Outgassing experimental measurements for the structural material of the ITER ECH Upper Launcher

Preliminary activities

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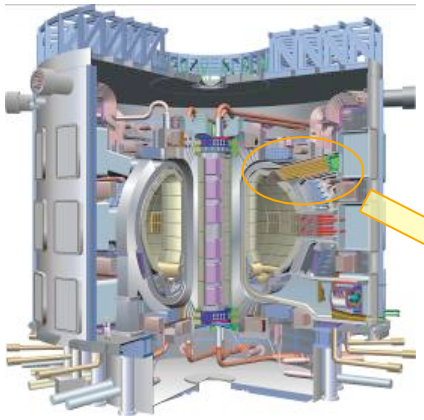
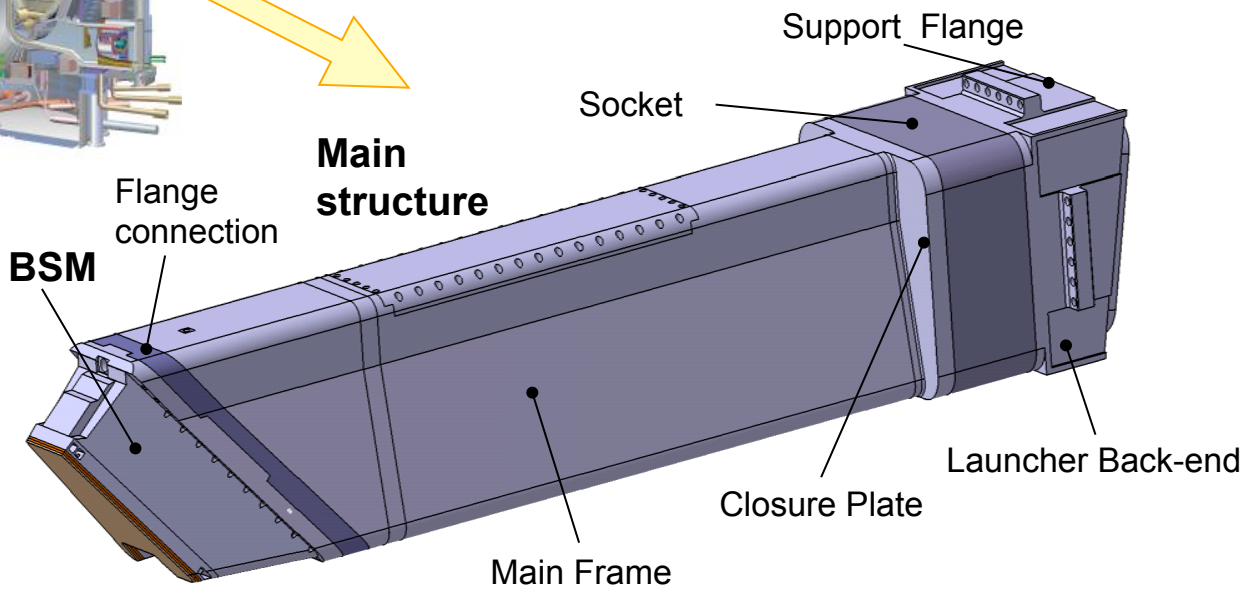
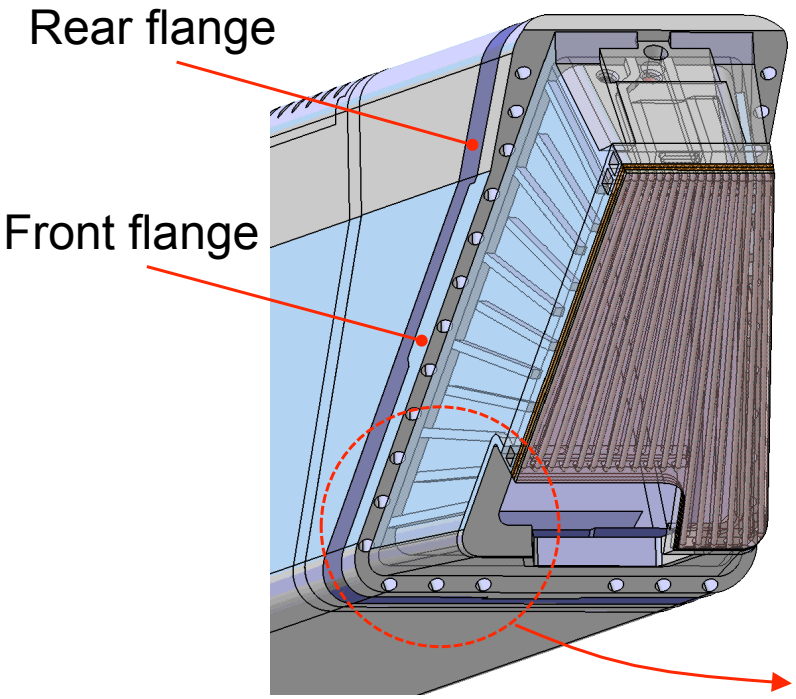
The Upper Launcher in ITER



