PSI STUDIES AT DIII-D

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Understanding of Plasma Surface Interactions (PSI) and the corresponding selection of suitable plasma facing materials are critical areas for all tokamak experiments and future D-T burning machines including ITER, Fusion Nuclear Science Facility (FNSF), and DEMO. The PSI program at DIII-D consists of three elements: 1) Model validation: the use of experimental results to benchmark codes with the goal of acquiring predictive capability, 2) ITER support: analyses focused on the selection of divertor surface material for ITER for robust operation and achieving the program goal of Q=10, and 3) High-Z surface material studies: address issues related to using metallic plasma-facing material is used for FNSF and DEMO with the goal of achieving high sputter-limited PFC lifetime and minimizing tritium inventory. A capability we use in the support of these elements is the Divertor Materials Evaluation System (DiMES), which contains a removable probe at the lower divertor surface of DIII-D, where material samples can be exposed to as few as a single well-characterized plasma shot. Different experiments, each consisting of a carbon DiMES probe surface with metal coatings of Be, W, V, Mo or Al, have been exposed to the outer strike point plasma on the lower divertor for accumulative discharge time of 4–20 s.

These short exposure times ensure controlled exposure conditions. The extensive arrays of DIII–D divertor diagnostics provide well-characterized plasma for modeling efforts. Post-exposure analysis provides a direct measurement of surface material erosion and re-deposition rates and the amount of retained deuterium. Whenever possible, experimental results were benchmarked with modeling codes to validate and extend the predictive capability of the codes. Such codes have been applied to the ITER design. We have performed numerous other experiments including injection of ^{13}C from the top of the machine to study impurity transport and distribution, long-term exposure of diagnostic mirrors, development of advanced diagnostics, study of vertical displacement discharge effects on W-surface and W-fuzz, and investigation of the disruption-tolerant Si-filled W surface design option. The latter led to the consideration of real-time low-Z material injection to modify a metallic PFC surface in order to mitigate material transport and damage such as the formation of W-fuzz. This paper will provide a summary of recent PSI studies at DIII-D and future plans for this program.

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