**TEM OBSERVATION AROUND CRACK IN FATIGUE-PRECRACKED 1TCT FRACTURE TOUGHNESS SPECIMEN OF F82H-IEA**—N. Hashimoto (Oak Ridge National Laboratory), H. Tanigawa (Japan Atomic Energy Research Institute), M. Ando (JAERI), and M. A. Sokolov (ORNL)

## OBJECTIVE

In order to investigate microstructural evolution with crack propagation, transmission electron microscopy (TEM) specimens were prepared from a fatigue-precracked specimen of IEA modified F82H (F82H-IEA) specimens.

## SUMMARY

Transmission electron microscopy (TEM) specimens of F82H-IEA were prepared from a middle section of the fatigue-precracked 1TCT specimens and fabricated by using the Focused Ion Beam (FIB) technique in order to investigate microstructural evolution with crack propagation. The TEM specimens, taken from the area around crack, the area of crack tip, and the area in ahead of the crack tip, indicated the presence of cell structure that was generally seen in fatigue-loaded ferritic/martensitic steels. It is possible that this cell structure affects the fracture toughness, however, the effect would be negligible for irradiated specimen due to elimination of the cell structure during irradiation.

## PROGRESS AND STATUS

### Introduction

To validate the potential of reduced activation ferritic/martensitic steel (RAF) as a structural material for fusion power plants, the strength with adequate toughness after irradiation must be guaranteed. As fusion materials, the RAFs have some advantages, such as superior swelling resistance and excellent thermal properties. However, one of serious disadvantage of RAF is its high ductile-brittle transition temperature (DBTT) after irra
diation.
The DBTT of RAFs could be determined by the master curve (MC) method [1], which categorize in terns of fracture toughness reference temperature. Most of RAF's fracture toughness values tend to be on the MC, however, F82H-IEA has some data points off the MC. One of possible reason of this deviation could be the effect of fatigue precracking.

In this experiment, in order to investigate microstructure around precrack and the contributions of fatigue precracking to DBTT, transmission electron microscopy (TEM) specimens of F82H-IEA were taken from a middle section of the fatigue-precracked 1TCT specimens and fabricated by using the Focused Ion Beam (FIB) processor.

### Experimental

The fatigue specimens of F82H-IEA used for this experiment were made by JAERI. The 1TCT specimens were made from 25mm thick F82H-IEA heat plate (Fe-7.5Cr-2W-0.15V-0.02Ta-0.1C, in wt.%), followed by precracking as defined in ASTM standered E1921. TEM specimens were prepared from a middle section of the fatigue-precracked 1TCT specimens and fabricated by using the FIB processor (Hitach FB-2000A) with a microsampling system at Japan Atomic Energy Research Institute (JAERI). There are some advantages of FIB fabrication compared to electro-polishing. First, the optimum sample can be taken from a proper area of bulk specimen. Second, reduction of magnetic field is possible due to reduction of volume by fabrication. The FIB fabricated specimens could be handled just as nonmagnetic materials. The main disadvantage of FIB is that fabrication tends to produce some damage in specimens. In this case, the Low Energy Gun Milling (LEG) mode is effective to remove damage by fabrication, and actually LEG was carried out at JAERI for all specimens after fabrication.

**Results and Discussion**

Fig. 1 shows the SEM image of crack propagation in a middle section of the fatigue-precracked 1TCT specimen. The precrack propagated downward in the figure. The crack seemed to propagate through prior austenitic grain (PAG) first, and then, propagate along with (PAG) boundaries at the end. Fig. 1 also indicates the cell structure with arrows that formed along and around the crack during the fatigue precracking.

