Subject: Erosion of boronization under different conditions


Group: Operations

Date: November 17, 2005

1. Purpose of Experiments
Include immediate goal of the experiments, scientific importance and/or programmatic relevance. Refer to any relevant program milestones.
Utilize between-shot boronization and Ohmic H-modes to understand the extent of boronization and whether the erosion of boron occurs primarily during RF heating, or is caused by the interaction of thermal plasma with surfaces, independent of explicit RF effects.

Background
Discuss Physics Basis of the proposed research. Prior results at Alcator or elsewhere, and any related work being carried out separately.
Between-shot boronization works. However several questions are still outstanding:
1) Does the extent of boronization match our previous measurements of the density in ECDC plasmas [1] - does the boronization extend from the resonance radius further out, or is it more localized?
2) Is the erosion of boron associated with some aspect of the RF; sheath-rectification enhancement of sputtering, enhancements from ion-orbit losses, or other fast-ion effects? Alternatively, is the erosion due to ‘standard’ plasma erosion at leading edges. Certainly we have evidence for both: There have been measurements of high plasma potentials in the SOL correlated with RF power (sheath rectification); During the most recent vacuum break the boron was most clearly eroded from the leading edges of divertor modules.

We have some new diagnostics as well. The IR camera view of the divertor plate between H and J ports is now reliably on and taking data. The view has been roughly calibrated. During the last run campaign the same view showed several leading edges getting hot - the same ones that showed B erosion during the vacuum break.
The periscope at K-top has been reinstalled during the vacuum break. With the periscope rotated so that the 1D array of views is aligned toroidally we now can monitor a number of points along the outer divertor cover plate for Mo and B source rates.

2. Approach
Describe the methodology to be employed; explain the rationale for the choice of parameters, etc. Describe the analysis techniques to be employed in interpreting the data, if applicable. If the approach is standard or otherwise self-evident, this section may be absorbed into the Experimental Plan.

The approach is to use between-shot boronization to address the issues raised above in the background section. We intend to use Ohmic H-modes because they are independent of RF and allow a comparison of the Mo erosion rate and Mo levels in the core for powers similar to RF-heated plasmas - so addressing the RF source question. We will look at the Mo and radiation level rise rate following L-H transition.

We would like to do this pre-boronization. The reason for this is that as we change the between-shot boronization resonance radius inward from shot to shot, we should find that as the resonance passes the K-top view of the outer divertor cover plate the Mo source rate drops. Furthermore, if we are lucky and the K-top view is of the ‘important’ Mo source location, we should see the Mo source rate rise back up in the period of order one shot.

First we need to characterize the Mo/B source rates, IR imaging, Mo levels in the core for Ohmic H-modes. Then, the between-shot boronization radius will be swept inward from discharge to discharge (each discharge following a boronization).

Once we evaluate the best location of boronization we can evaluate how long it lasts for different length boronizations.

There is a concern that the impurity levels pre- overnight boronization may be too high to do this experiment properly. Namely the impurity level reduction due to the first overnight boronization is necessary to achieve decent Ohmic H-modes. In addition, the impurity reduction due to this first boronization, the effect of which lasts for a long time for most surfaces, may be significantly larger than the reduction in impurities during a between-shot boronization. In any case we might want to repeat this post overnight boronization.

3. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

- Toroidal Field: 5.3 Tesla (normal direction) ramping down to 4T for Ohmic H-modes
- Plasma Current: 1.2 MA (normal direction)
- Working Gas Species: D2
- Density: NL04 ~ 1.0 x 10^{20} m^{-2}
- Equilibrium configuration: start from 1050810014 but with 1.2 MA and field ramped down to 4T

4.2 Auxiliary Systems

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4.3 Diagnostics
List required diagnostics, and any special setup or configuration, e.g. non-standard digitization rate.

Scanning probes (FSP, ASP, ISP) for characterization of the SOL. Bolometric measurements of radiated power, spectroscopy measurements of core Mo (McPherson), core and pedestal diagnostics (ECE, Thomson, PCI,…). We need a measure of the boron density in the core (Chromex and GPI at inner wall). We also need the IR and new K-top Chromex measurements.

4. Experimental Plan
Both sections must be filled in.

5.1 Run sequence Plan
Specify total number of runs required, and any special requirements, such as consecutive days, no Monday runs, extended run period – 10 hours maximum – etc.

At least one run day to explore various boronization locations with ECDC resonance scans. More time may be needed after first overnight boronization.

5.2 Shot sequence plan
For each run day, give detailed specification for proposed shot sequence: number of shots at each condition, specific parameters and auxiliary systems requirements, etc. Include contingency plans, if appropriate.

ECDC between shot boronization:
a) - 2-4 shots with Ohmic H-modes to develop them and determine the proper field to ramp down to.
b) ECDC boronization w/resonance at R=90 cm (field sweep range 10 cm total) for 20 minutes (if using 10% diborane). The RF should not be pulsed (100% duty cycle). Follow this with as many shots as needed to evaluate effect and wear it off.
c) Step resonance location inward in major radius to locations at 80, 75, 70, 65, 60 cm. After each boronization evaluate the effect on Mo source rates, IR camera images, Mo levels in core and rise with H-modes.
d) If there is a minimum return to it and reevaluate that spot.

Note - we may want to reduce step size in order to better define the ECDC boronization coating as we pass the location of the K-top periscope views. These are at ~ R=70 cm.

5. Anticipated Results

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Discuss possible experimental outcomes and implications. Indicate if the program may be expected to lead to publications, milestone completions, improved operating techniques, etc. Indicate if the experiments are intended to contribute to a joint research effort, or an external database.

If the boronization lasts much longer with Ohmic H-modes than with RF in terms of total joules to the plasma then we have determined that RF effects are important. We should also get a measure of the deposition width with the K-top periscope measurements.

6. References
Include references both to external and internal literature or communications which bear on this proposal. See Section 2.