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Comparison of helium glow and lithium evaporation wall conditioning techniques in achieving high performance H-mode discharges in NSTX

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Experiments in NSTX demonstrated reproducible operation with inter-discharge lithium evaporation, eliminating the need for inter-discharge helium glow discharge cleaning (HeGDC), improving plasma confinement as well as the duty cycle. To assess the viability of operation without HeGDC and directly compare with inter-discharge lithium evaporation, the inter-discharge HeGDC duration was systematically reduced in four steps from the standard nine minutes to zero. Good discharge reproducibility without HeGDC was achieved with lithium evaporation doses of 100 mg or higher; evaporations of 200-300 mg typically resulted in very low ELM frequency or ELM-free operation, reduced recycling, and improved energy confinement. Similar results were obtained in the inverse experiment, i.e. when lithium evaporation was terminated, and inter-shot HeGDC was re-initiated, with a gradual increase in HeGDC duration and decrease in external fueling. Finally, an experiment in which a large lithium dose (~25g, ~100 times the typical inter-shot evaporation) prior to operations was conducted. In this case, about 100 plasma discharges over three run days were conducted with neither inter-discharge Li evaporation nor HeGDC. Nearly all of these achieved H-mode, but the pulse lengths and performance were not reproducible.

While the discharges with longer inter-discharge HeGDC times performed modestly better than those with shorter or no HeGDC durations, the discharge performance improved substantially in NSTX with increasing lithium dose in these strongly shaped plasmas, which were analyzed with SOLPS edge transport code. Data-constrained interpretive modeling with SOLPS quantified the edge transport change: the electron particle diffusivity decreased by 10-30x. The electron thermal diffusivity decreased by 4x just inside the top of the pedestal, but increased by up to 5x very near the separatrix. These results provide a baseline expectation for lithium benefits in NSTX-U, which is optimized for a boundary shape similar to the one used in this experiment. New results from upcoming wall conditioning experiments in NSTX-U will also be presented, when available.

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