Lawrence Berkeley National Laboratory

Recent Work

Title

FRACTURE MODE DETERMINATIONS BY SCANNING ELECTRON MICROSCOPY

Permalink

<https://escholarship.org/uc/item/74f256h5>

Authors

Sasaki, G.
Yokota, M.J.

Publication Date

1974-08-01

Submitted to Metallography

RECEIVED
LAWRENCE
RADIATION LABORATORY

LBL-3120
Preprint *c.8*

JUN 7 1975
LIBRARY AND
DOCUMENTS SECTION

FRACTURE MODE DETERMINATIONS BY SCANNING
ELECTRON MICROSCOPY

G. Sasaki and M. J. Yokota

August, 1974

Prepared for the U. S. Atomic Energy Commission
under Contract W-7405-ENG-48

TWO-WEEK LOAN COPY

*This is a Library Circulating Copy
which may be borrowed for two weeks.
For a personal retention copy, call
Tech. Info. Division, Ext. 5545*

LBL-3120
c.8

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

FRACTURE MODE DETERMINATIONS BY SCANNING ELECTRON MICROSCOPY

G. Sasaki and M. J. Yokota

Inorganic Materials Research Division, Lawrence Berkeley Laboratory and
Department of Materials Science and Engineering, College of Engineering;
University of California, Berkeley, California

Methods available for investigating fracture in metals and alloys have generally been limited to observation of fracture surfaces either by its replication and examination by transmission electron microscopy (TEM) or more directly by examination on the scanning electron microscope (SEM). These methods alone, however, cannot provide direct correlation between the microstructural features of the alloy and the initiation and growth of the fracture process. Ohtani, et al., in a recent paper,¹ described a technique which involved a nickel plating step where they tried to correlate the fracture surface and microstructure of a bainitic steel. The method, however, required a complicated nickel removal step, which subjected the fracture surface to great risk of damage. In the technique to be described in the present communication, a transoptic mounting powder was used in place of nickel plating, which provided a simpler and more rapid method of determining the fracture mode.

The method consisted of removing a small portion of the fractured specimen so that the fracture surface made an obtuse angle ($\sim 120^\circ$) with respect to the surface to be polished. This preparatory step made it easier during observation on the scanning electron microscope to focus simultaneously on both the fracture and etched surfaces. The specimens were next mounted in transoptic powder so that the fracture surface was protected from damage and a polished surface roughly

normal to it could be prepared. Etching times were much longer than for specimens normally prepared for light microscopy. It was then possible to free the specimen by simply breaking open the mount without use of a solvent. Observation was made on the scanning electron microscope via secondary electron emission with the specimen tilted to obtain optimum focus and contrast on both the fracture and etched surfaces. Examination of the intersection of the fracture surface and the polished-etched surface showed the exact path with respect to the microstructure that the fracture process took.

Examples of scanning micrographs of an Fe-12% Ni alloy produced by this technique are shown in Figs. 1, 2 and 3. All fracture surfaces are from Charpy V-notch specimens tested at -196°C . A specimen which failed via quasi-cleavage fracture is shown in Fig. 1. The quasi-cleavage nature of the fracture is clearly illustrated by the fracture profile produced by the intersection of the fracture and etched surfaces. The etched surface shows cleavage initiation to have occurred along lath packet boundaries and also within packet boundaries, possibly along individual laths. The cracks nucleated predominantly normal to the tensile stresses (point B) but were frequently found at 45° to the fracture surface also (point A).

Figure 2 shows predominately intergranular fracture occurring in the same Fe-Ni alloy described above but which was additionally heat treated in the two phase $\alpha + \gamma$ region. Austenite formed preferentially at the prior austenite and lath packet boundaries in this temperature region² and lead to a weakening of these boundaries. The intergranular

nature of the fracture is clearly shown by the fracture profile in Fig. 2. Note how the crack at point A had tried to follow along the prior austenite boundary (arrows).

Ductile dimple rupture in a grain refined sample of the above alloy is shown in Fig. 3. Much of the dimple formation appears to have resulted from inclusion nucleated voids such as at points A and B. The growth of voids appears not to be affected by austenite grain boundaries.

ACKNOWLEDGEMENT

The authors acknowledge the help and encouragement of Professor E. R. Parker and V. F. Zackay in conducting this work which was done under the auspices of the U. S. Atomic Energy Commission.

REFERENCES

- [1] H. Ohtani, F. Ferasaki and T. Kunitake, Trans. Iron and Steel Inst. (Japan) 12, 118 (1972).
- [2] M. J. Yokota, G. Sasaki and W. A. Horwood, Developing High Impact Toughness in Interstitial-Free Fe-Ni Alloys at LN Temperature, LBL-2278, Inorganic Materials Research Division, Lawrence Berkeley Laboratory, Berkeley, California, 1974.

FIGURE CAPTIONS

Fig. 1. SEM of fractured and etched surfaces showing quasi-cleavage fracture. XBB 747-4851

Fig. 2. SEM of fractured and etched surfaces showing predominately intergranular failure. XBB 747-4851

Fig. 3. SEM of fractured and etched surfaces showing ductile dimpled rupture. CBB 747-4511

Fig. 1

Fig. 2

Fig. 3

—LEGAL NOTICE—

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

TECHNICAL INFORMATION DIVISION
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720