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Modifications of impurity transport and divertor sources with lithium wall conditioning in NSTX[1]

FILIPPO SCOTTI, Princeton Plasma Physics Laboratory

In the National Spherical Torus Experiment (NSTX), a large spherical tokamak with graphite plasma facing components (PFCs), lithium evaporative coatings are routinely used for wall conditioning. In lithium-conditioned H-mode discharges, core carbon accumulation is generally observed with concentrations $\leq 10\%$, measured by charge exchange recombination spectroscopy. Lithium ions do not accumulate significantly and have core concentrations $\leq 0.1\%$. In this work, modifications in carbon and lithium sources and transport due to lithium coatings are analyzed. The change in ELM behavior (from ELMy to ELM-free) together with modifications in carbon neoclassical transport, due to changes in main ion temperature and density profiles, analyzed with NCLASS, NEO and MIST transport codes, can lead to an increased carbon confinement. The high lithium diffusivity due to the presence of a strong impurity (carbon) prevents core accumulation. Spectroscopic impurity influxes (Li I-II, C II-III measured by filtered cameras and divertor spectrometers via the S/XB method) and 2D multi-fluid code analysis (UEDGE) are employed to understand impurity sources and SOL parallel and perpendicular transport. Only a moderate reduction in the measured carbon sputtering yield and divertor carbon influxes is observed with lithium coatings on graphite PFCs. The expected reduction due to the coverage of graphite surfaces with lithium, in fact, can be counteracted by the degradation of the coatings and the change in divertor plasma parameters, due to the transition of the SOL to a sheath-limited regime. Prompt re-deposition of sputtered lithium atoms, meanwhile, strongly reduces the net lithium erosion and the divertor lithium source as evident from measured ionized lithium influxes which are $< 10\%$ of neutral lithium influxes.

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