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Outgassing Measurements for the ITER EC H&CD Upper Launcher

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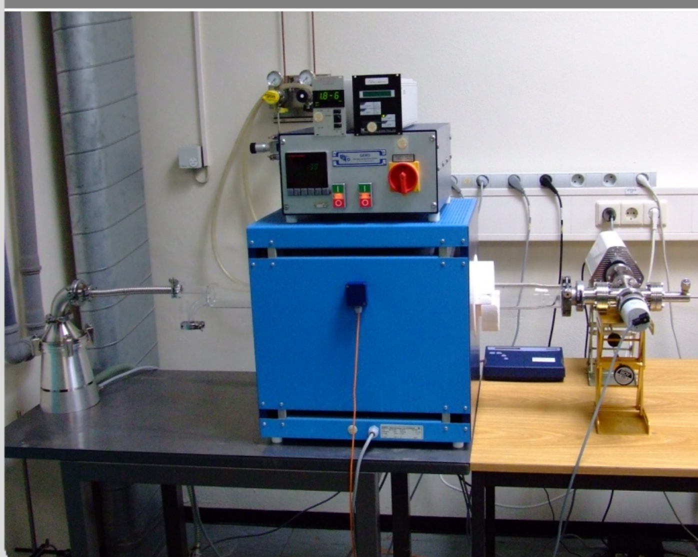
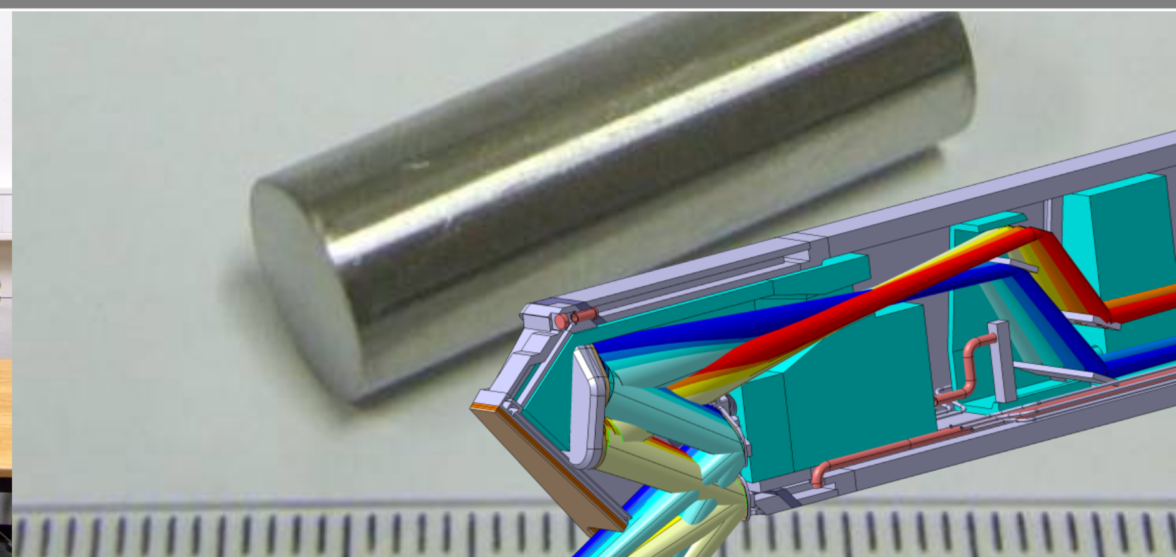
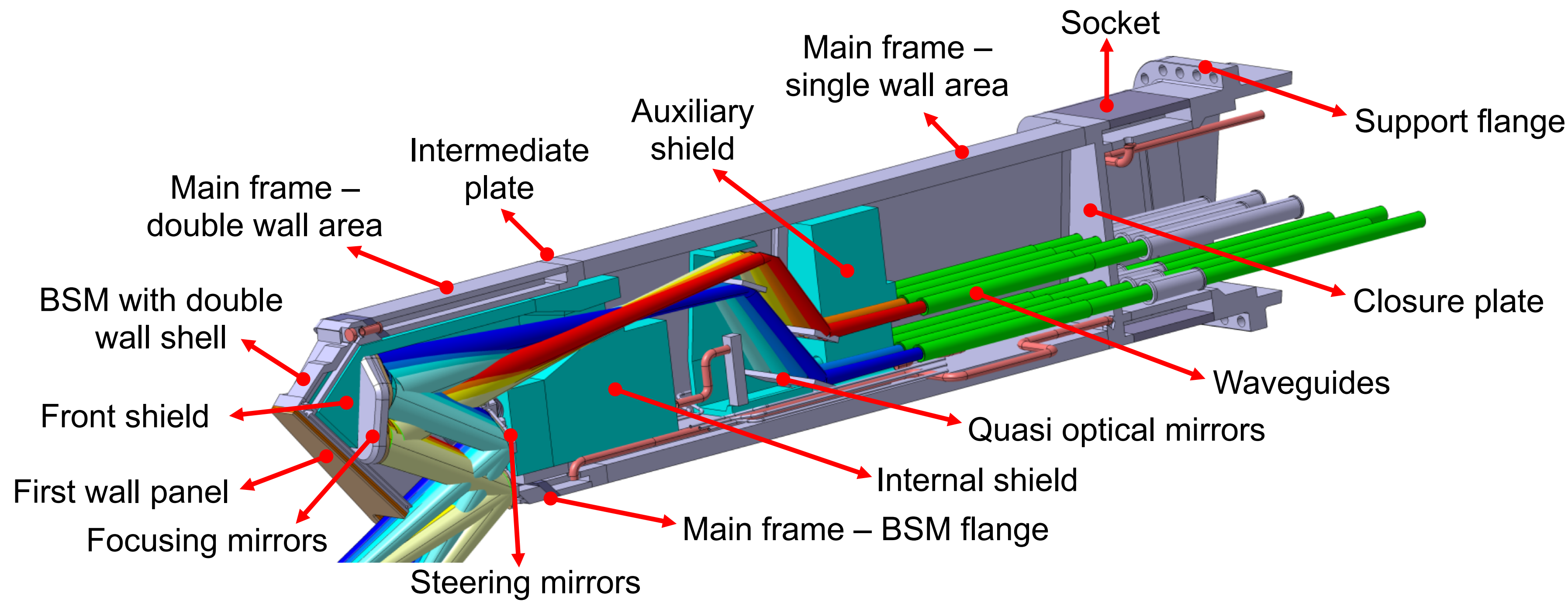




