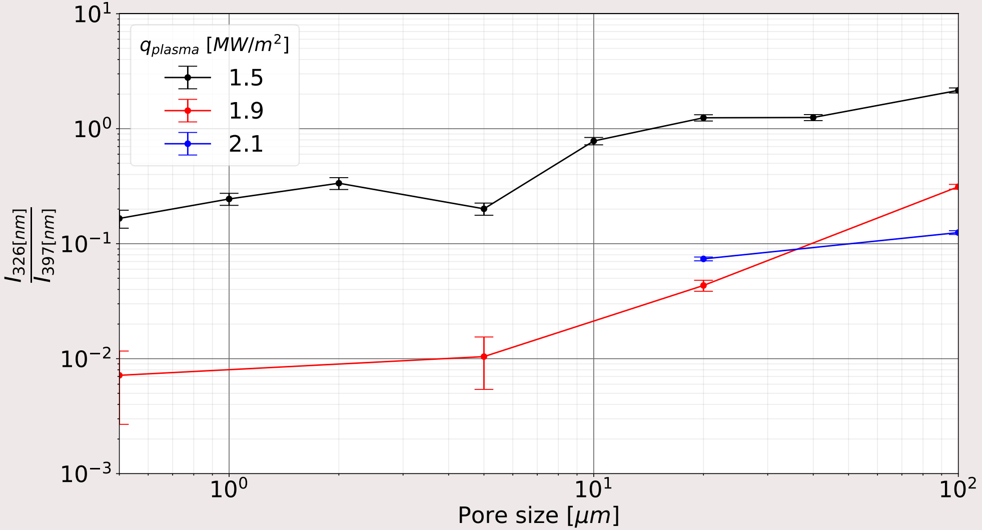

Felt strip

Spectrometer show intensity increases with pore size

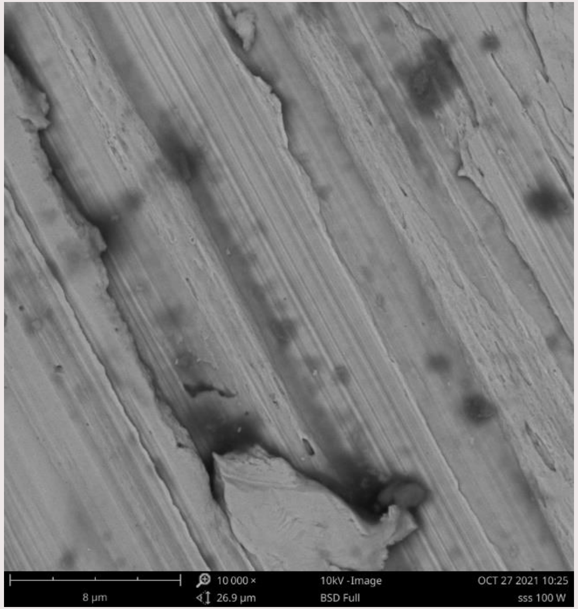
- Line integrated
- Error bar is standard deviation of the measurements
- Intensity is normalized



