ADDITIONAL CHARACTERIZATION OF V-4Cr-4Ti EXPOSED TO FLOWING Li – B. A. Pint and K. A. Unocic (Oak Ridge National Laboratory)

OBJECTIVE

Characterize specimens exposed to flowing Li in a thermal gradient to evaluate the effects on V-4Cr-4Ti and a multi-layer electrically-insulating coating needed to reduce the magneto hydrodynamic (MHD) force in the first wall of a lithium cooled blanket.

SUMMARY

In order to further understand the behavior of specimens exposed in the loop, microstructural characterization is being performed on the V-4Cr-4Ti tensile specimens that showed dynamic strain aging at 500°C. Initial results are presented. Also, further characterization on the dual layer MHD coatings is planned.

PROGRESS AND STATUS

Introduction

Previous reports[1,2] presented 500°C tensile behavior of V-4Cr-4Ti after various exposures including flowing Li in a thermal convection loop with a peak temperature of 700°C for 2,355h.[3] The results were unusual and more characterization was warranted which is now being undertaken. Also, the dual layer (Y_2O_3/V) MHD coatings deposited by physical vapor deposition that were exposed in the loop were not fully characterized because a method was not apparent to evaluate the electrical resistivity without damaging the coatings. Using focused ion beam milling may now provide an opportunity to study those coatings.

Experimental Procedure

Details of the thermal convection loop exposure have been presented previously.[3] The specimens consisted of miniature tensile specimens (type SS-3: 25 x 4 x 0.9mm), tab specimens and specimens with a dual layer MHD coating linked in a chain held together with V-4Cr-4Ti wire. The tensile specimens were annealed for 1h at 1050°C prior to exposure in Li. The exposure temperature for each specimen is estimated by using a linear extrapolation of the temperatures measured at the top and bottom of the each leg.[3] Tensile testing was conducted at 500°C in a vacuum with a base pressure of 10^{-6}Pa (10^{-8}Torr) and a strain rate of $10^{-3}s^{-1}$. Initial microstructural characterization is being performed, first consisting of scanning electron microscopy (SEM) of the fracture surfaces and metallographic cross-sections of the tensile specimens. Additional characterization of the microstructure (e.g. hardness profiles and transmission electron microscopy (TEM)) will be conducted as warranted.

Results and Discussion

Figure 1 shows a summary of fracture surfaces and deformation regions of the tensile specimens fractured at 500°C in vacuum. All of the specimens show some ductile behavior. The as-received specimen showed the most ductility, Figure 1a. (In general, all of the specimens showed an increase in ultimate tensile stress (UTS) compared to the unexposed specimens and some decrease in ductility.) The specimen exposed to isothermal Li at 800°C for 1,000h (Figure 1b) and the specimen from the top of the hot leg (highest temperature, ~627°C, Figure 1d) show a 45° orientation of the fracture surface suggesting a change in the deformation mechanism near the maximum shear stress. To evaluate the operating mechanism and grain orientations, electron backscatter diffraction in the SEM and TEM will be used. The initial characterization