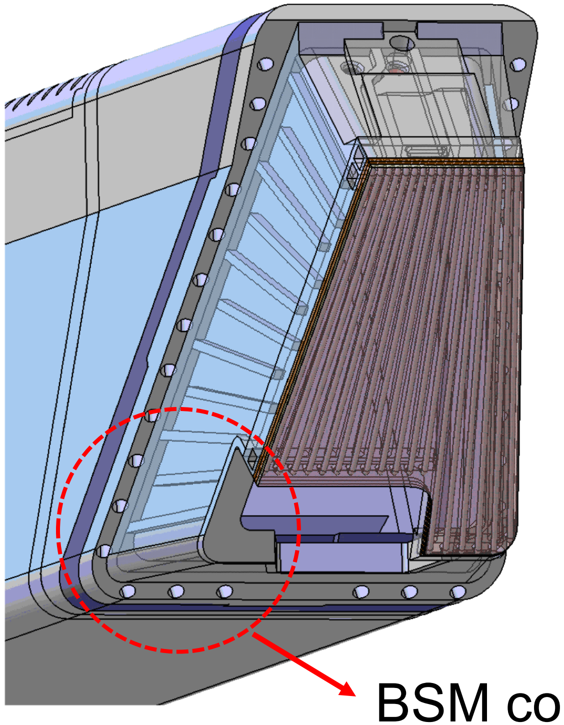
The EC H&CD Upper Launcher



In-vessel component:

- 316L(N)-IG stainless steel as structural material
- T=120-150°C (240°C for baking)
- Internal vacuum ~ 10^{-3}-10^{-2} Pa

Hot Isostatic Pressing (HIPing)



BSM corner prototype

HIPing: one of the preferred manufacturing routes for Upper Launcher (UL) components.

Outgassing measurements: why?

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ITER Vacuum Handbook:

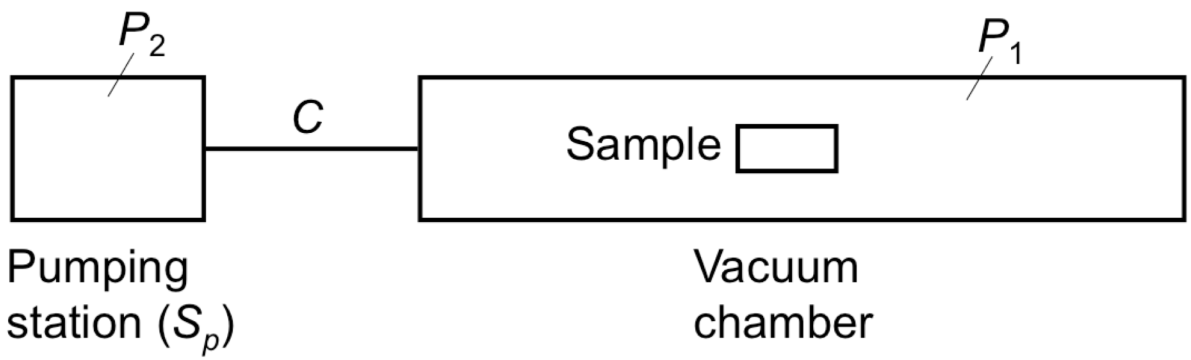
UL belongs to the 1^{st} class of the Vacuum Quality Classification (VQC)

		Maximum Steady State Outgassing rate $Pa.m^3.s^{-1}.m^{-2}$		
VQC^{+}	**Outgas temperature °C**	**Hydrogen isotopes**	**Impurities**	**Testing Guidelines**
1	$100^{‡}$	1×10^{-7}	1×10^{-9}	Appendix 17
2	20	$1 \times 10^{-7*}$		Appendix 17
3	20	1×10^{-8}		Appendix 17
4	20	1×10^{-7}		Published data and conformity to clean work plan.

No outgassing data in literature for HIPed stainless steel

Experimental measurements are necessary to verify the compliance with the limits

Measurement technique



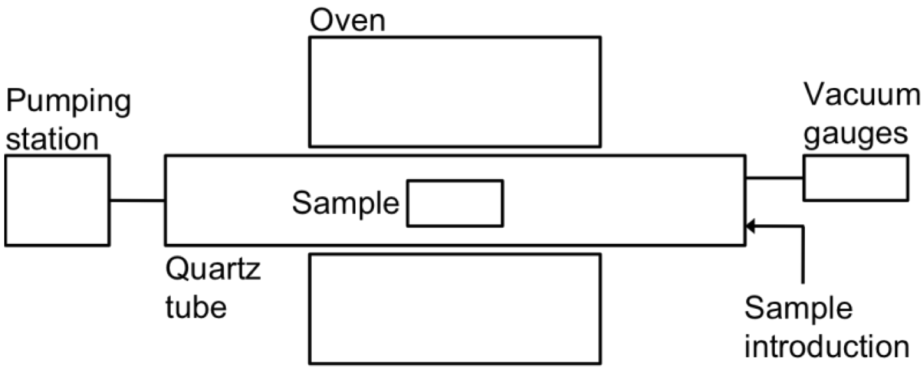
- Conductance method: $Q = C\left(P_1 - P_2\right)$
- Variant of conductance method: $Q = CP_1$ (only if $C \ll S_p$)

After blank and sample runs, the specific outgassing rate q of the sample is calculated as

$$q = \frac{C\left(P_{sR} - P_{bR}\right)}{A_r} \quad [\mathrm{Pa\ m^3\ s^{-1}\ m^{-2}}]$$

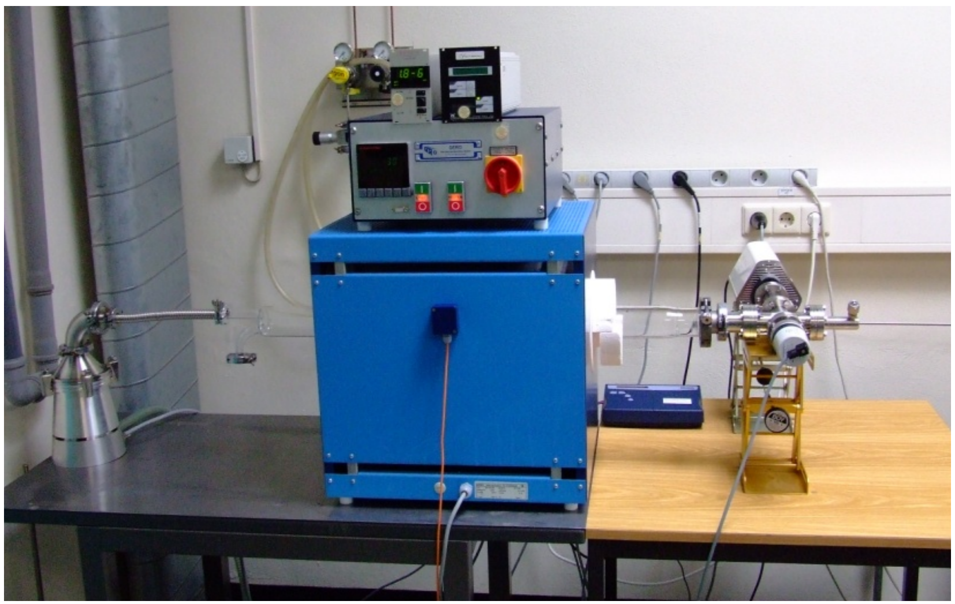
Specific *partial* outgassing rates of the sample can be calculated.