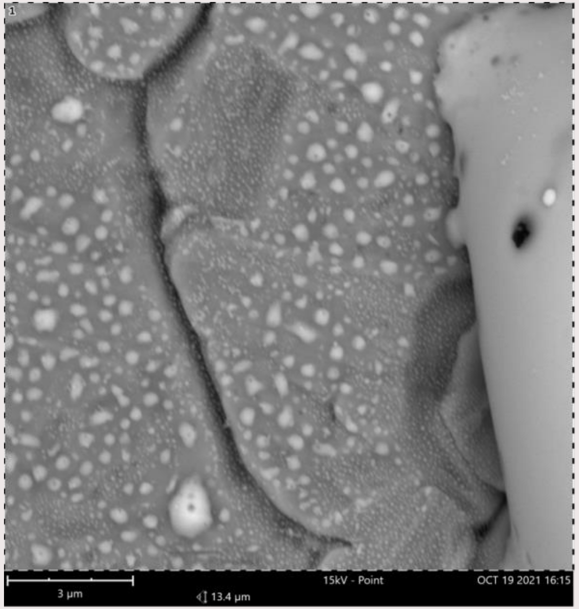
Kajita et al. 2020



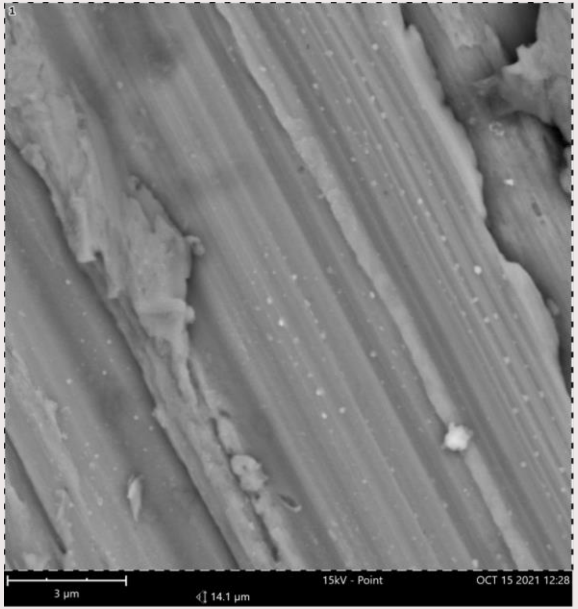
3D printed target showed most Sn erosion, but it is convenient



