Topic: EX-D

The nearly continuous improvement of discharge characteristics and edge stability with increasing lithium coatings in NSTX

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The understanding of regimes with 1) high pressure at the top of the H-mode pedestal, and 2) devoid of large ELMs is important for scenario optimization of ITER and future devices. Lithium wall coatings have been shown to both improve energy confinement, through expansion of the H-mode pedestal width, and eliminate ELMs in NSTX. Here, we present analysis of variable pre-discharge lithium evaporation from multiple experiments, for more insight into the pedestal expansion and ELM suppression physics. First, a nearly continuous improvement of a number of discharge characteristics, e.g. reduced recycling, ELM frequency, and edge electron transport, with increasing pre-discharge lithium evaporation has been identified [Maingi, *PRL* **107** (2011) 145004; Boyle *PPCF* **53** (2011) 105011]. These correlations ran contrary to initial expectations that the beneficial effects would saturate at much lower evaporation amounts than used in experiments. Profile and stability analysis clarified the mechanism responsible for ELM avoidance and the role of lithium: lithium coatings reduce recycling and core fueling; thus the density and its gradient near the separatrix are reduced. The temperature gradient near the separatrix (from $0.95<\psi_N<1$) is unaffected; hence the pressure gradient and bootstrap current near the separatrix are reduced, leading to stabilization of kink/peeling modes thought to be responsible for the NSTX ELMs. Thus, the enhanced edge stability with lithium coatings is correlated with the reduction of the pressure and its gradient from $0.95<\psi_N<1$. The key ingredient for ELM avoidance is control of the particle channel *independent* of the thermal channel from $0.95<\psi_N<1$: the n_e profile is continuously manipulated via the amount of lithium evaporation and resulting recycling control, leading to reduced neutral fueling.

The surprising and beneficial facet of the NSTX data, however, is the continued growth of the edge transport barrier width in these circumstances, leading to 100% higher plasma pressure at $\psi_N \sim 0.8$, the approximate top of the n_e profile barrier with high pre-discharge evaporation. Analysis shows enhanced transport from $0.95<\psi_N<1$; coupled with the heating power reduction to stay below the global β_N limit, the pressure gradient and associated bootstrap current are maintained below the edge stability limit, thus avoiding ELMs. This allows the H-mode edge transport barrier to expand further and in such a way that peeling stability improves as a result of the inward shift of the bootstrap current. *Research sponsored in part by U.S. Dept. of Energy under contracts DE-AC05-00OR22725, DE-AC02-09CH11466, DE-FC02-04ER54698, DE-AC52-07NA27344, DE-FG03-99ER54527 and DE-FG02-99ER54524.