Lithiated graphite as a hydrogen-pumping surface for improved plasma performance

J.P. Allain[1], D.L. Rokusek[1], H.W. Kugel[2], C. H. Skinner[2], R. Kaita[2], R. Maingi[3], R. Majeski[2], D.K. Mansfield[2], V. Soukhanovskii[4]

[1]*Purdue University, West Lafayette, IN 47907, USA*
[2]*Princeton Plasma Physics Laboratory, Princeton, NJ 08543, USA*
[3]*Oak Ridge National Laboratory, Oak Ridge, TN 37831*
[4]*Lawrence Livermore National Laboratory, Livermore, CA 94551*

Lithium has enhanced the operational performance of fusion devices such as: TFTR, CDX-U, FTU, T-11M and NSTX [1-5]. Lithium in the solid and liquid state has been studied extensively in laboratory experiments on both its erosion and hydrogen-retaining properties [6]. However, questions still remain on the role that lithiated surfaces have on hydrogen isotope recycling because of the difficulty of *in-situ* measurements of surfaces in tokamaks. Understanding the lithium surface chemistry and its effect on particle recycling is vital in the implementation of the new liquid lithium divertor in NSTX and in future machines using lithium. Particle-beam laboratory facilities at Purdue aim to mimic the tokamak environment and include a lithium evaporator and sophisticated surface diagnostics. Processes at the surface and near-surface are studied *in-situ* under energetic particle irradiation. The primary approach is correlation of surface chemistry data from X-ray photoelectron spectroscopy (XPS) and thermal desorption spectroscopy with mass spectrometry to look at emission of implanted D. Additional complementary techniques also include the use of an Omicron cluster that has a HR-EELS (high-resolution electron electron energy loss spectroscopy), SEM (secondary electron microscopy) and low-energy electron diffraction (LEED).

We have evaporated lithium onto various substrates including ATJ graphite to mimic deposition during the recent NSTX campaign. In-situ surface characterization and particle desorption is conducted during Li deposition to study the effect of lithiated coatings on D retention during D_2 ion exposures at energies less than 500 eV/amu. The data are also used to benchmark surface codes (e.g. TRIM-SP and ITMC) that are coupled to erosion/redeposition modeling codes used for NSTX. Care was taken to replicate as close as possible conditions at the divertor floor of NSTX with systematic control of experimental parameters (e.g. incident particle energies, bombarding particle fluence, Li vapor fluence, and particle species.) Temperature effects is the subject of a separate paper. We also compare a set of fiducial experiments on lithium coatings on two alternate substrates: stainless steel and molybdenum. In this paper we assess the influence of lithium chemistry on deuterium particle pumping as a function of Li vapor fluence and time evolution of Li surface layers. Results show that the chemical state of lithium atoms on graphite is dominated by lithium peroxide (Li_2O_2) bonds, which can inhibit effective hydrogen bonding and consequently control hydrogen recycling. We will correlate the results of the laboratory experiments with surface characterization and analysis of the NSTX divertor tiles and Si witness samples measured *ex-situ*.

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