W7-X boronisation research plan

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1 Short overview

Amount	kind of samples	need	project	TOMAS days
28	boronized graphite	He GD	W7-X	6
20	hydrogen doped boronized graphite	He ECWC	W7-X	4

2 Scientific relevance and reasoning

Glow discharge (GD) in H_2 plasma and Electron Cyclotron Wall Conditioning (ECWC) in He plasma have been actively used on W7-X to condition the wall and it's effects have been reported ([1],[2] and EUROFUSION WPS1-PR(16) 16175).

boronized graphite

Glow discharge erodes the boronized wall, it would be interesting to be able to predict to what extend, to this end we will measure ion energy distributions for different GD settings using the Retarding Field Energy Analyzer (RFEA) and expose samples for chosen energies. The aim is to then predict with an erosion code like ERO or rustBCA the observed erosion. If this is possible, it would showcase the effectiveness of the erosion codes, enabling it's deployment on W7-X measured fluxes.

hydrogen doped boronized graphite

W7-X has homogeneous EC wall conditioning in the form of pulse trains. It should be investigated how ECWC performsin removal from boron-coated graphite, as mentioned in EUROFUSION WPS1-PR(16) 16175, ECWC outgassing should follow a time power law ($\propto t^{-0.7}$), we wish to observe a similar time law for removal to show that TOMAS is equipped for such experiments. If this is observed, further samples may be prepared to investigate Ion Cycltron Wall Conditioning.

3 TOMAS setup and days estimate

GD

GD experiments will be carried out on 28 boronized graphite samples, grouped 4 per shot for 7 shots. 4 samples per exposures to have reasonable statistics and 4 exposures for different energies each to have reasonable confidence in the yield-energy curve form. Furthermore 4 samples per exposure for 3 exposures will be conducted for yield-time estimation (should be linear, extra measurement for validation).

EC

EC experiments will be carried out on 20 hydrogen-doped boronized graphite samples, grouped 4 per shot for 6 shots to have sufficient statistics in outgassing per time and in the observation of the time law.

Both

The days estimate comes from the possibility to do 2 exposures per day, with one day of preparatory work, calculated on a maximum of 3 exposure days per week. During experiments the QMS, the MW interferometer and optical spectroscopy will be acquiring data.

4 Sample analysis

Most of this will be outsourced to experts within FZJ whom will be credited appropriately. On the non-doped samples mainly erosion will be measured while on the doped samples outgassing will be measured. On the erosion samples other measurements will also be performed

1. roughness measurement before and after
2. (if adequate) ellipsometry before and after
3. FIBSEM after and on one control

4.1 Roughness measurements

The exposure to the plasma may give inhomogeneous sputtering which might be of interest, as such a simple 1D profilometry measurement may be made before and after exposure, or, if needed, a full 2D surface map. Both of the needed devices are located in the mirror lab overseen by dr. Litnovsky.

4.2 Thickness estimate

Thickness estimates may be made using ellipsometry on the non-doped specimens prior to the exposure and after exposure prior to being analysed using FIBSEM (dr.Rasinski).

References

[1] A Goriaev, T Wauters, R Brakel, S Brezinsek, A Dinklage, J Fellinger, H Grote, D Moseev, S Sereda, O Volzke, and W7-X team. Wall conditioning at the wendelstein 7-x stellarator operating with a graphite divertor. *Physica Scripta*, 2020(T171):014063, mar 2020.

[2] Tom Wauters, Andrei Goriaev, Arturo Alonso, Juergen Baldzuhn, Rudolf Brakel, Sebastijan Brezinsek, Andreas Dinklage, Heinz Grote, Joris Fellinger, Oliver P. Ford, Ralf König, Heinrich Laqua, Dmitry Matveev, Torsten Stange, and Lilla Vanó. Wall conditioning throughout the first carbon divertor campaign on wendelstein 7-x. *Nuclear Materials and Energy*, 17:235–241, 2018.