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Divertor Erosion on DIII–D*

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A campaign to measure the *in-situ* graphite divertor plate erosion rates in the DIII–D lower divertor is yielding a quantitative database for modeling, allowing for a more confident extrapolation of component lifetime in a reactor size tokamak. The principle method of obtaining this data is the DiMES probe. Recent experiments have focussed on ELMing attached divertor plasmas with typical strike point conditions of: $\Gamma_i \sim 0.3–1 \times 10^{23}$ s^{-1} m^{-2}, $T_e \sim 40–70$ eV, $n_e \sim 2–5 \times 10^{19}$ m^{-3}, heat flux 0.7–2 MW/m^2. Spectroscopic measurements show a gross erosion rate of carbon ~60 cm/burn-yr at 0.7 MW/m^2 incident heat flux and an effective sputtering yield >10%, in agreement with modeling (REDEP/WBC). These high yields arise from oblique incidence and carbon self-sputtering. The region of net erosion is ~ 2 cm wide and is peaked near the strike point with values ~ 10 cm/burn-yr. A comparison of ELMing and ELM-free plasma exposures shows that carbon erosion is affected little by the presence of ELMs on DIII–D.

Long term exposures of DIII–D tiles agree with the DiMES erosion rates and show that the net erosion at the outer divertor (and subsequent transport) determines the net redeposition at the inner divertor, resulting in a codeposited inventory build-up of deuterium with D/C ~ 0.25. The magnitude of this net source of carbon from the outer divertor can account for the constant carbon inventory accumulation in the core plasma of an ELM-free H–mode, demonstrating that erosion is playing an important role in the ability of current devices to produce steady-state, high performance discharges. In general, the results directly indicate (and indirectly through model benchmarking) that attached divertor erosion of low-Z materials poses a serious limitation to the operation lifetime of a long-pulse tokamak, through both net plate erosion (up to 50 cm/burn-yr at 2 MW/m^2) and hydrogenic species codeposition.

The first experimental results on divertor erosion with detached plasmas ($T_e \leq 2$ eV) are expected to be presented.

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