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The Effects of Temperature and Oxidation on Deuterium Retention in Solid and Liquid Lithium Films on Molybdenum Plasma-Facing Components¹

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Liquid metal plasma-facing components (PFCs) enable in-situ renewal of the surface, thereby offering a solution to neutron damage, erosion, and thermal fatigue experienced by solid PFCs. Lithium in particular has a high chemical affinity for hydrogen, which has resulted in reduced recycling and enhanced plasma performance on many fusion devices including TFTR, T11-M, FTU, CDX-U, LTX, TJ-II, and NSTX. A key component to the improvement in plasma performance is deuterium retention in Li; however, this process is not well understood in the complex tokamak environment. Recent surface science experiments conducted at the Princeton Plasma Physics Laboratory have used electron spectroscopy and temperature programmed desorption to understand the mechanisms for D retention in Li coatings on Mo substrates. The experiments were designed to give monolayer-control of Li films and were conducted in ultrahigh vacuum under controlled environments. An electron cyclotron resonance plasma source was used to deliver a beam of deuterium ions to the surface over a range of ion energies. Our work shows that D is retained as LiD in metallic Li films. However, when oxygen is present in the film, either by diffusion from the subsurface at high temperature or as a contaminant during the deposition process, Li oxides are formed that retain D as LiOD. Experiments indicate that LiD is more thermally stable than LiOD, which decomposes to liberate D₂ gas and D₂O at temperatures 100 K lower than the LiD decomposition temperature. Other experiments show how D retention varies with substrate temperature to provide insight into the differences between solid and liquid lithium films.

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