1.5 THREE DIMENSIONAL FRACTOGRAPHY OF HFIR-IRRADIATED F82Hs – H. Sakasegawa, H. Tanigawa (Japan Atomic Energy Agency), and Y. Katoh (Oak Ridge National Laboratory)

OBJECTIVE

The objective of this work is to perform 3D fractography on HFIR-irradiated F82Hs to study details of irradiation effects on the tensile rupture mechanism. This work is part of the U.S. Department of Energy – Japan Atomic Energy Agency fusion materials collaboration.

SUMMARY

The 3D fractography was performed using a scanning electron microscope. Three pictures of tensile specimen rupture surfaces were taken from different tilt angles and 3D images were produced from these pictures using a software program. From the representative result shown here, it was revealed that the irradiated specimen of F82H-MOD3 heat irradiated to 2.7 dpa at 573 K showed a shear rupture mode, with a small area fraction of dimpled surface.

PROGRESS AND STATUS

Introduction

3D fractography is very useful technique to study rupture mechanisms. For example, FRActure Surface Topography Analysis (FRASTA) technology was developed and published [1]. This technology focuses on the growth history of a crack, which is strongly correlated to the remaining useful life of a material, and reveals how a crack front interacts with microstructural features. This result can contribute to understanding the rupture mode in detail and help in the development of materials with more appropriate mechanical properties. In the case of F82H, it is well known that its ductility drastically degrades and uniform elongation becomes near zero after irradiation around 573 K to less than a few dpa. This irradiation embrittlement should be understood and allowed for in planning to actually use F82H as a blanket material with appropriate structural soundness.

Experimental

In this work, scanning electron microscopy (SEM) images were obtained on ruptured HFIR irradiated tensile specimens (SS-J3 type) using the JEOL JSM-6010LA in cell 4 in Building 3025E, Oak Ridge National Laboratory. Three or five pictures were taken from different tilt angles. These pictures were then processed with the software, Alicona MeX, to produce a 3D image of the rupture surface [2].

Results and Discussion

Figure 1 shows the result of tensile test at 573 K on F82H-MOD3 heat (Fe-0.1C-8Cr-2W-0.2V-1.0Ta) [3] irradiated at 573 K to 2.7 dpa (ID: HX4) [4]. The irradiated sample clearly showed irradiation embritllement and the uniform elongation was reduced to 0.1 %, compared to that of unirradiated F82H which is generally larger than 2 %. The tensile ruptured surface is shown in Figure 2 (a). Though the upper right position was contaminated, we clearly observed some dimples which indicated that this specimen had a local ductile fracture mode. Figure 2 (b) shows the image of the rotated and tilted specimen. This picture gives three dimensional information of the fracture surface, but it is difficult to observe the topographical detail.

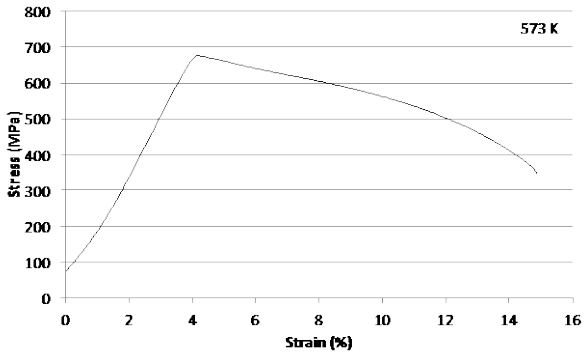
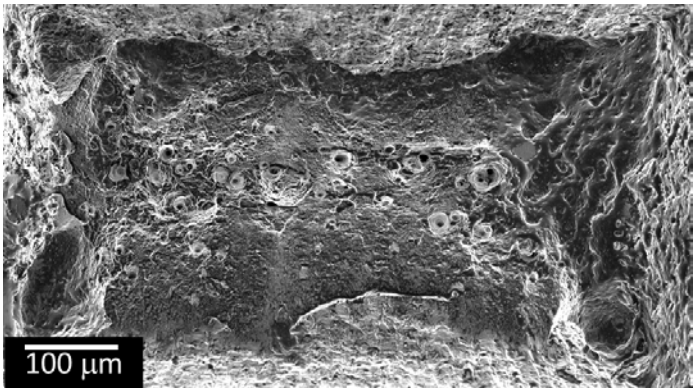
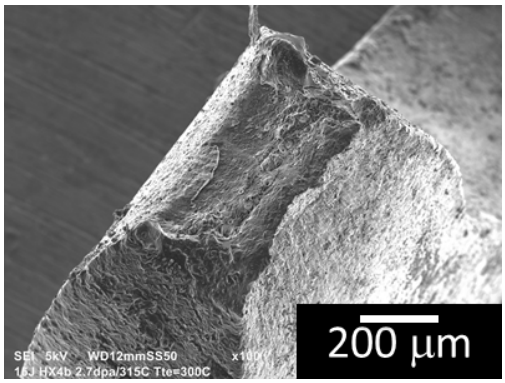


Figure 1. Tensile test result on specimenID: HX4, F82H MOD3 heat, irradiated to 2.7 dpa at 573 K and tested at the irradiation temperature.