Sintered ss disk, grade 100



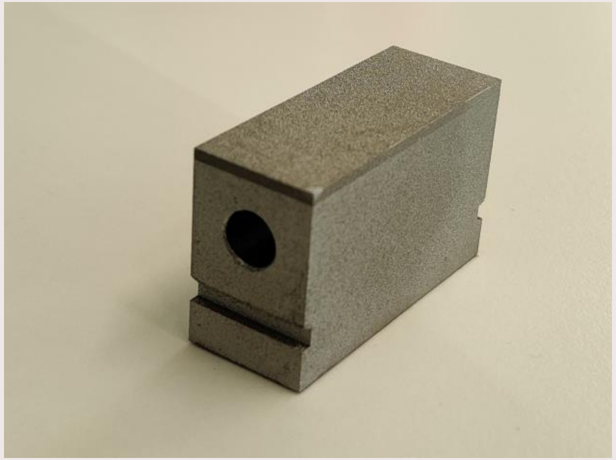
3D printed W

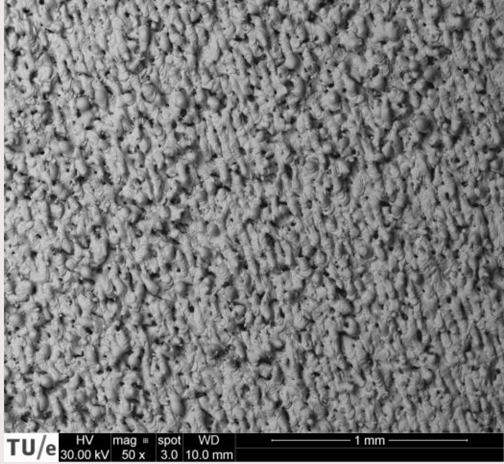


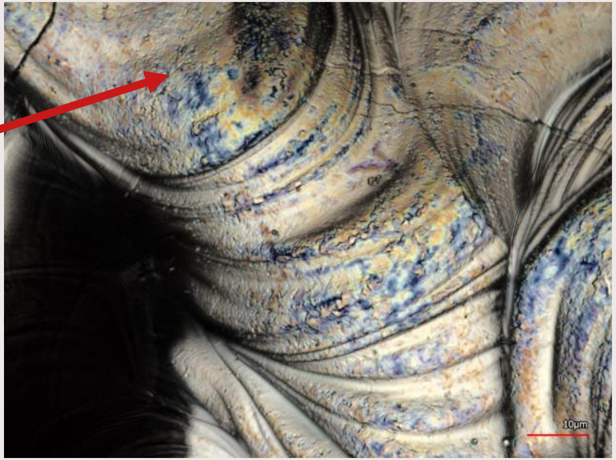
Felts W

AUG CPS

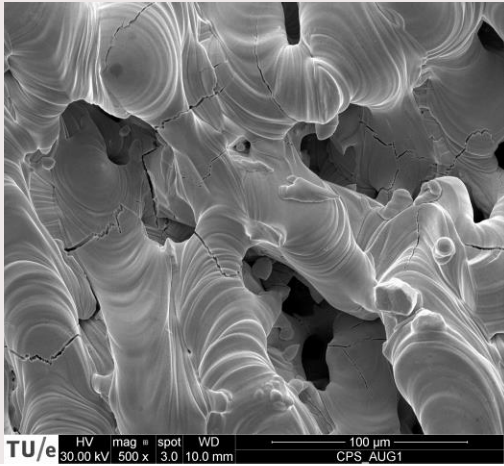
- Sintered layer using 3D printing
- Wicking test to get a better understanding of the pore size







Discoloration
due to oxidation

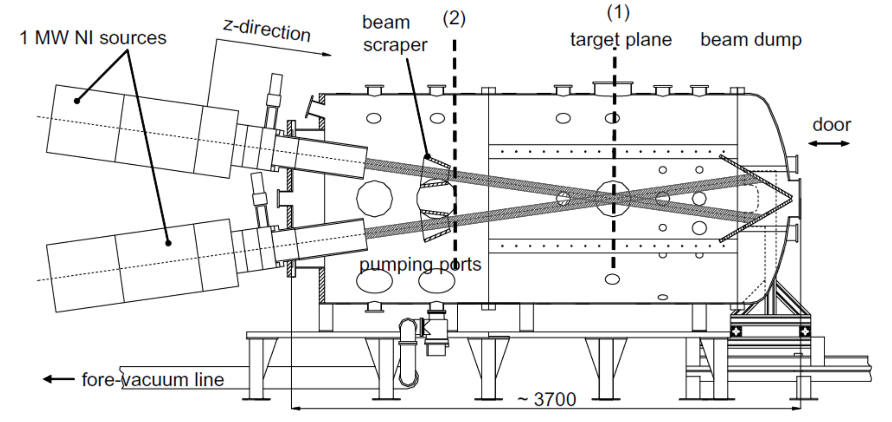


Developed in Sustainable process engineering (SPE) group, department of chemical engineering and chemistry at TU/e. Supervised by Arash Rahimalimamaghani

GLADIS test

- Expose target similar conditions as AUG
- Improve FEM model
    - Heat conductivity
    - Porosity
- Gain confidence to not exceed temperature limit in AUG

