STUDY OF THE LONG-TERM STABILITY OF MHD COATINGS FOR FUSION REACTOR APPLICATIONS -- B. A. Pint, L.D. Chitwood, J. H. DeVan and J. R. DiStefano (Oak Ridge National Laboratory)

OBJECTIVE

The objective of this task is to assess the long-term, high-temperature compatibility of high electrical resistance coatings with lithium at high temperatures. So-called magnetohydrodynamic (MHD) coatings on the first wall of magnetic confinement reactors are essential to reduce the MHD force that would otherwise inhibit the flow of the lithium coolant. Initial experimental work is being conducted on bulk ceramics to determine maximum-use temperatures of candidate ceramics such as AlN and CaO.

SUMMARY

This project began in June 1999. Initial testing has been performed on AlN+5%Y_2O_3 at 400°-700°C. With increasing temperature, this material was increasingly attacked by lithium in 1000h tests and there was a corresponding increase in the aluminum content of the lithium. These results suggest that the maximum use temperature of AlN in lithium may be 600°C or less. Currently, 1000h experiments are being completed with yttria-free AlN and CaO specimens at 400°, 500° and 700°C.

PROGRESS AND STATUS

Experimental Procedure

A welded capsule system was used to test bulk specimens, Figure 1. Capsules were loaded in glove boxes in a controlled environment. An inner vanadium (V-4Cr-4Ti) capsule was used to better simulate the environment that the ceramic will see in operation. Because vanadium is not oxidation resistant, the vanadium capsule was then placed into a stainless steel capsule prior to exposure. These capsules were then tested in 3 calibrated box furnaces for 1000h. After allowing the lithium to melt, the capsules were inverted to submerge the specimen in lithium. At the end of 1000h, the capsule was again inverted to allow the lithium to drain away from the specimen. After opening, the specimen was cleaned by distilling off any remaining lithium followed by a final cleaning in alcohol. Initial tests were conducted at 400°, 500°, 600° and 700°C on AlN+5%Y_2O_3 with dimensions of 0.6x10x10mm. Because of extensive attack of the AlN, the only characterization that was performed was specimen mass change and measurement of the composition of the lithium by Lockheed Martin Energy Systems (Y12) in Oak Ridge, TN. In future tests, measurements also will be made of electrical resistivity and the microstructure will be examined.

Results and Discussion

Initial testing of AlN with 5%Y_2O_3 showed increasing attack over the range 400°-700°C. Whereas previous work showed a 0.02% mass loss after 100h at 400°C[1], there was a 0.08% mass loss after 1000h at 400°C and a 1.92% mass loss after 1000h at 600°C. After 1000h at 700°C, only tiny fragments of the specimen were recovered. This material had a starting thickness of only

Table I. Lithium composition determined by spectrographic analysis.

Conditions	Nitrogen	Aluminum
Starting Lithium	244 wppm	<10 wppm
After 1000h at 400°C	292 wppm	800 wppm
After 1000h at 600°C	232 wppm	1500 wppm
After 1000h at 700°C	258 wppm	>4000 wppm

0.6mm, subsequent tests used specimens at least 2mm thick in an attempt to prevent the complete loss of the coupon. After testing, the lithium showed an increase in aluminum content with test temperature indicating some dissolution of AlN at all temperatures and a major dissolution at 700°C, Table I. The nitrogen did not significantly increase during the test. This may indicate that the V-4Cr-4Ti capsule walls gettered some of the nitrogen. Nevertheless, the high Al levels in the lithium suggest that some reaction is taking place and that the maximum use temperature of AlN in Li may be 600°C or less.

It is believed that the high (5%) yttria content of the AlN likely contributed to the extent of the attack because of selective attack of the Y_2O_3 by lithium. Previous work showed higher attack of Y_2O_3 than AlN in lithium at 400°C.[1] Because Y_2O_3 is generally a grain-boundary phase in AlN, selected attack may have increased the disintegration of the specimen at 700°C. Pure AlN may perform differently. Therefore, subsequent tests were conducted on yttria-free AlN and high-purity CaO. Exposures of these materials will be complete at the end of January 2000.

REFERENCES

1. R. J. Lauf and J. H. DeVan, J. Electrochem. Soc. 139 (1992) 2087.

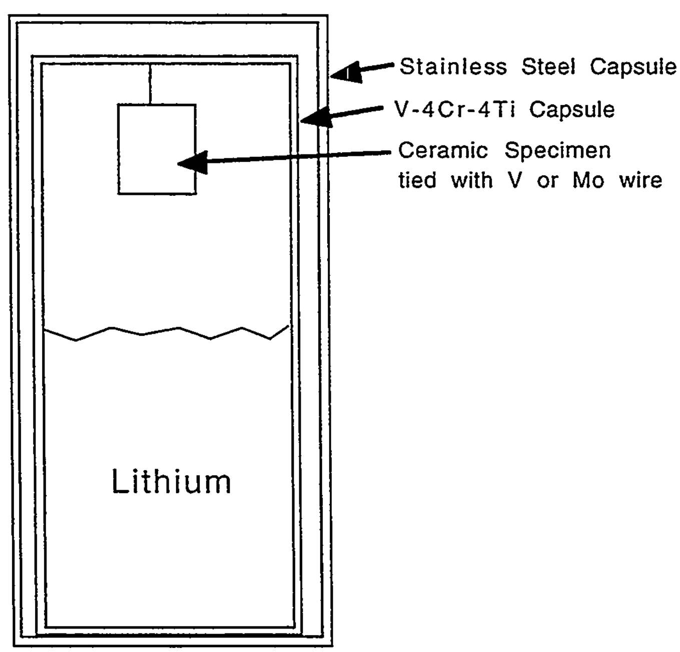

Figure 1. Schematic of the ORNL Li capsule test. After melting the Li, capsule is inverted to submerge the specimen. At the end of the test, the capsule is again inverted to free the specimen from the Li for removal.