Modeling of Carbon Transport in the Divertor and SOL of DIII–D During High Performance Plasma Operation*

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High temperature, low density plasmas reduce the power requirements for noninductive current drive required for profile control in many high performance advanced tokamak scenarios. Such plasmas typically lead to a higher temperature, lower density edge plasma generally less favorable for impurity control and heat removal. On DIII–D, divertor plasma conditions during high performance single-null operation with a low density scrape-off layer (SOL) are found to be in a conduction limited regime with strike point electron temperatures well above threshold for physical sputtering of the graphite divertor tiles and 2) ion temperatures at the midplane in the SOL in the range of a few hundred eV. Significant plasma impurity content is observed in these discharges, consistent with poor divertor screening.

Modeling of these high performance conditions using the 2-D multifluid UEDGE code demonstrates the poor divertor screening on the outer divertor leg. Modeling indicates a strong flow of carbon from the divertor to the SOL region near the separatrix is seen under these conditions, consistent with the large ion temperature gradient and fairly low frictional drag from the background deuteron plasma. UEDGE not only predicts a significant carbon content of the core plasma, but also predicts that the level of core carbon drops much less than linearly with the sputtering coefficient at the plasma surface interaction region. This prediction is consistent with results of spectroscopic measurements presented at this conference [Whyte et al.] showing that while the divertor carbon source has dropped significantly over the past several years of repeated plasma exposure, wall conditioning and boronizations, the typical core plasma carbon content has not been reduced.

A detailed analysis of the carbon transport from the outer and inner divertor legs, and from the main chamber walls predicted by UEDGE under these high performance conditions will be presented. In addition to fluid code modeling, Monte Carlo modeling will also be carried out to identify the regions of the wall that contribute most to core carbon content. Comparisons to spectroscopic data from the divertor and midplane will be used as a guide to setting the appropriate divertor and main chamber carbon sources. The use of gas puffing with divertor pumping to alter divertor conditions and induce SOL flow will be modeled as a technique for reducing core carbon.

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