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Study of D retention and impurity emission properties of oxidized B4C coatings under deuterium irradiation in NSTX-U

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Conditioning and irradiation induced modifications on Plasma Facing Component (PFC) materials play a key role in the plasma performance in tokamak machines. Boronization is a conditioning technique widely used in carbon based machines due to its associated sputtering reduction and oxygen gettering properties. The National Spherical Tokamak Upgrade (NSTX-U) used boronization with d-TMB during the 2015-2016 experimental campaign as the main PFC preparation method. The Materials Analysis Particle Probe (MAPP), an innovative PFC chemical characterization facility, recently commissioned in NSTX-U, was used to investigate the evolution of boronized ATJ graphite when irradiated with energetic D ions in the Lower Divertor (LD) of NSTX-U. MAPP was used to insert graphite samples into the outboard LD of the tokamak and retract them (with no exposure to atmosphere) into an analysis chamber for X-ray Photoelectron Spectroscopy (XPS) interrogation every twenty four hours. The results show that a thin boron carbide film is deposited onto the carbon PFCs following each boronization procedure. Furthermore, the XPS data indicate that the oxygen content of the samples increases with plasma exposure, going from 5% to almost 20% after tens to hundreds of plasma discharges. Moreover, comparisons of the duration of the plasma discharges pre and post boronization seem to correlate these incremental increases of oxygen content with the performance of the machine. In addition to the characterization of ATJ samples, MAPP also exposed a TZM (Ti, Zr and Mo alloy) sample during the campaign. Similar XPS analysis was carried out with this sample, and the results indicate no chemical interaction between the B coatings and the TZM sample. However, the boronization procedure covered the substrate beyond the probed depth of XPS. As was the case of the ATJ samples, oxygen plays a key role in the evolution of the chemistry of the TZM surface. TZM is a candidate material to replace graphite in the lower and upper divertors of NSTX-U, hence a detail investigation of its behavior under machine conditions is highly relevant. Such observations are only possible due to the improved time resolution and surface sensibility (20 nm) of MAPP. The benefits associated with this diagnostic are twofold. Firstly, it can provide light on plasma–surface interactions and provide correlations with PFC surface conditions at the fundamental level. Secondly, its in vacuo surface analysis capability can be used to give an updated description of the PFC state to machine operators and physicists to guide their decisions on surface conditioning during the experimental campaign.
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Eligible for student paper award?

Yes

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