Experimental setup



$$C = \frac{1}{6}\sqrt{\frac{2\pi RT}{M}}\frac{d^3}{l}$$

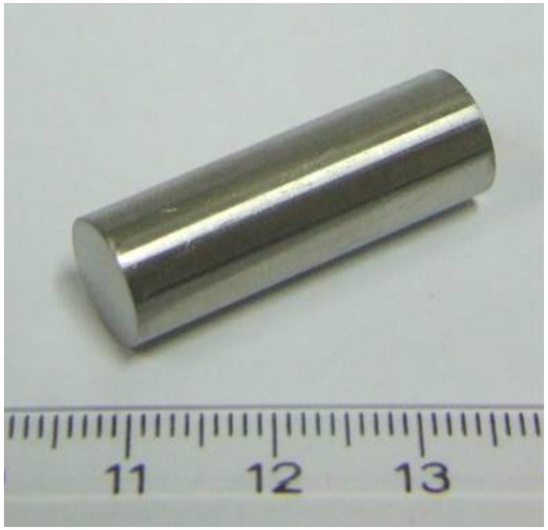
For N_2: $S_p / C \approx 143$



q depends on:

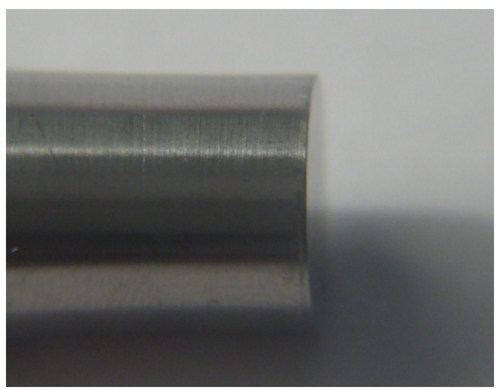
- time
- temperature
- surface finish
- material
- manufacturing process
- etc...

Stainless steel samples

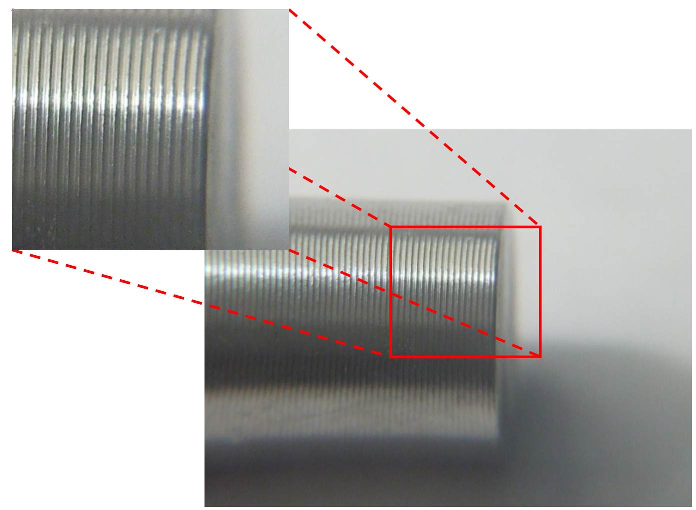


3 pairs →
- AISI 316LN by Powder HIPing
- AISI 317LMN by Rolling
- AISI 317LMN by Rolling + solid HIPing

In each pair:



