§62. Plasma Surface Interactions in Lithium Coating on Graphite Materials

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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 experiments.[3-5]

The basic experiment was performed in the small laboratory apparatus (0.27 m in diam., 0.45 m in length). A 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 ℃. A deposition monitor enables us to measure the deposition rate of lithium. A graphite sheet is placed on inner wall of the vessel to simulate graphite tiles used in actual devices. After lithium deposition, the graphite sheet is exposed to the hydrogen grow discharge which is maintained by the voltage applied between a mesh anode and the vessel (cathode). Lithium film is also deposited on another small sample graphite substrate (2cm x 2cm), which is analyzed by an in-situ Auger electron spectroscopy (AES). Erosion of the graphite is evaluated by the measurement of CH_4 partial pressure during the H_2 discharge.

It is well known that the Auger spectrum of carbon is different depending on its chemical bonding state, i.e., carbide or graphite. To investigate the change of the chemical bonding due to the reaction of the carbon with the lithium, three types of sample are prepared : (i)lithium-deposited sample, (ii)lithium-deposited sample with post anneal at 200°C for 90 minutes, and (iii)lithium-deposited sample exposed to the hydrogen plasma. These samples are analyzed by the AES but any change of the Auger spectra is not observed. This result indicates that the deposited lithium does not affect the chemical bonding of the graphite.

To get information on the effect of lithium deposition on the suppression of carbon impurities, the graphite sheets with and without lithium deposition are exposed to the hydrogen plasma and CH_4 partial pressure is measured by a differentially-pumped quadrupole mass spectrometer. Figure 1 shows discharge current dependence of CH_4 yield with and without lithium deposition. CH_4 yield is almost proportional to the discharge current, which implies that the CH_4 is produced by the ion flux to the wall. It is also notable that CH_4 yield is reduced only by ~25% with the lithium deposition even though the film thickness is ~100 nm. Considering that the ion implantation range of hydrogen ions are less than a few nm in the lithium film, such small reduction is presumably due to imperfectness of the lithium coverage on the graphite surface because of the graphite surface roughness.

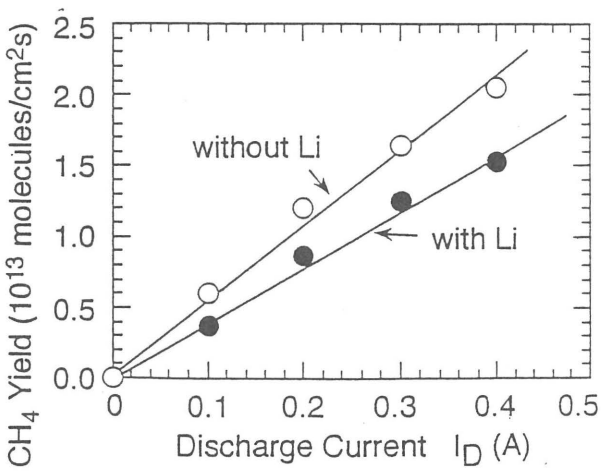

Fig. 1. Discharge current dependence of the CH_4 yield with (filled circles) and without (open circles) the lithium deposition on the graphite wall.

References
1) Isozumi,T., Yoshida, S., Sugai, H. : Kaku-Yugo Kenkyu 60(1988)304.
2) Snipes et al. : J. Nucl. Mater. 196-198(1992)686.
3) Sugai, H., et al. : J. Nucl. Mater. 220-222 (1995) 254.
4) H. Sugai et al. : Vacuum 47(1996)981.
5) H. Toyoda et al. : to be published in J. Nucl. Mater.