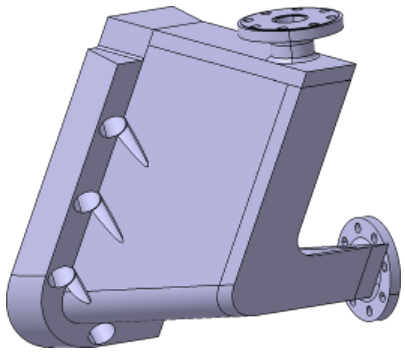
Physical mission:
control of the MHD instabilities
in the ITER plasma.



Plasma facing side

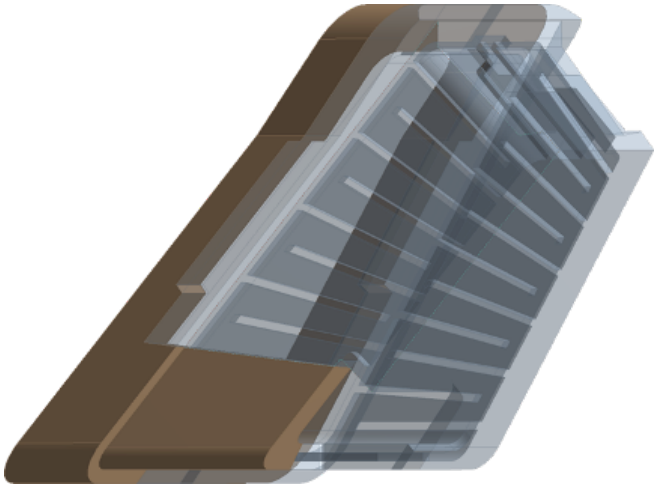


Volumetric heat loads up to 3 W/cm^3: double wall structure.



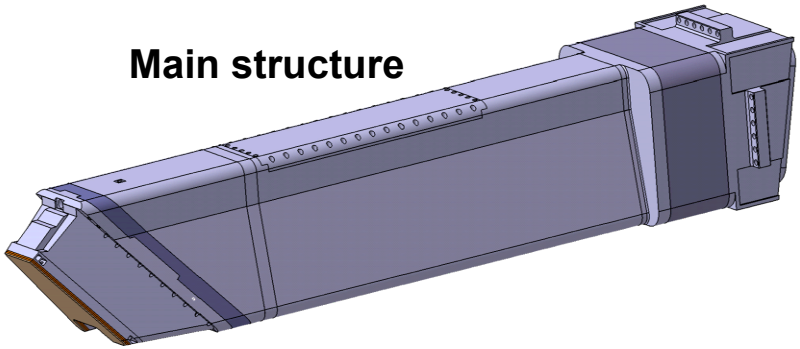
BSM Corner prototype

LHT facility at FZK



The BSM Corner prototype is installed, together with the rear flange, in the Launcher Handling Test facility at FZK for thermohydraulic analysis.

Structural material of the UL



The BSM housing and the main structure is made of SS 316 LN IG.