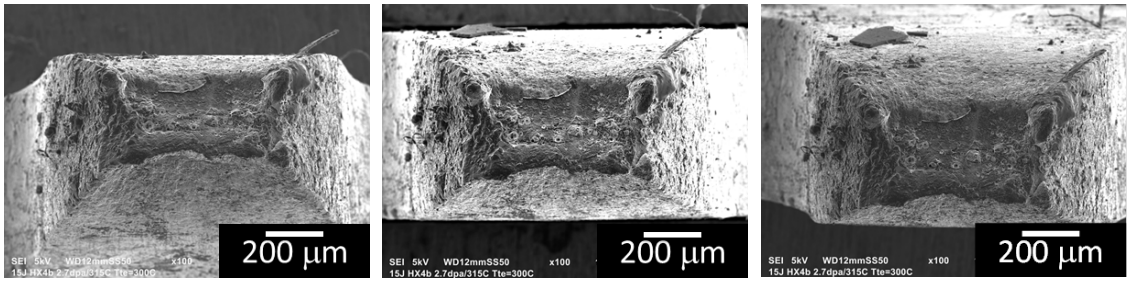
(a) Top view



(b) Skew view

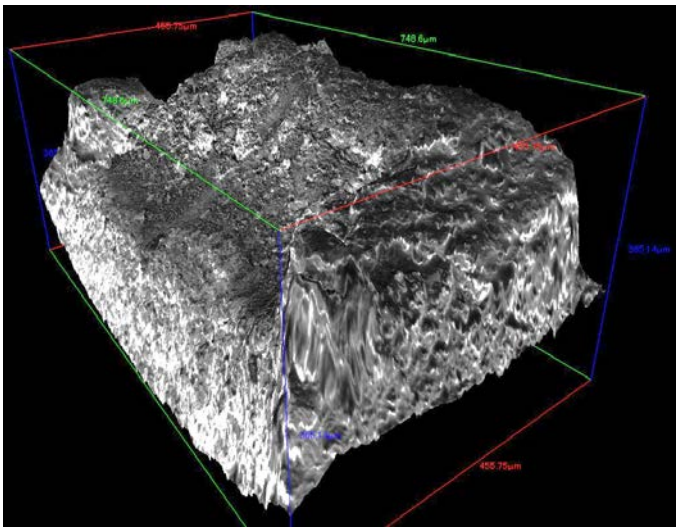
Figure 2. Two SEM images of the fracture surface of the specimen described in Figure 1.

Figure 3 (a) shows three pictures taken at tilt angles of -5, 0, and +5 degrees to produce a 3D image. These images were then processed using the software MeX and obtained the 3D profile image shown in Figure 3 (b). The corresponding quantitative data are shown in Figure 4. These data indicated that the fracture surface slanted and showed a shear rupture mode with an angle of about 54 degrees to the tensile axis. This information cannot be obtained from Figure 2, which was the result of ordinary fracture surface analysis. This information is expected to be very helpful to understand details of irradiation effects on rupture mechanism, and it may be possible to obtain true fracture initiation strain, which value is more consistent with the true tensile fracture nature than is reduction in area. In future work, we will evaluate more tensile ruptured specimens after irradiation and perform the 3D topography using this technique to clarify the irradiation embrittlement.



+5 degree **0 degree** **-5 degree**

(a) Tilted views to process for 3D image of tensile fracture surface of HX4



(b) Obtained 3D image of the tensile fracture surface of HX4

Figure 3. Detailed images processed to provide a 3D image of the fracture surface.

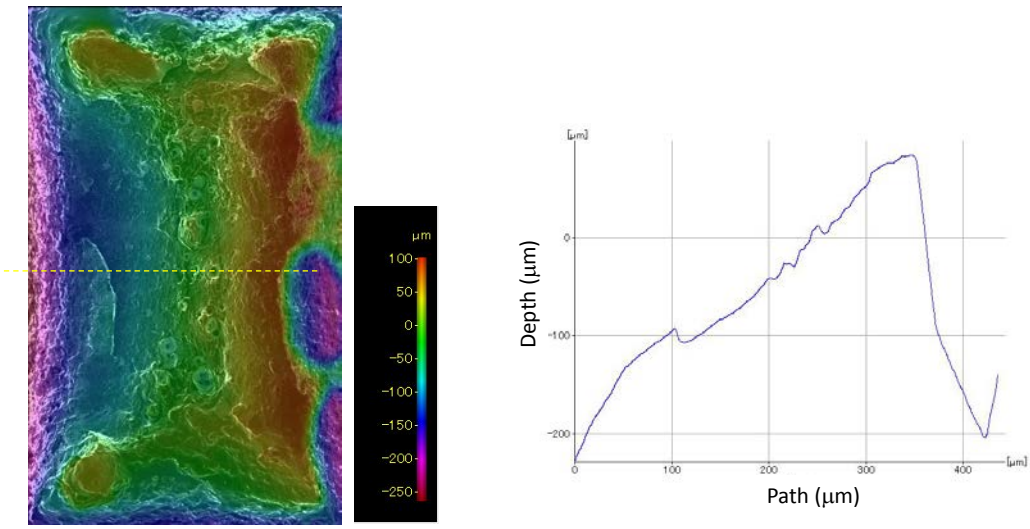


Figure 4. 3D profile of the tensile fracture surface (Left) and line profile (Right) of the relative heights along the broken yellow scan line indicated on the 3D profile.

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