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Reduction of Net Erosion of High-Z PFC Materials in DIII-D Divertor Due to Re-Deposition and Low-Z Coating

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We report a substantial reduction of net compared to gross erosion of a tungsten PFC surface observed in DIII-D divertor in good agreement with modeling, and suppression of molybdenum erosion by a local gas injection. A sample featuring a 1 mm and a 1 cm diameter 15-24 nm thick W films deposited on a Si substrate over a carbon inter-layer was exposed in the lower divertor of DIII-D using the Divertor Material Evaluation System (DiMES). The exposure was performed in lower single null L-mode deuterium plasma discharges near the attached outer strike point (OSP) for a total of ~16 s. The plasma density ne = 1.2x10^{19} m^{-3} and electron temperature T_e = 32-35 eV near OSP were measured by the divertor Langmuir probes. Net erosion was determined by comparing Rutherford backscattering (RBS) measurements of the W layer thickness on the 1 cm spot before and after the exposure, and gross erosion was estimated from similar measurements on the 1 mm spot. The measured net and gross erosion rates were 0.14 and 0.48 nm/s, respectively, giving net/gross erosion ratio of 0.29. REDEP/WBC modeling of this experiment yielded a very close ratio of 0.33. A second exposure of a sample with similar W coatings on a Mo inter-layer performed in similar geometry at similar T_e but ~x3 higher ne yielded erosion rates about twice higher and net/gross erosion ratio of 0.38. Modeling of the second experiment is in progress. In another experiment, two Mo-coated Si samples 1 cm in diameter were exposed near attached OSP, first in L-mode for ~14 s, second in H-mode for ~7 s, with ^13CH_4 gas injected ~12 cm upstream of the samples. Suppression of Mo erosion was evidenced in situ by the disappearance of MoI line radiation at 386.3 and 390.2 nm once the gas injection was turned on. Post-mortem RBS analysis found the erosion of Mo near the center of the samples being below the measurement resolution of 0.3 nm, corresponding to a rate of 0.02 nm/s. Compared to the previously measured erosion rates in L-mode of 0.4–0.7 nm/s this constitutes a reduction of more than x20. Carbon deposition was measured on both samples, corresponding to a rate of ~20 nm/s in L-mode and ~4 nm/s in H-mode. The ratio of ^{13}C/^{12}C carbon in the deposits was about 1.6 on both samples, indicating that the deposition was largely from the gas injection.

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