Normal ITER condition: T=120-150°C

Outbaking condition: T=240°C

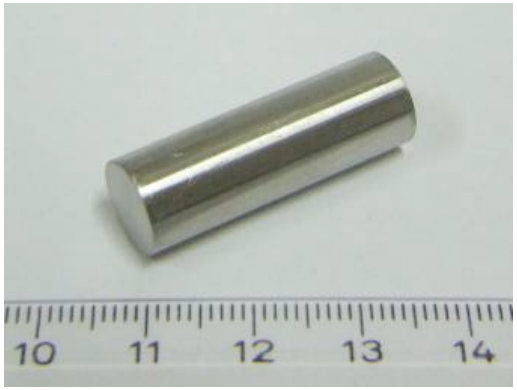
Gas released from the structural material poisons the ITER plasma!

Outgassing

- Outgassing is the evolution of gas from a solid or liquid in a vacuum.
- The outgassing rate of a solid or liquid is the amount of gas leaving per unit of time and per unit of exposed surface at a specified time after the start of evacuation, so it is measured in Pa m^3 s^{-1} m^{-2} (Pa m s^{-1}).

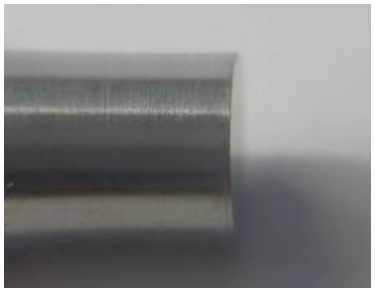
Measurements of total and partial outgassing rates are *in progress* for several SS-samples made of different fabrication techniques.

SS-samples

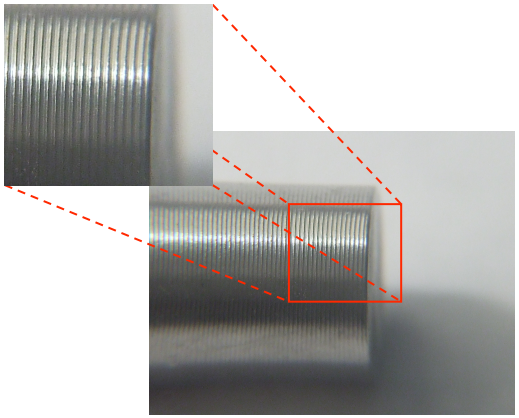


3 pairs
- SS 316 LN by P HIPing
- SS 317 LNM by Rolling
- SS 317 LNM by Rolling + HIPing

In each pair:

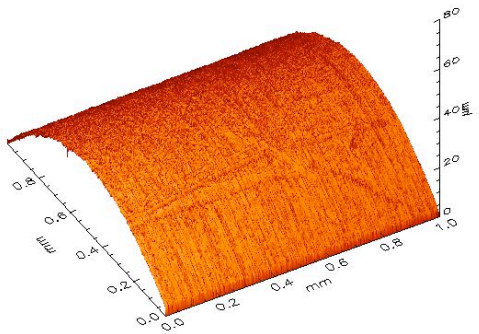


Polished sample

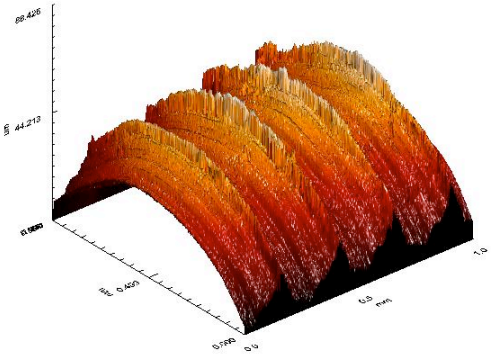


Sample with rills

Roughness measurement - 1

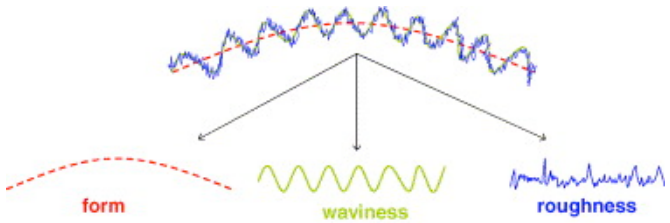


By optical method, raw data related to an area of 1 mm^2 are obtained.

