Plasma Facing Surface Composition During NSTX Li Experiments*

C.H. Skinner[1], R. Sullenberger[2], B. E. Koel[2], M. A. Jaworski[1], H.W. Kugel[1].

[1]*Princeton Plasma Physics Laboratory, Princeton NJ, 08543 USA.*

[2]*Department of Chemical and Biological Engineering, Princeton University NJ 08540*

Liquid plasma facing materials avoid issues with radiation damage, helium blisters and erosion lifetime compared to solid materials. Liquid lithium has the further advantage of binding with hydrogen isotopes, and lithium conditioning has reduced recycling and enhanced plasma performance on many fusion devices. On the National Spherical Torus Experiment (NSTX), two lithium evaporators can be inserted at the top of the vessel and evaporate lithium onto ATJ graphite PFCs between discharges[1,2]. To understand the plasma surface interaction and provide a design basis for next-step devices that aim to take advantage of the benefits of lithium, it is important to characterize the plasma facing surface chemical composition and its interaction with the plasma.

Sophisticated surface analysis instruments can characterize surfaces in atomic detail, but are not easy to implement in a tokamak vacuum vessel[3,4]. However, much of the relevant surface chemistry is accessible in laboratory investigations. Since tokamaks typically do not have ultrahigh vacuum (UHV) conditions, surface reactions with residual gases can occur in the time interval between lithium evaporation and the next discharge. We report x-ray photoelectron spectroscopy (XPS) investigations of the oxidation of metallic lithium by gases typically found in a tokamak residual vacuum such as water and carbon monoxide as well as oxygen and air and compare the oxidation rate to the kinetics of gases impinging on the surface. We conclude that the PFC surface at the initiation of the discharge should be considered as a mixed material rather than a pure 'lithium coating'.

The binding of deuterium to lithium or lithium compounds is central to the reductions in recycling and performance improvements in fusion devices with lithium PFCs. We plan to investigate the uptake of deuterium by various lithium-based surfaces. A fresh lithium surface will be prepared by evaporation under ultrahigh vacuum conditions. A laboratory source will provide a flux of deuterium atoms or ions and the deuterium uptake will be measured by temperature programmed desorption. The deuterium uptake of metallic and oxidised lithium surfaces will be compared.

[1] C.H. Skinner et al., Phys. Scripta (2011) at press
[2] R. Kaita et al., in this conference and references therein.
[3] C.H. Skinner et al., 2011 J. Nucl. Mater. 415 (2011) S773–S776.
[4] B. Heim et al., ISFNT-10 Portland (2011).

*Support is provided by the U.S. DOE Contract Nos. DE AC02-09CH11466