§17. Particle Control by Low-Z Materials Coating

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Recently, in situ coating of thin lithium layers with a vacuum evaporation method has been performed in a small laboratory device to demonstrate a new possibility for wall conditioning [1]. Subsequently, wall conditioning with lithium pellet injection was developed in TFTR[2]. This technique led to a reduction of carbon impurities and 15-20 % improvements in supershot plasma performance. However, the underlying mechanisms for the effects of lithium-based conditioning have not been fully understood. In order to evaluate the effect of lithium evaporation onto first walls, we performed laboratory experiment[3].

The basic experiment was performed in the small laboratory apparatus (0.27 m in diam., 0.45 m in length). A small stainless steel oven (~2cm^3) is placed 5 cm above the bottom of the vessel. Solid lithium is put in the oven, which can be heated to 500 °C. A deposition monitor enables us to measure the deposition rate of lithium. Discharges are maintained between a mesh anode and the vessel (cathode).

To make sure the chemical reactivity of lithium with hydrogen or oxygen gas, these gases were separately fed into the vessel at a constant flow rate of 3 sccm, immediately after lithium evaporation. The lithium layer clearly showed the gettering effect for oxygen gas, which was not observed in case of hydrogen gas. The oxygen sorption [O] is plotted as a function of the evaporated lithium [Li] (Fig.1). Within the measured range of [Li]<6×10^{-3} mol and average film thickness ($\bar{d}$) <170 nm, the experimental points well fit the linear relationship, [Li]=2[O], thus suggesting the formation of lithium oxide (Li$_2$O).

As is mentioned, lithium layers are inert for hydrogen molecules. However, they are very reactive with hydrogen atoms and ions. After lithium evaporation, a dc glow discharge (200 V, 0.3 A) in hydrogen was turned on. The resultant change in the pressure was measured with the deposited lithium weight [Li] as a parameter. As shown in Fig. 2, the hydrogen uptake is enormously large and does not saturate even when the lithium layer thickness exceeds $\bar{d}$=300 nm. The solid line in Fig. 2 indicates the relation [H]=[Li], and the experimental results roughly agree with this relation. In other words, the capacity of hydrogen uptake is approximately equal to the number of lithium atom in the vessel.
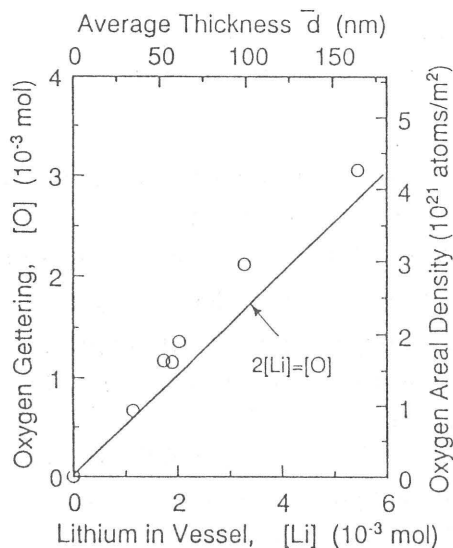

Fig. 1. The amount of oxygen gettered by the lithium layer [O] as a function of the amount of lithium evaporated in the vessel [Li].

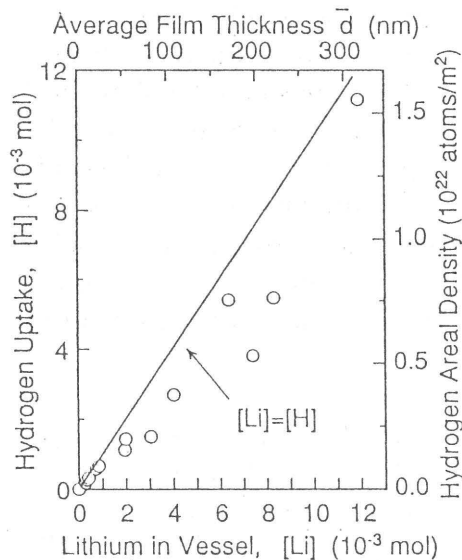
Fig. 2. The amount of hydrogen atom sorbed by the lithium layer [H] as a function of the amount of lithium evaporated in the vessel [Li].

References
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2) Snipes et al., J. Nucl. Mater. 196-198(1992)686.
3) Sugai, H., et al., J. Nucl. Mater. 220-222(1995) 254.