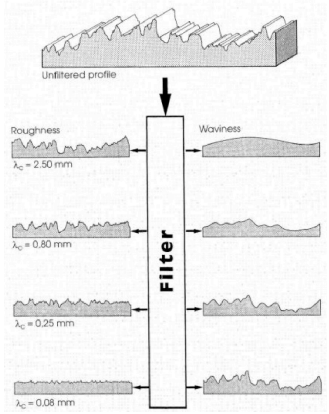


Polished sample

Sample with rills



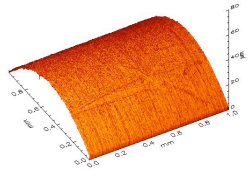
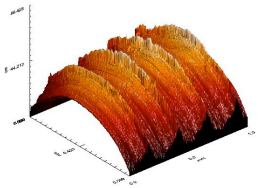
Roughness and waviness are distinguished by the cut-off length λ_c, whose value is suggested by the normative.

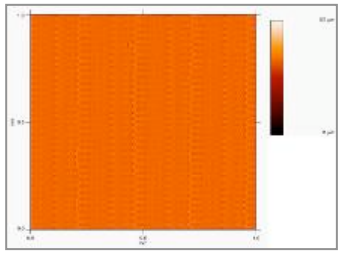


Roughness measurement - 2

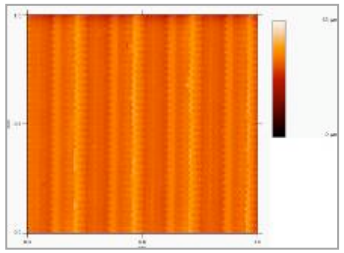
Purpose: determination of the surface factor of each sample

$$f_s = \frac{A_r}{A_g}$$

-  ⟶ Roughness profile and parameters ⟶ $f_s \approx 1.2$
-  ⟶ 2 tests were made for SS 316 LN



Roughness profile without rills (λ_c = 0.029 mm). They are considered waviness.

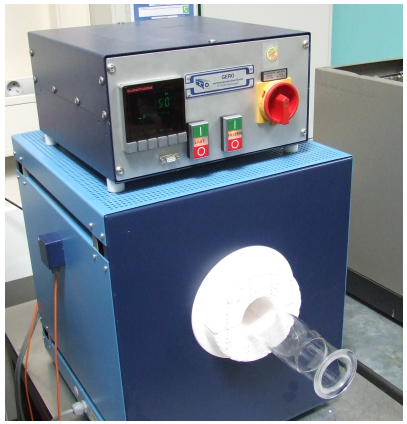


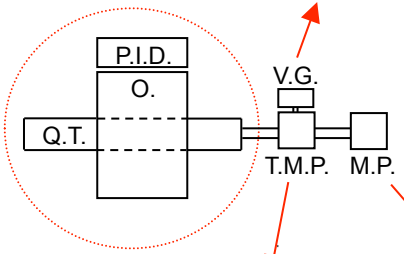
Roughness profile with rills (λ_c = 0.143 mm).

Same result as f_s!

The surface factor is calculated as in the polished case: $f_s \approx 1.8$

Vacuum test



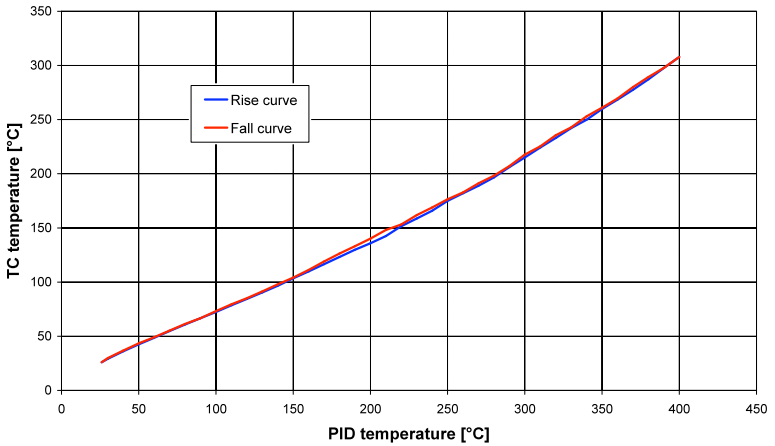


Vacuum test setup: a pressure of $5*10^{-7}$ mbar is reached inside the quartz tube, at room temperature.

