Laboratory Assessment of ITER-Relevant Boron Layer Fuel Removal using Glow Discharge Cleaning and Ion Cyclotron Wall Conditioning in the TOMAS Device

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The TOMAS device is a toroidal plasma facility dedicated to active studies of wall conditioning and plasma–wall interactions [1]. It operates using several wall conditioning techniques, including Glow Discharge Cleaning (GDC), Electron Cyclotron Wall Conditioning (ECWC), and Ion Cyclotron Wall Conditioning (ICWC). TOMAS is equipped with a comprehensive set of diagnostics for characterizing low-temperature, weakly ionized plasmas used in wall conditioning [2]. These diagnostics include Langmuir probes, a microwave (MW) interferometer, Time-of-Flight Neutral Particle Analyzer (ToF NPA), Quadrupole Mass Spectrometry (QMS), Optical Emission Spectroscopy (OES), and video cameras.

A key feature for plasma–wall interaction studies is the TOMAS Sample Load-Lock system, which integrates a material sample holder with active heating and a Residual Field Energy Analyzer for localized ion energy distribution measurements [3]. The facility is currently being upgraded to include a new sample manipulator with three degrees of freedom, active cooling for rapid temperature control, and expanded integration with in-situ diagnostics such as Laser-Induced Desorption (LID) QMS and Laser-Induced Breakdown Spectroscopy (LIBS).

In alignment with the updated ITER baseline for boronization, TOMAS plays a critical role in laboratory assessments of fuel removal and isotope exchange in amorphous boron layers deposited on tungsten substrates. These studies utilize GDC and ICWC plasmas to expose B:D layers—boron layers containing varying amounts of deuterium—under controlled conditions. Typical exposure parameters are refined based on pre-characterization of both the boron layers and the plasma, with experiments conducted at 70 °C and 220 °C to simulate short-term (STM) and long-term maintenance (LTM) conditions.

Following plasma exposure, the samples undergo post-characterization to determine the amount of deuterium removed, hydrogen retained, total boron erosion, and depth profiles of deuterium and other impurities such as oxygen and carbon.

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[2] Yu. Kovtun et al., JINST 18 C02034 (2023)
[3] A. Goriaev et al., AIP Conf. Proc. 2984, 040007 (2023)

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