Understanding tungsten divertor sourcing, SOL transport, and its impact on core impurity accumulation in DIII-D high performance discharges *

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The DIII-D metal rings campaign demonstrated the ability to run high performance plasmas with tungsten at the outer divertor strike point and provided detailed information on W sourcing and transport from the divertor in a mixed material environment. Using two isotopically distinct toroidal rings of W-coated metal inserts, advanced tokamak (AT) discharges (P_{AUX}=14 MW, H_{98} =1.5-1.6, β_N =3.6-3.7) show performance similar to all-C divertor discharges, with low core W concentrations (few 10^{-5}) for the case of central ECH and rapid ELMs (f_{ELM}~200 Hz). W impurities transported to the midplane, measured by collector probes inserted in the far SOL, predominantly originate from the outer strike point (OSP) region rather than from a W source positioned in the far SOL. Conversely, for discharges with larger, less frequent ELMs (f_{ELM}~60 Hz) the W impurities are shown to transport equally from the OSP and far-SOL regions. Direct measurement of gross W sputtering shows peak source rates during Type-I ELMs of 1-2x10E16 /cm^2/s, many times the inter-ELM rate (1-2x 10E15 /cm^2/s). Detailed analysis shows that C impurity and D fuel ions contribute equally to W divertor sourcing during ELMs, in contrast to the JET-ILW where D ions are the main contributor, or to the inter-ELM case on DIII-D where C dominates the W sputtering. In addition, ELM-resolved measurements of W sourcing for differing BT directions reveal the peak W erosion rate during large ELMs shifts radially due to a combination of drift effects and ELM wetted area. For L-mode experiments, OEDGE modeling suggests that measured asymmetries in the collected W may be explained by a W buildup in the SOL at the crown of the plasma, driven by the parallel grad-T_i force.

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