Measurements of Tungsten Net Erosion in the DIII-D Divertor via WI and WII Spectroscopy and Comparison to Re-deposition Models[1]

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The net erosion rate of tungsten-clad plasma-facing components (PFCs) in fusion devices during transient events such as edge-localized modes (ELMs) cannot be measured via post-mortem sample analysis. This necessitates the development of *in-situ*, time-resolved measurement techniques. Leveraging newly calculated atomic rate coefficients and a recently developed ultraviolet spectroscopy system for DIII-D [1], we present the first detailed, *in-situ*, spectroscopic analysis of the net erosion of high-Z PFCs in a fusion device. W gross (net) erosion can be calculated from the spectroscopic intensity of an emission line from W^0 neutrals (W^+ ions) multiplied by the ionizations/photon, S/XB, coefficient for that WI (WII) line.

In L-mode discharges from the DIII-D Metal Rings Campaign [2], the W net erosion near the outer strike-point (OSP) is observed to be nearly equal to the gross erosion when the neutral W ionization length, λ_{iz}, is large compared to the W gyro-radius, ρ_w, and the width of the magnetic sheath, λ_{sh}. As the λ_{iz} decreases, the rate of tungsten net erosion also decreases relative to W gross erosion, with a strong inflection point near $\lambda_{iz}/\rho_w \approx \lambda_{iz}/\lambda_{sh} \sim 2\text{-}3$. At the lowest ionization lengths achieved, $\lambda_{iz}/\rho_w \approx \lambda_{iz}/\lambda_{sh} \sim 0.4$, W net erosion decreases to as little as ~20% of the gross erosion. These results are compared to two different analytic models, which assume that the W re-deposition physics is dominated by (a) the gryo-orbit trajectories of sputtered W ions [3] or (b) electrostatic forces within the magnetic pre-sheath [4]. Measurements of W net erosion are generally lower than the models predict when λ_{iz} is large. This discrepancy is attributed to non-local W re-deposition, which is not included in the models. Conversely, when λ_{iz} is small relative to ρ_w and λ_{sh}, substantially more W net erosion is measured than predicted by the analytic models. Monte Carlo modeling with ERO indicates that W re-deposition from charge states higher than W^+ may also be important [4], but spectroscopic measurements of additional W charge states were not available. Calculated W net erosion rates during ELMs using both models [3, 4] will also be presented and compared to experimental data.

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