Experimental observations of lithium as a plasma-facing surface in the DIII-D tokamak divertor

D.G. Whyte[a], T.E. Evans[b], C.P.C. Wong[b], W.P. West[b], R. Bastasz[c], J.P. Allain[d], and J.N. Brooks[d]

[a]University of Wisconsin, 1500 Engineering Dr., Madison, Wisconsin, 53706, USA

[b]General Atomics, San Diego, California, USA

[c]Sandia National Laboratories, Livermore, California, USA

[d]Argonne National Laboratory, Argonne, Illinois, USA

Abstract. Several experiments exposing a $5\ \mathrm{cm}^2$ solid and liquid lithium to the divertor plasma of the DIII-D are described. The divertor plasma strikepoint cleans and conditions the initially solid lithium surface. The effective sputtering rate and transport of lithium was found to be acceptable. Lithium has a sputtering yield of solid lithium <10% for $T_e \sim 20$ eV. The sputtered lithium is ionized in a short distance from the divertor and promptly redeposited. Experiments and modeling show the sputtered lithium is well shielded by the divertor plasma. The behavior of the liquefied lithium was dominated by its macroscopic movement and injection into the plasma caused by $J \times B$ magnetohydrodynamic (MHD) forces. Plasma MHD events, such as edge localized modes (ELMs) and locked modes, are found to provide simultaneously the energy to melt the lithium and the transiently high scrape-off layer (SOL) currents to cause the $J \times B$ motion. The macroscopic removal of lithium from the small sample, comprising <1/1000th of the wetted divertor area, leads to measurable contamination of the core plasma by lithium. The quantity of injected lithium was sufficient to degrade confinement and/or cause disruptions. These observations indicate that surface stability and MHD motion are the most critical issues with regard to liquid-metal divertor surfaces.