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Compatibility of high-flux helium plasma irradiated molybdenum with liquid lithium

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Abstract: Molybdenum is presently considered as the primary potential substrate materials for liquid lithium plasma-facing components for its advantages of corrosion resistance and wettability for liquid Li. However, when liquid lithium is introduced into a practical magnetic confined fusion device, the underlying substrate may be exposed to the plasma due to the destruction of lithium layer. Consequently, it is necessary to evaluate the combined effects of the helium plasma irradiation and liquid lithium corrosion on molybdenum. In this work, the compatibility of irradiated molybdenum with liquid lithium was investigated. The molybdenum specimens were firstly exposed to plasma beam with helium ion flux 5×10^{22} $m^{-2}s^{-1}$ for 5, 15, 30, 60, 120 and 180 minutes. A nano-fuzz layer with inhomogeneous nano-voids were formed on the molybdenum surface after exposure to the helium plasma, and the thicknesses of fuzz layers were almost equal to ~350 nm for the different exposure times due to the continuous plasma sputtering. The results of wettability test showed that the nano-fuzz decreased the wettability of liquid lithium on the surface of irradiated molybdenum. Finally, the static corrosion test of irradiated specimens in liquid lithium was carried out at 623 K for 1350 hours. Molybdenum showed greatly corrosion resistance to liquid lithium regardless of exposure to plasma or not. A carburized layer including Mo_2C was formed on the surface region of molybdenum. The diffusion of carbon to bulk was suppressed by the fuzz layer. Furthermore, the hardness molybdenum surface increased by the carburization of surface.

Keywords: Molybdenum, Liquid lithium, Fuzz, Carburization, Wettability, Ion irradiation, Corrosion

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