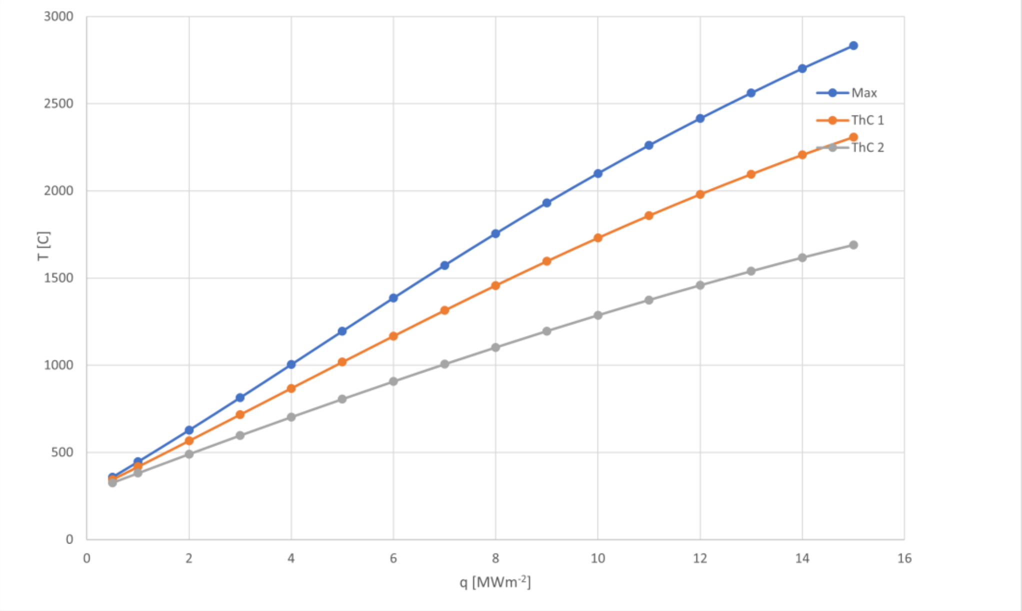
1. Dry test
2. Sn filled



Greuner et al., 2007

GLADIS relevant test

- Pulse time is 5s
- ThC1 is closer to the surface than ThC2.
- Maximum heat flux in GLADIS should be 4MW/m^2 to prevent temperature from getting higher than 1000°C
- Might want to go to 5MW/m^2 incase the model is not correct



Summary

- Reducing pore size can reduce Sn droplet ejection
- This can be achieved using sintering (with a laser)
- A CPS for AUG has been developed

