DEVELOPMENT OF ELECTRICALLY INSULATING COATINGS FOR SERVICE IN A LITHIUM ENVIRONMENT*

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OBJECTIVE

The objectives of this task are to (a) develop electrically insulating coatings, with emphasis on the basic understanding of the thermodynamic conditions and kinetics of coating development needed to achieve stable coatings of CaO that are compatible in an Li/Li-Ca environment; (b) perform detailed postexposure analysis of the surface layers by several electron/optical techniques to characterize the elemental and phase compositions, quantify stratification in the layers, and establish the role of compositional changes in the coating defects and microstructure; (c) measure the electrical resistance of the coatings, before and after exposure external to Li; and (d) establish optimal procedures from the standpoint of sample preparation procedures, exposure time and temperature, and sequence of operations in order to obtain reliable and reproducible coatings with adequate electrical resistance for use in an Li environment.

EXTENDED ABSTRACT

A paper on this subject was presented at the 9th International Conference on Fusion Reactor Materials in Colorado Springs, Oct. 10-15, 1999. An extended abstract of that paper is given below.

Several experiments were conducted to develop electrically insulating CaO coatings on a V-4Cr-4Ti alloy for application in an Li environment. Coatings were developed by a vapor phase transport process external to Li and in-situ in an Li-Ca environment at elevated temperature. In the vapor phase study, several geometrical arrangements were examined to obtain a uniform coating of Ca on the specimens, which were typically coupons measuring 5 to 10 x 5 x 1 mm. After Ca deposition from the vapor phase, the specimens were oxidized in a high-purity argon environment at 600°C to convert the deposited metal into oxide. The specimens exhibited insulating characteristics after this oxidation step. Several promising coated specimens were exposed to high-purity Li at 500°C for 48-68 h to examine coating integrity. Microstructural characteristics of the coatings were evaluated by scanning electron microscopy and energy-dispersive X-ray analysis. Electrical resistance of the coatings was measured between room temperature and 700°C before and after exposure to Li by a two-probe method.

Results showed that thick adherent coatings can be fabricated by thermal/chemical vapor deposition process, especially if a double Ca treatment is applied. Coatings developed in-situ in an Li-Ca environment had thicknesses much less than desired. Furthermore, the coating composition was nonuniform, with significant presence of V in several locations on the coated surface. Microstructural analysis of the coatings developed by the thermal/chemical process showed almost 100% CaO over a coating thickness of 20-30 μm; electrical resistance of such coatings was at least two orders of

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magnitude higher than the minimum required for blanket application. Electrical resistance of in-situ-developed coatings was adequate at temperatures up to ≈350°C, but decreased substantially at higher temperatures. The results obtained in this study indicate that CaO is a viable coating for a V-Li advanced blanket, but needs significant additional effort, especially from the standpoint of structure/composition relationship to its electrical resistance. Furthermore, in-situ measurement of resistance in Li is required in order to simultaneously evaluate the coating integrity, its resistance, and Li compatibility.