Polished sample

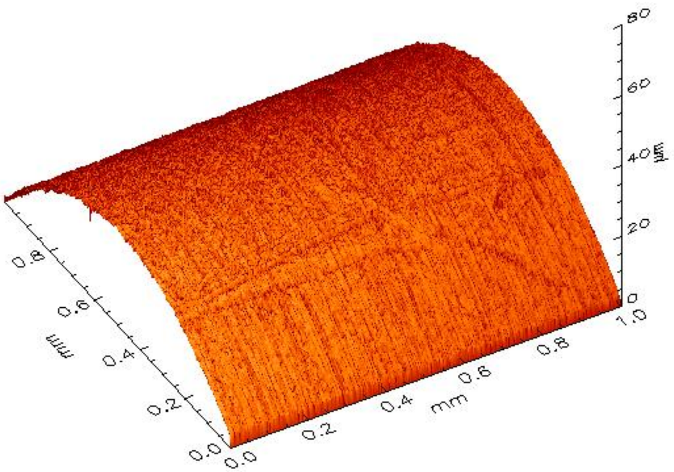


Sample with rills

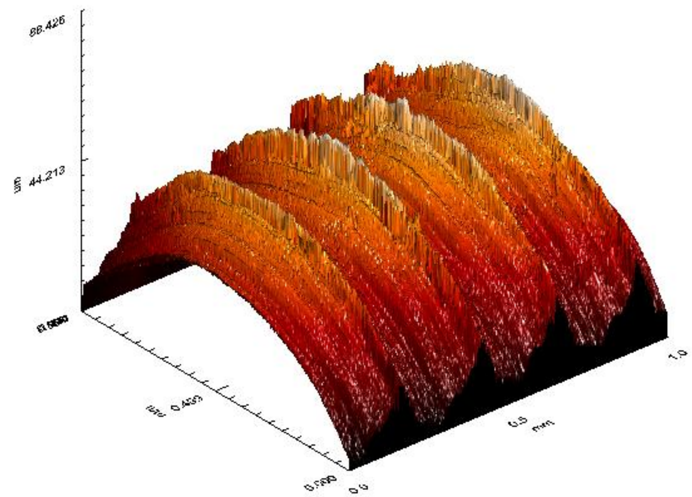
Roughness measurements

Purpose: determination of the surface factor of each sample

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



Raw data related to an area of 1 mm^2 obtained by optical method.



