Ultra-high Temperature Ceramic TiB_2 Response to Steady-State Deuterium Plasma

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This work summarizes the first ever hydrogenic retention data on bulk UHTC TiB_2 following deuterium plasma exposure. Structural, ultra-high temperature ceramic (UHTC) TiB_2 is a promising candidate for plasma-facing armour applications in fusion devices due to its high melting temperature as well as its high temperature strength and thermal conductivity [1]. TiB_2 materials also my act as oxygen getters and offers reduced radiative plasma cooling from sputtered mid- and low-Z atoms compared to that of higher-Z refractory metals. Despite exciting material properties, TiB_2 is relatively untested under fusion-relevant plasma loading conditions. This work aims to reduce uncertainties in TiB_2 plasma-material interaction behaviour by characterizing deuterium plasma induced erosion and retention response of the material.

TiB_2 samples were exposed to low-incident ion energy, E_i, deuterium plasma (E_i ~20 eV, below physical sputtering yield thresholds) in the PISCES-RF linear plasma device. Sample temperatures spanned from 70 to 825°C to quantify temperature dependent erosion and hydrogen trapping processes. With an exception for the 825°C exposed sample, x-ray photoelectron spectroscopy (XPS) measurement on the samples found slight boron depletion within the first five nm of the plasma-facing surfaces, with Ti/B fractions measuring 0.7 – 0.9. The Ti/B fraction following the 825°C exposure was three times greater than the other samples at 2.6, indicating that 825°C surpassed a threshold in thermal-dependent erosion processes for boron and is consistent with previous work on TiB_2 [2]. Retained deuterium following ~1.1×10^{26} ions/m^2 deuterium fluences was measured in the samples using thermal desorption spectroscopy (TDS) to temperatures up to 815°C. Total deuterium uptake was measured to be 0.74 – 7.3×10^{19} D/m^2 with desorbed deuterium concentration peaking after the 500°C exposure and reducing with both lower and higher sample exposure temperature. This behaviour is in contrast with tungsten where, generally, hydrogenic uptake peaks near 200°C [3]. We will explore possible mechanisms for the temperature dependent erosion behaviour and discuss the impact early deuterium retention results have on TiB_2 viability as a plasma-facing component material candidate.

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