Category: EX/FT - Fusion Technology

NSTX Lithium Technologies and Their Impact on Boundary Control, Core Plasma Performance, and Operations*

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Replenishable liquid lithium PFCs show promise towards resolution of density and impurity control, tritium and dust removal, and long-lifetime walls for diverted high power DT reactors by providing a low-Z, pumping, and self-healing plasma facing surface [1-3], and enabling a lithium wall fusion regime [4]. Motivated by this potential, NSTX high-power divertor plasma experiments have successively used injected Li pellets, evaporated Li, and injected Li powder to apply Li coatings to plasma facing components [5-7]. At first, using a sabot style, low velocity, edge pellet injector, up to 30 mg of lithium was applied by injecting Li pellets of 1 to 5 mg mass into ohmic helium discharges. These were followed by deuterium reference discharges with NBI heating which exhibited edge density reduction and performance improvements [5, 6].

Since 2006, first one, and now two LIThium EvaporatoRs (LITERs) (Fig.1) have been used routinely to evaporate lithium onto the lower divertor region (Fig.2) at total rates of 10-70 mg/min for periods 5-10 min between discharges [6, 7].

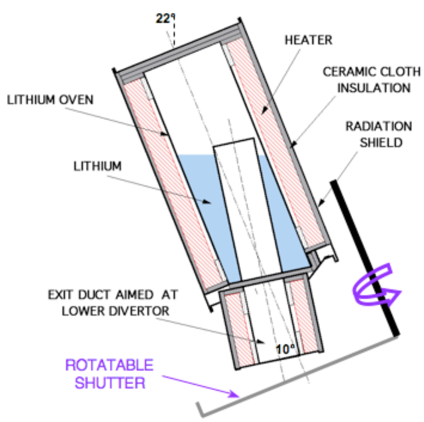

Fig.1 Diagram of LIThium EvaporatoR (LITER).

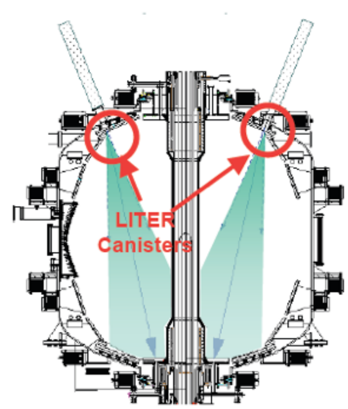

Fig.2. Poloidal cross section of NSTX and LITERS aiming at lower divertor..

Prior to each discharge, the evaporators are withdrawn behind shutters. Noteworthy improvements in the performance of NBI-heated divertor discharges have resulted from these Li depositions including reduced edge recycling, and suppression of ELMs [6, 7]. These evaporators are now used for more than 80% of NSTX discharges. Experiments with a 3rd new technique of Li delivery have been initiated [8]. Using a recently developed piezoelectric resonant acoustic injector, macroscopic amounts of Li

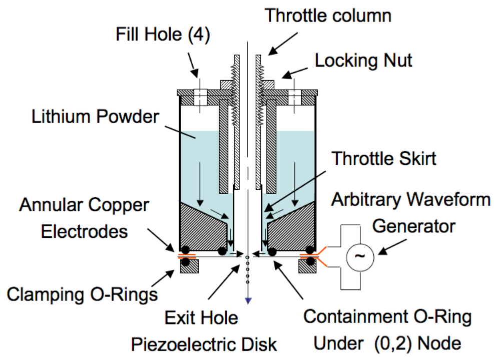

Fig. 3 Schematic of Li powder dropper.

microspheres (in the form of powder with 44 μm median diameter) were injected in real time into the NSTX scrape-off layer (Fig.3). The NSTX H-Mode plasmas proved to be remarkably tolerant to this method of Li injection up to fluxes as high as 35 mg– a rate stoichiometrically equivalent to amount of deuterium needed to the fuel.

Several operational issues have been encountered with lithium wall conditions including the need for increased core fueling, as recycling is reduced to avoid deleterious MHD instabilities in the plasma startup, and increasing impurity confinement and core impurity radiation during the extended discharges, as confinement improved. In addition, special procedures are needed when the vacuum vessel is vented to allow safe access to the interior, and for PFC preparation prior to vessel evacuation for the resumption of experimental operations.

The next step in this work is installation of a liquid lithium PFC on the outer part of the lower divertor (Fig.4) . The Liquid Lithium Divertor (LLD) consists of a toroidal array of four 80° plates, each consisting of a 165 micron face-layer of Mo with 45% porosity, plasma sprayed on a protective barrier of 0.25 mm stainless steel, bonded to a 1.9 cm thick copper substrate. Each section is separated by a row of graphite diagnostic tiles containing magnetic sensors, thermocouples, Langmuir probes and bias electrodes [9]. Initial Li loading will be done by evaporative coating using the 2 LITER units.

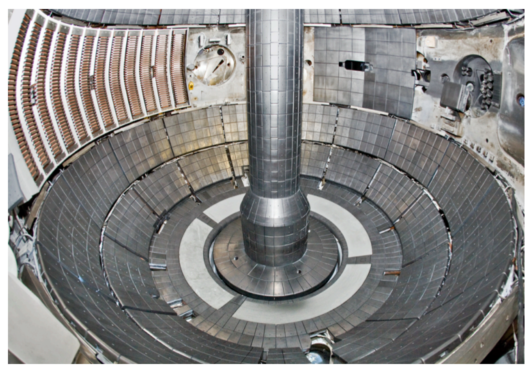

Fig.4. Photo of Liquid lithium Divertor (LLD-1).

The design, methods, and application of these lithium technologies, and their impact on boundary control, core plasma performance, and operations will be presented.

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