Deuterium retention enhancement in lithiated graphite plasma-facing surfaces

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Motivation

Lithium conditioning by thermal deposition at prescribed doses have been adopted in NSTX resulting in siginficant effects on plasma performance including: reduction of ELMs, a reduction and/or elimination of required HeGDC time between discharges, reduced edge neutral density, reduced edge and SOL plasma density, extended plasma shots without LITER deposition, increased pedestal electron and ion temperature, and improved energy confinement.

The main assumption is that a likely mechanism responsible for the effects observed on NSTX plasmas was the retention of hydrogen by coatings of lithium on ATJ graphite tile surfaces. The main binding channel understood to be the ionic lithium hydride bond. Results from experimental data by Sugai and Allain however challenge this description namely by the well-known complex lithium intercalation in graphite. The likelihood that the dominant retention mechanism is governed by lithium-hydride bonding seemed small. Therefore the question was how then could a mixed lithiated graphite system retain hydrogen so effectively? And are there implications to future PMI materials? **This paper summarizes** the experimental and complementary data that identifies the key mechanism of enhanced hydrogen retention observed on lithiated graphite both in controlled *in-situ* off-line experiments at Purdue, post-mortem NSTX tile analysis, in-vacuo PMI probe data in NSTX and computational atomistic simulations. Results also motivate the question of possible alkali-doped graphite and other carbon allotrope materials as viable plasma-facing surfaces in burning plasma environments and the incredible multi-scale phenomenon of how ultra-thin lithium-graphite mixed films can impact the meter-scale plasma in NSTX.

Methods

Post-mortem NSTX analysis, *in-situ* off-line surface chemistry experiments, PMI probe analysis and quantum-mechanical atomistic simulations. Controlled deuterium dose exposures of various lithium amounts on ATJ graphite surfaces compared to control experiments (no Li) and analysis of post-mortem surface chemistry of NSTX tiles.

Results

Experiments show that deuterium is bound in the lithiated graphite system by Coulombic interactions between C in the presence of Li and lithium/oxide complexes. Possible saturation doses of D retention are also observed.

Conclusions

The electropositive nature of Li and the multi-body interaction of Li, C, O and D are primarily responsible for the enhanced retention of deuterium observed in lithiated graphite and its impact to the plasma-facing surfaces in NSTX.