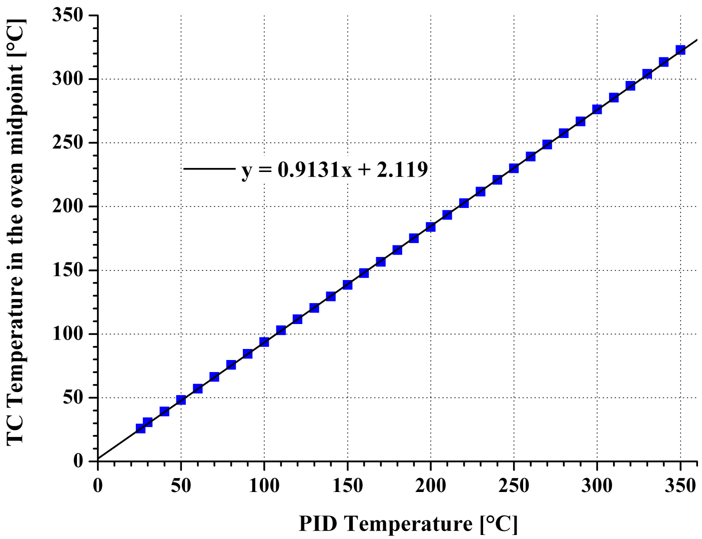
Polished sample

$f_s \approx 1.2$

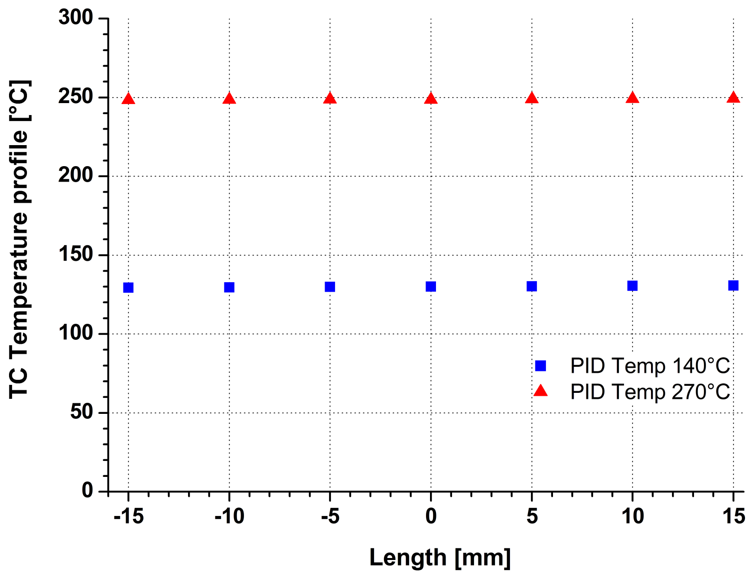
Sample with rills

$f_s \approx 1.8$

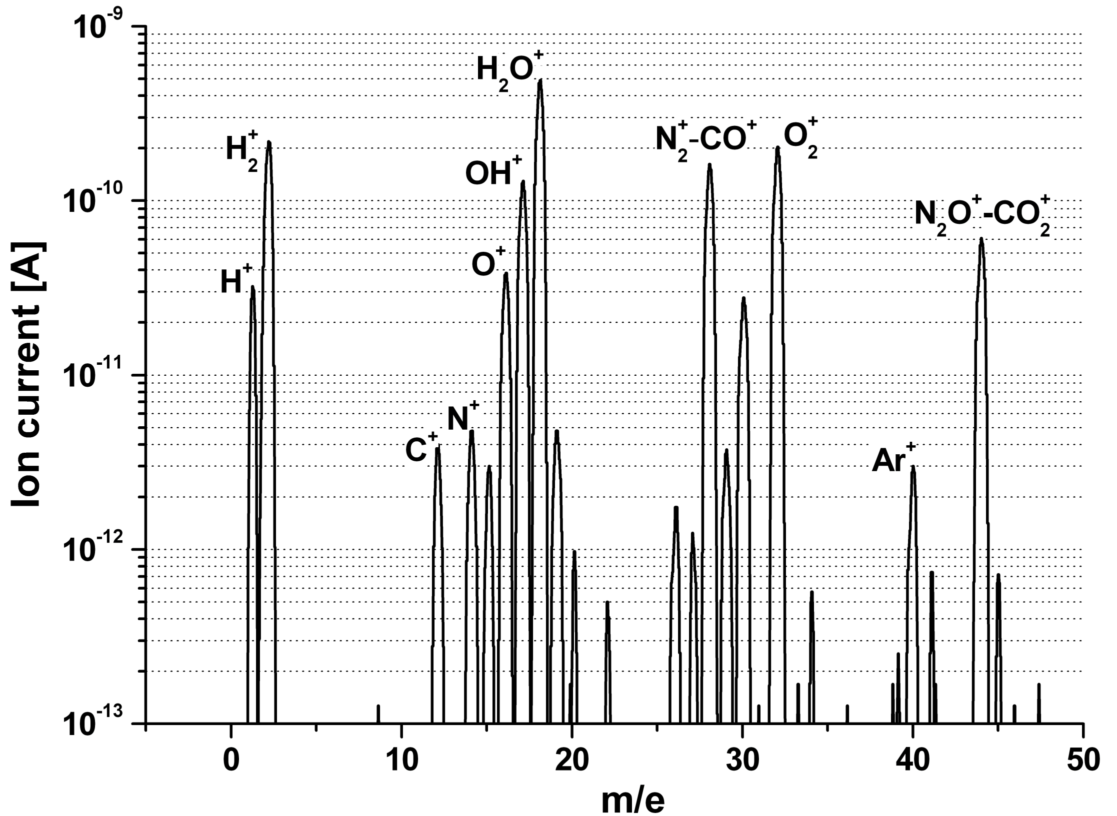
Temperature calibration



Calibration at pressures of ~ 10^{-5} Pa covering the temperature range of interest.