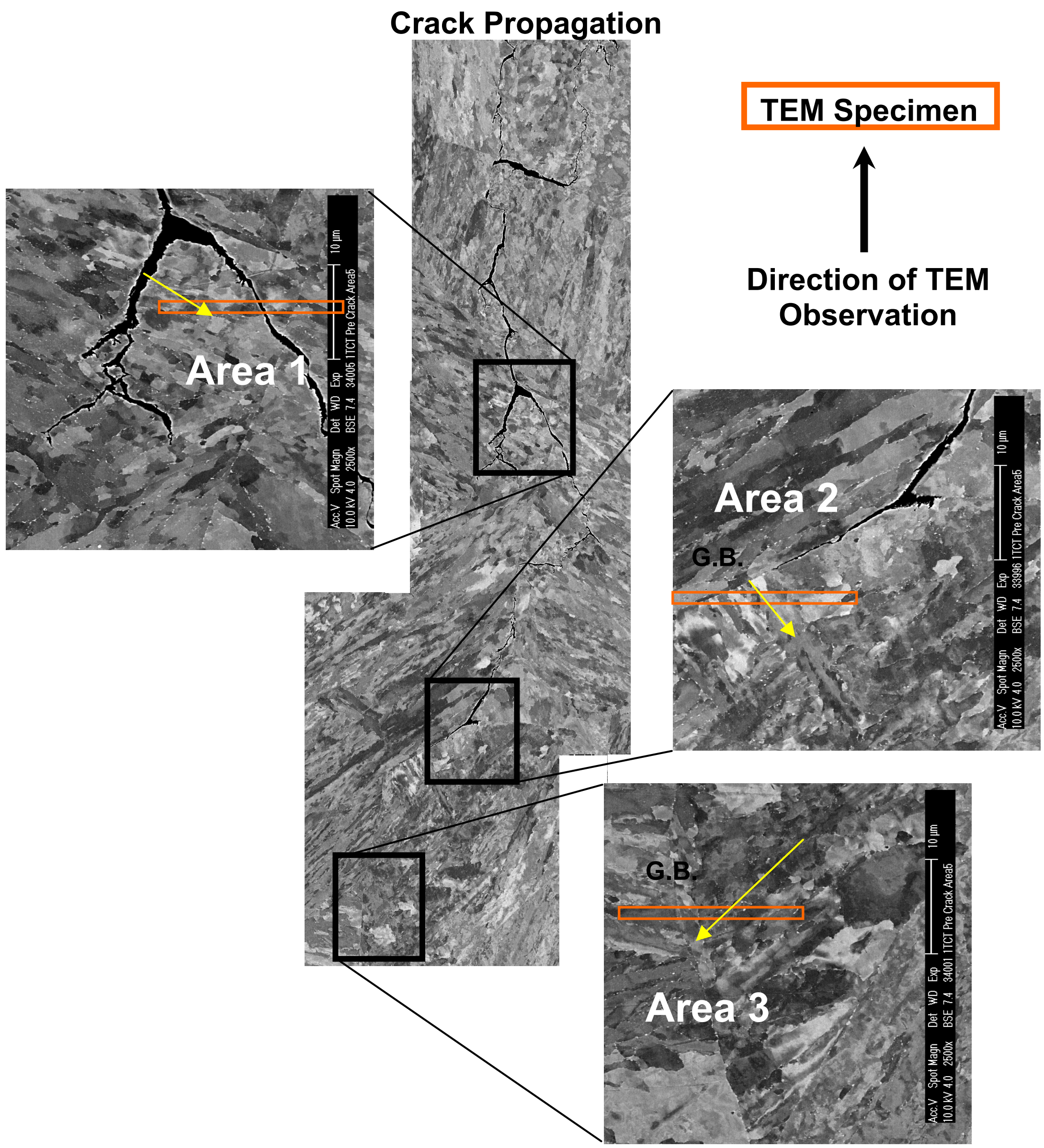


Fig. 1. SEM image of crack propagation in the fatigue-precracked 1TCT specimen. TEM specimens were prepared from three areas as highlighted in this figure. Arrows indicate directions of cell structure development.