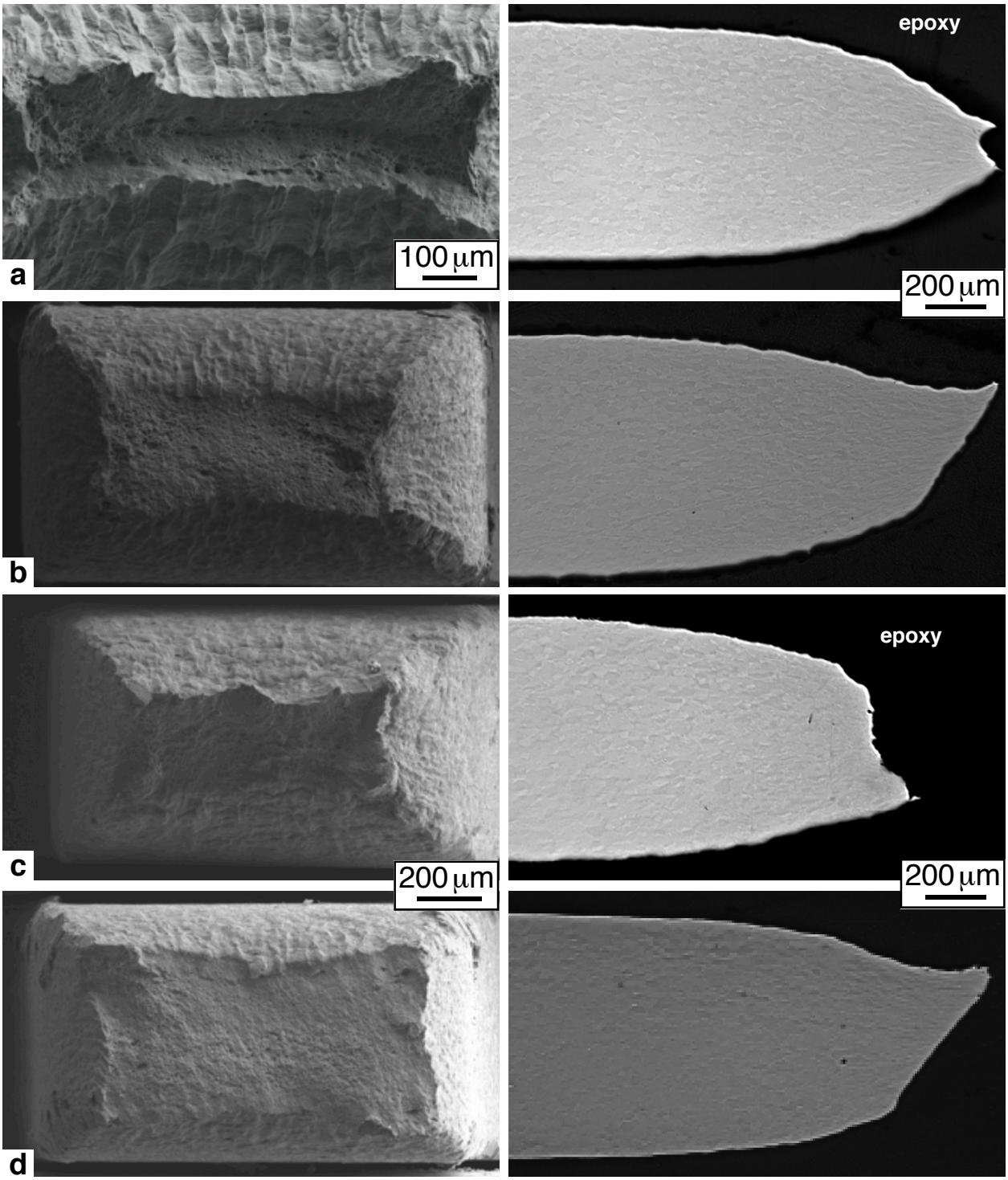

Figure 1. SEM of fracture surface and light microscopy of cross sections for V-4Cr-4Ti tensile specimens tested at 500°C: (a) as-received, (b) 800°C isothermal capsule exposure in Li, (c) cold leg, ~516°C and (d) hot leg, ~627°C. All of these specimens showed dynamic strain ageing at 500°C.

of the tab (spacer) V-4Cr-4Ti specimens in the loop showed precipitate coarsening and depletion near the surface. However, the initial evaluation of these specimens did not reveal similar behavior in these specimens. As each specimen was too small to perform a chemical analysis, V-4Cr-4Ti tab and tube wall specimens were used to measure chemistry changes. These analyses consistently showed a decrease in the O content and an increase in the C and N contents.[1, 3-5] These changes in interstitial content are expected based on Li thermodynamics of gettering O, but low affinity, compared to vanadium, for C and N. One goal of the characterization is to determine if these composition changes are uniform or if there is a gradient within the material and if location in the loop affected the microstructure. Ultimately, a better understanding of the precipitate evolution during exposure in the loop should explain the variations observed in the dynamic strain aging behavior during 500°C tensile testing and the differences observed between these specimens and those exposed to static Li in an Ar-filled glove box.[6]

References

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