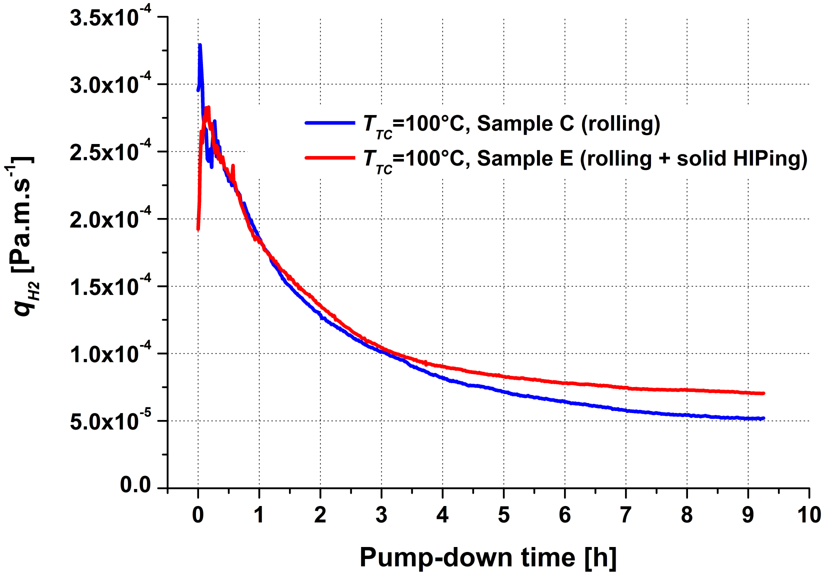


Typical mass spectrum



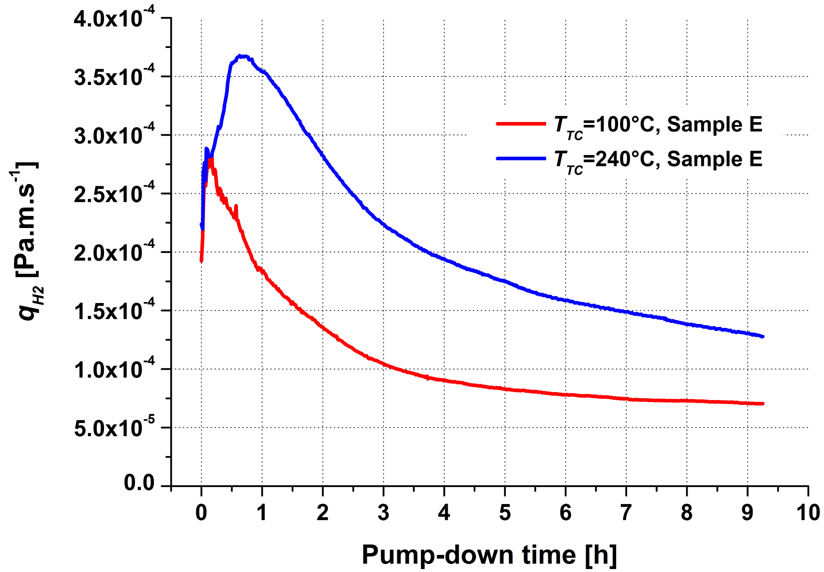
Gas species: H_2, H_2O, N_2/CO, O_2, Ar, N_2O/CO_2...

First results - 1

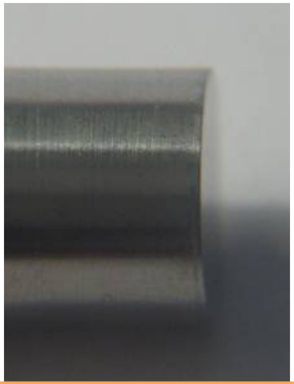


Effect of the solid HIPing

Effect of the temperature



First results - 2



AISI 316LN samples by Powder HIPing

q [Pa m s^{-1}]	Polished sample	Sample with rills
N_2/CO	1.63×10^{-4}	6.58×10^{-4}
O_2	3.27×10^{-5}	1.09×10^{-4}
Ar	2.31×10^{-6}	8.97×10^{-6}
N_2O/CO_2	4.65×10^{-5}	1.88×10^{-4}

Effect of the surface finish at T_{TC}=100°C

Vacuum baking

ITER Vacuum Handbook:

Vacuum Classification	Temperature (°C)	Time (hr)	Comment
VQC 1	240	24	
VQC 1*	350	24	Stainless steel and beryllium

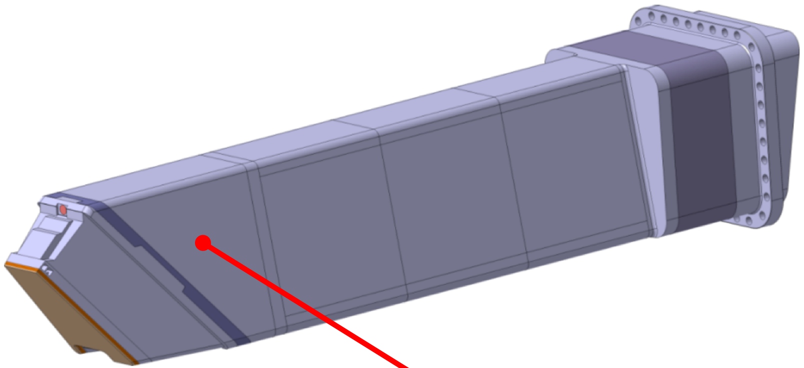
* For vacuum items in line vicinity of plasma

Literature (Elsey, 1975):

300 series SS sample preparation	Measurement temperature [°C]	Specific outgassing rate of H_2 [Pa m s^{-1}]
Vacuum baking for 25 h at 300°C	100	2.8×10^{-7}
Vacuum baking for 25 h at 300°C	100	5.9×10^{-8}

Vacuum baking conditions must be consistent with the outgassing limits.