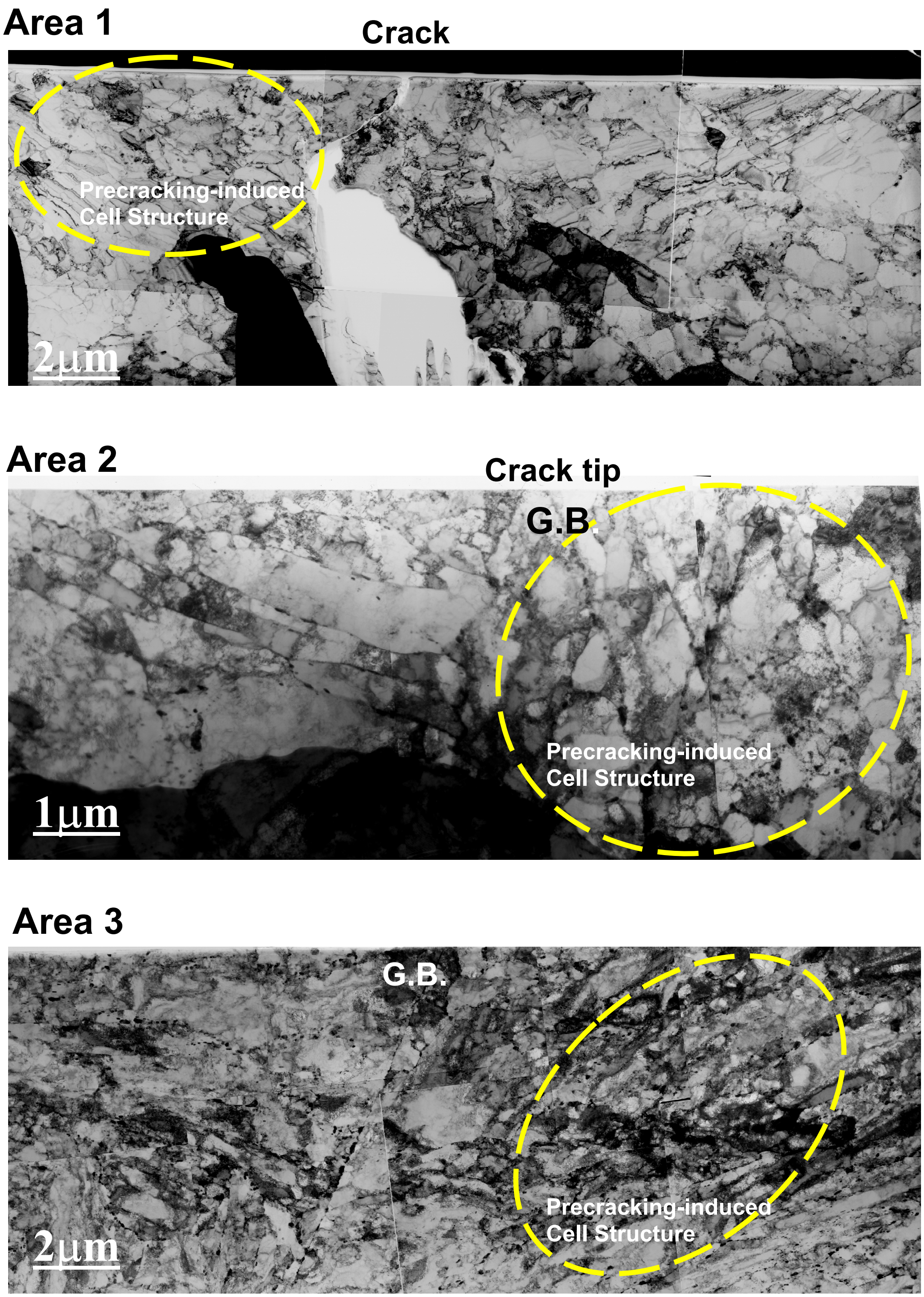


Fig. 2. TEM images sampled from the fatigue-precracked 1TCT specimen. Area 1 includes the crack with cell structure, area 2 taken at the crack tip shows cell structure along with a PAG boundary, and area 3 ahead of the crack tip also shows cell structure coming from the crack tip.

Three of TEM specimens were sampled from the fatigue-precracked 1TCT specimen (Fig. 1); the area 1 which includes the crack, and the area 2 taken at the crack tip with a PAG boundary, and finally the area 3 in ahead of the crack tip with a PAG boundary, as shown in Fig. 2.

Each TEM image showed the presence of cell structure along and around crack. Cell structure formed during fatigue precracking is very different from microstructure of as-prepared specimen. The left side of the crack in the Area 1 indicated lengthwise narrow band of cell structure that grew perpendicularly from the branch of the crack (see arrows in Fig. 1). Also, the right side of the PAG boundary in the Area 2 showed lengthwise narrow band of cell structure from the PAG boundary in front of the crack tip. The cell structure of the right side in the area 3 seemed to be grown from the crack tip into the PAG boundary. It should be noted that the specimen of the area 3 was distorted during fabrication process, indicating the presence of residual stress around this area.

From these results and the information concerning about development of cell structure during fatigue fracture process [2, 3], it could be conformed that stress due to fatigue precracking developed fatigue-induced cell structure and crack. The direction of the development would be a direction the maximum shear stress was applied. The crack would propagate with looking for the best direction for development, such as PAG boundaries and fatigue-induced cell structure in front of the crack tip, till the end of fatigue loading.

The formation of fatigue-induced cell structure might have somewhat of effect on fracture toughness data points off the MC, however, the effect would be negligible for irradiated specimen due to elimination of the cell structure during irradiation.

The possible explanation for the data points off the MC can be found in this progress report [4].

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**References**

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