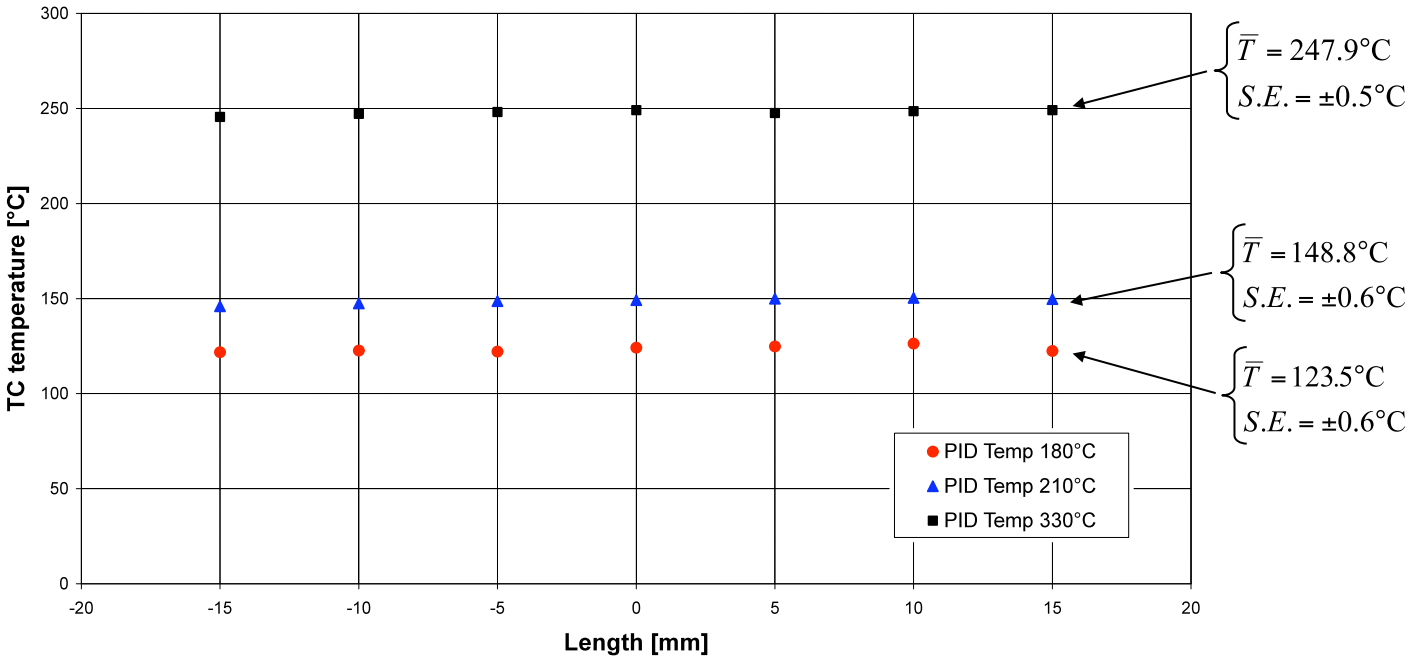
Temperature calibration - 1

Comparison at atmospheric pressure of the temperature readings between the PID controller and a K-thermocouple inside the quartz tube.

Calibration curves in the mid-point of the oven: mean values on 30 min, 1800 samples.



Temperature calibration - 2



New steps

- Temperature calibration under vacuum.
- Total and partial outgassing measurements:

$$Q = (P_1 - P_2) * \frac{C}{A}$$

- Comparison with the ITER requirements. The required outgassing rates at 100°C for hydrogen isotopes and impurities are respectively $1*10^{-7}$ and $1*10^{-9}$ Pa m s^{-1}.

At 200°C, the measured Q for steel is $1.1*10^{-5}$ Pa m s^{-1}.

It is difficult to satisfy these requirements!!!

Other activities

Attended conferences and training courses:

- Russian-German Workshop on ECRH and Gyrotrons (Greifswald, May 2009);
- 2nd Summer school on fusion technologies (FZK, September 2008);
- Catia and Smarteam.

Planned conferences and training courses:

- Effective negotiations (Karlsruhe, 29-30 June 2009);
- EUROMAT (Glasgow, 7-10 September 2009);
- Project management.