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Reduction of Net Erosion of High-Z Divertor Surface by Local Redeposition in DIII-D[1]

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Utilizing the unique capability to expose material samples to well characterized diverted plasmas, recent DIII-D measurements have confirmed theoretical expectations of the relative net and gross erosion rates of molybdenum in the divertor region. Knowledge of these erosion rates is important for predicting first wall lifetime in future fusion devices. Theory suggests that the net erosion rate will be much less than gross erosion due to prompt local deposition of eroded ions by gyro-orbit motion, the strong E-field toward the target and friction with the fast plasma flow toward the target. However, experimental evidence to date has been contradictory. The results here, which are the most definitive to date, are consistent with the basic theoretical predictions. The net and gross erosion rates were measured utilizing 1-cm and 1-mm diameter Mo samples that are mounted on the DIII-D Divertor Material Evaluation System (DiMES) system and simultaneously exposed near the attached outer strike point of an L-mode plasma for 4 s. Due to the spatial extent of the re-deposition, the larger sample gives the net erosion while the smaller sample is indicative of the gross erosion. Post-mortem ion beam analysis (RBS) of the larger sample, indicates a 2.9 nm film thickness reduction (or 0.72 nm/s net erosion rate). Similar analysis of the smaller sample yields a 1.3 nm/s gross erosion rate, consistent with spectroscopic measurements of Mo I emission. The net to gross erosion ratio of 0.56 is consistent with calculations using a modeling package including REDEP/WBS and OEDGE codes. Using as input the measured plasma density and temperature profiles from divertor Langmuir probes, these codes estimate a net to gross erosion ratio of 0.46. Details of the modeling and implications for future devices will be discussed.

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