Research plan

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1 Thickness and density estimation

We wish to know how the various wall conditioning schemes affect the PFM, to this end we need to know both the sample thickness before and after and it's density. We want to know the density as to see how it is dependent on the substrate and to infer how many atoms got sputtered.

1.1 Boronized Tungsten

My proposal for measuring the thickness of the samples would be to use three methods, the first two methods concern a general estimate of the thickness whilst the third would be sample-specific. We first half-coat one sample by applying sticky tape during coating and peeling it off afterwards, enabling the first method: the use of a profilometer to determine the jump in height. The second method which we'll also apply on this half-coated sample is the use of a SEM either by drilling small holes in the coated surface and determine the thickness that way or looking at the side of the sample. The third method is to use the ellipsometer in the mirror lab, this last method is also what we'll be using for the normal samples, it is however good to have many thickness estimates of the half-coated sample as we'll need it later and as it's a good check to see if the ellipsometry measurements are accurate. Note that most of these techniques (especially the ellipsometry) will only be possible if the tungsten surface is polished to within a few nanometers.

To now measure the density we'll perform ion beam analysis on the half coated sample. To see how this works, follow the following train of thought: After analysing the experimental data from the IBA (ERDA) we'd know that there are x amount of B^{10} atoms per cm^2 and y amount of B^{11} atoms per cm^2 on the surface of the sample, using the mass of both of these isotopes and the measured thickness (of which we have 3 independent measurements), we can infer the density:

$$\rho = \frac{1}{d \times 1cm^2} \left(x \times \text{massa } B^{10} \text{ isotope} + y \times \text{massa } B^{11} \text{ isotope} \right) \tag{1}$$

Assuming this density to hold for the other samples, we can infer how many atoms were sputtered from the change in thickness which we'll measure using ellipsometry.

1.2 Boronized Graphite

My proposal for measuring the thickness of the boron layer on graphite would be to use two methods, we'll also be using the half-coated sample enabling the use of a profilometer. The second method which we'll apply in conjunction is by using the ellipsometer in the mirror lab, note that the SEM wouldn't be able to see the difference between carbon and boron and is thus not possible to use here. We then proceed as mentioned for tungsten, inferring the density using IBA.

2 Doping estimation

As we'd later want to measure the outgassing efficiency of the various wall conditioning systems, we'd like to dope the samples with some atoms (e.g deuterium) and measure the concentration before and after the various wall conditioning schemes. We'll probably measure these concentrations using ERDA.

3 Exposure: Erosion rate

We'd like to expose the samples to either hydrogen, helium or mixed hydrogen and helium. Each under different wall conditioning regimes, either Glow Discharge, Ion Cyclotron Wall Conditioning, Electron Cyclotron Wall Conditioning or ICWC and ECWC at the same time. We'll first do some spectroscopy to see the amount of impurities in our plasma (if any are visible, our spectrometer is quite low-resolution). And then expose the pure boron to test the erosion rate with different powers.

3.1 ICWC

In TOMAS the IC creates both neutrals and ions, mostly with energies below 1keV. Unfortunately the TOMAS IC matching system only enables coupling to the plasma up to 40kW, as such this will be our operating frequency together with a magnetic field of 0.114T (2000A input current) at 1500W, 3500W and 5500W injected power, with a pressure of 10^{-4} mbar during the discharge of the 1500W, maintining the same base pressure (not the neutrals pressure) for the higher powers. I.e when the penning gauge indicates 10^{-3} mbar without IC and 10^{-4} mbar with IC at 1500W, we'll be doing 5500W for the same 10^{-3} mbar gas. Whilst the powers we'll use are very small compared to larger devices, due to the way everything is measured, as will be mentioned, it will be possible to extrapolate. ICWC at TOMAS is a monopole working in a mode conversion scheme, as such most of the particles evenly spread to the wall. This enables

us to extrapolate measurements performed by the ToF-NPA to the full vessel and use it as a prediction on how neutrals erode the sample, this already has been implemented in the NPA analysis code making it very straightforward to infer expected erosion rates. The question now is the erosion rates due to ions, unfortunately the retarding field energy analyser seems to have some hickups when doing IC discharges which we'll try to fix over the next couple of weeks.

3.2 ECWC

We don't expect any 10eV< energy neutrals or ions, as such the main player if erosion occurs will be electrons. Even though I'm not sure how to estimate the correlation between the electron energy and flux to the erosion rate, the electron density and temperature will be measured using a langmuir probe. If I figure out how this has an influence, it can be added to the ICWC estimations.

3.3 ECWC+ICWC

These sometimes are used in conjunction, so we'll also do exposures with these, note that the erosion rate will drastically increase.

3.4 Glow Discharge

Even though GD is falling out of favour, we'll do some exposures if time permits, with the same pre-measurements as IC

4 Exposure: Outgassing efficiency

This is for much later, after all the erosion estimations have been done, but under all the previously mentioned techniques, we'll use the same measurements and estimate the outgassing rate by constructing a sample with the same amount of doping in the BCA simulation.