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In-situ erosion and deposition measurements of plasma-facing surfaces in Alcator C-Mod[1]

HAROLD S. BARNARD, MIT Plasma Science and Fusion Center

The Accelerator Based In-situ Materials Surveillance (AIMS) diagnostic was recently developed to demonstrate the novel application of ion beam analysis (IBA) to in-vessel studies of plasma materials interactions in Alcator C-Mod. The AIMS diagnostic injects a 900 keV deuterium ion beam into the tokamak's vacuum vessel between plasma discharges while magnetic fields are used to steer the ion beam to plasma facing component (PFC) surfaces. Spectroscopic analysis of neutrons and gamma rays from the induced nuclear reactions provides a quantitative, spatially resolved map of the PFC surface composition that includes boron (B) and deuterium (D) content. Since AIMS is sensitive to low-Z elements and C-Mod regularly boronizes PFCs, the evolution of B and D on PFCs can be used to directly study erosion, deposition, and fuel retention in response to plasma operations and wall conditioning processes. AIMS analysis of 18 lower single null I-mode discharges show a net boron deposition rate of 6 ± 2 nm/s on the inner wall while subsequent inner wall limited discharges and a disruption did not show significant changes in B. Measurements of D content showed relative changes of >2.5 following a similar trend. This suggests high D retention rates and net B deposition rates of $\sim$18 cm/year of plasma exposure are possible and depend strongly on the plasma conditions. Ex-situ IBA was also performed on the same PFCs after removal from C-Mod, successfully validating the AIMS technique. These IBA measurements also show that the B content on the inner wall varied toroidally and poloidally from 0 to 3000 nm, demonstrating the importance of the spatial resolution provided by AIMS and the sensitivity of PFCs to B-field alignment. AIMS upgrades are underway for operation in 2014 and we anticipate new measurements correlating the evolution of PFC surfaces to plasma configuration, RF heating, and current drive scenarios.

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