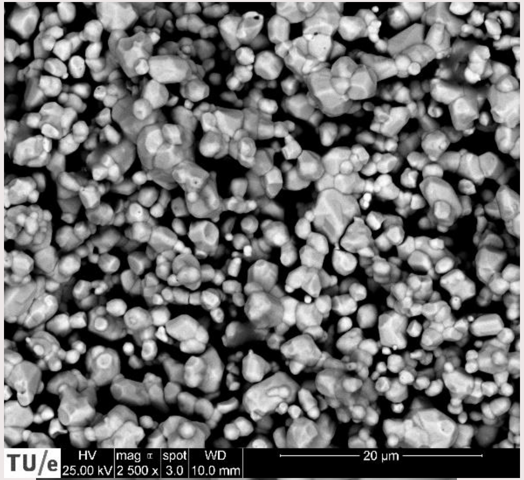
Planning

- April: Test CPS in GLADIS first dry later wetted
- Summer: Test in AUG

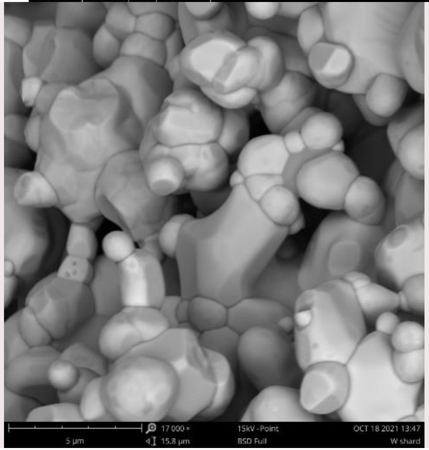
The importance of underfilling

Heater at 600C

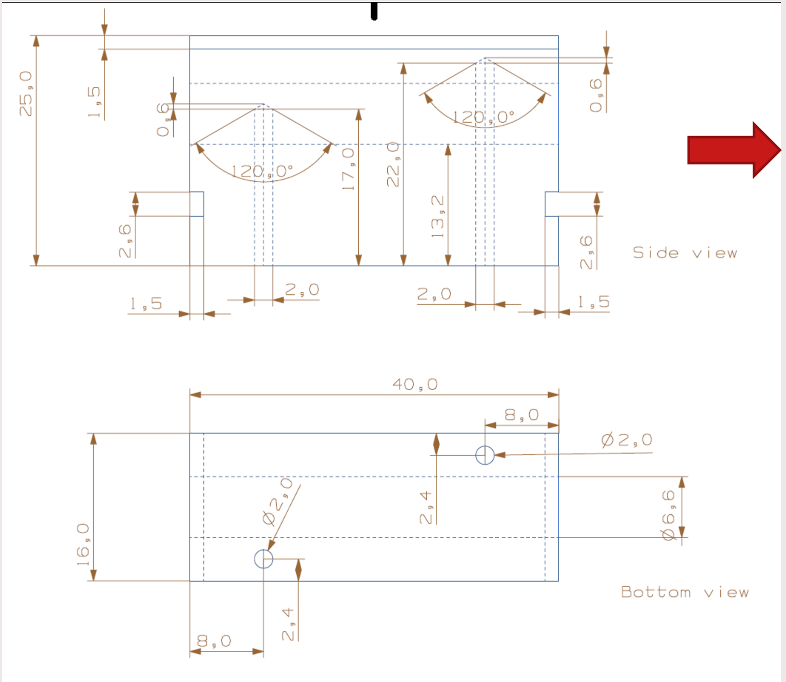
Before Wetting



After Wetting



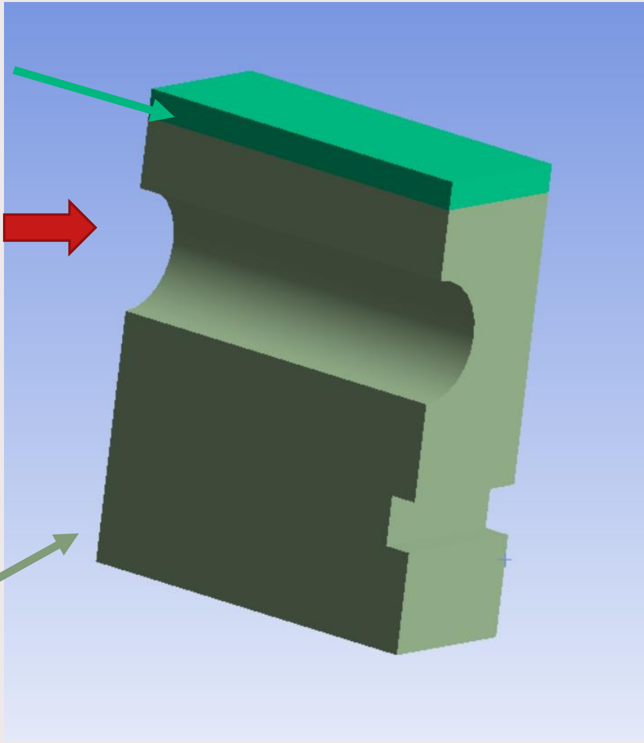
Geometry



Technical drawing, units in mm.

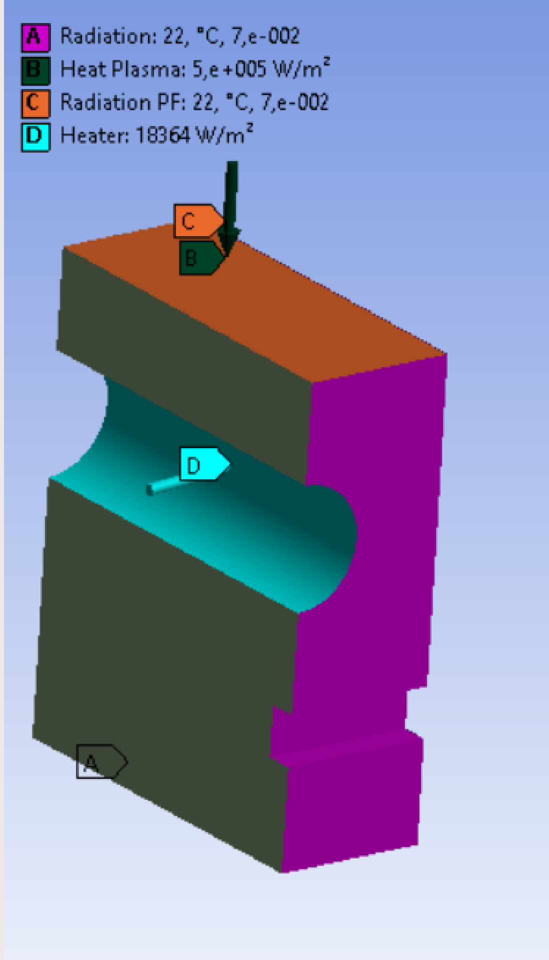
Simplification in FEM

- Bore holes neglected
- Only a quarter modelled (Symmetrical)



Boundary conditions

- Constant heat flux PFS
- Constant heat flux heater
- Radiation on nonsymmetrical surfaces
- T dependent cp, k and emissivity
- Rule of mixture for the porous material
- Porosity of 40%



Heater

- Time=600sec
- Temperature difference with sensors<0,2°C
- Use 30W for the heater