Double wall prototype and outgassing - 1



MAN DWE
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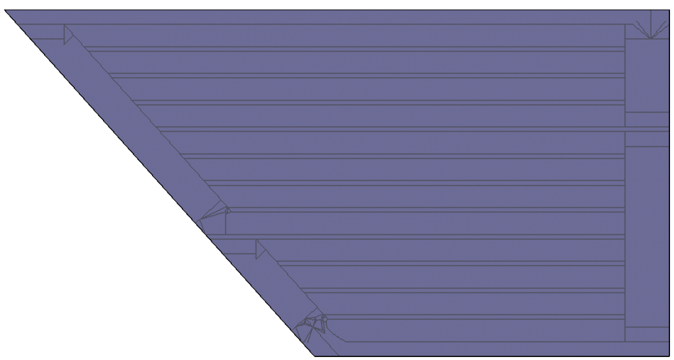
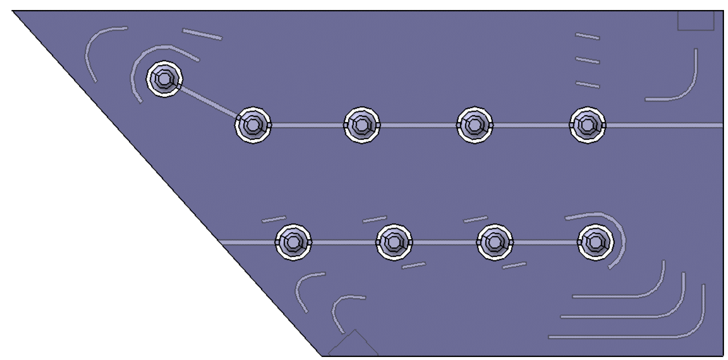
Nuclear heat loads up to 0.8 W cm^{-3}

2 manufacturing options:

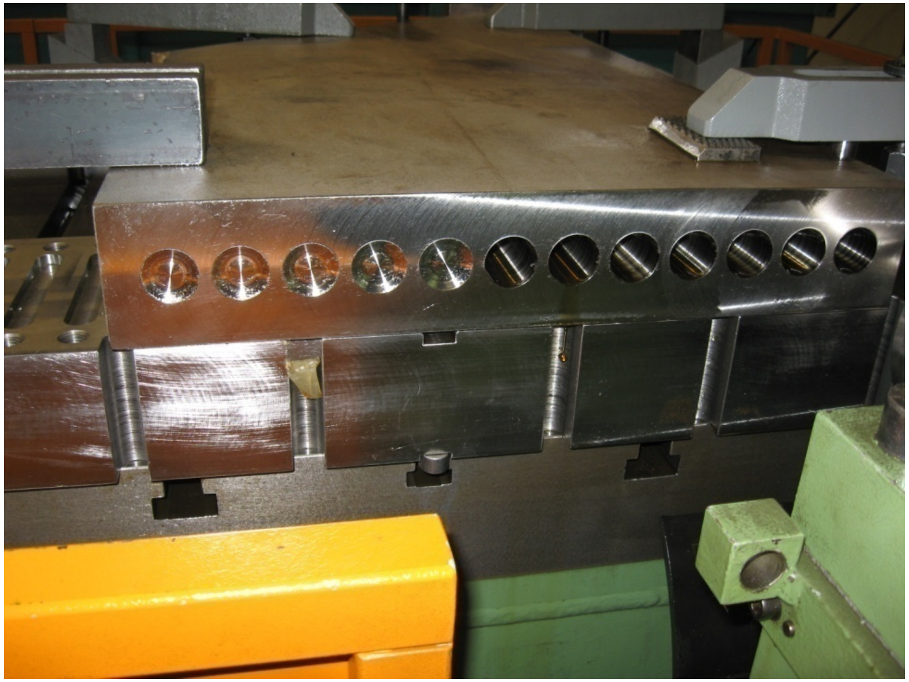




A suited vacuum chamber is going to be built for outgassing measurements of large prototypes.

Double wall prototype and outgassing - 2

Prototype obtained
by deep hole drilling



Conclusions and outlook

- Outgassing limits pertaining to VQC are defined in the ITER Vacuum Handbook.
- An experimental setup has been developed to investigate the outgassing rates of HIPed SS samples.
- Preliminary results have shown that improvements of the setup are necessary: higher sample/chamber volume ratio, load lock system...
- Outgassing measurements are also foreseen for other manufacturing routes in order to verify the compliance with the outgassing limits.