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Multi-physics modeling of the long-term evolution of plasma-exposed surfaces

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We report on a new simulation capability for predicting plasma-surface interactions, including the evolution of the plasma-facing component (PFC) surface layer that is continually modified by contact with the fusion plasma. This involves a wide range of physical phenomena: our current model includes components for a) the scrape-off layer plasma including fuel ions and extrinsic impurities (using SOLPS[1]), b) transport and redeposition of eroded wall material (using the newly developed Monte Carlo code GITR), c) the implantation of plasma ions into the material and subsequent wall erosion (using F-TRIDYN, and extension of TRIDYN [2]), and d) the dynamics of the subsurface (Xolotl, a new continuum cluster dynamics code). These components are being integrated to yield predictive capability for the changes in surface morphology, fuel recycling and tritium retention, and how these are impacted by material erosion and redeposition, initially targeting tungsten exposed to mixed hydrogenic and helium plasmas. Initial simulations have focused on a recent set of experiments at the PISCES linear facility, where tungsten was exposed to helium plasmas with fluxes of 0.5-4⊠1022 /m2/s for durations of 5000-10000s, with incident energies of ~250eV controlled through biasing. Initial simulations have demonstrated the effect of including bubble bursting and sputtering on the subsurface evolution, as well as validation against erosion and migration measurements in PISCES. Integrated simulations for ITER-like parameters in a toroidal geometry will be presented. *Research supported by the US Department of Energy under DE-AC05-00OR22725
[1] W. Miller et al, Comp. Phys. Comm. 51 (1988) 355.
[2] R. Schneider et al, Contrib. Plasma Phys. 46 (2006) 3.

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