§58. Effects of Transmutant Products on Microstructure and Tensile Properties of Copper Irradiated with Fast Neutrons

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Cu and Cu-5Ni doped with either natural boron (20% ^{10}B) or isotopically enriched boron (91% ^{10}B) were irradiated with fast neutrons in FFTF/MOTA at 646 K to 6.3 dpa and 683 K to 4.9 dpa. The boron addition was intended to simulate the high helium production rate during fusion neutron irradiations. Nickel is one of the solid transmutant elements expected to be generated during fusion neutron irradiation. The He/dpa ratio varied from 0.1 to 224. The dependence of irradiation-induced microstructures and mechanical properties (yield stress change and uniform elongation) on the helium level was examined.

In pure Cu, the void size distribution changed from unimodal to bimodal with the increase of He/dpa ratio. As summarized in Fig. 1, the swelling peak occurred at a He/dpa ratio of 5 to 10.

Nickel was shown, in the previous study, to have a strong influence toward the void swelling[1]. In the present study, the swelling of Cu-Ni rapidly decreased with He/dpa ratio.

The yield stress change was well correlated with microstructure based calculations describing contributions to hardening by voids and dislocations. Cavity formation and growth at grain boundaries resulted in enhanced grain boundary fracture and significant loss of elongation in the case of high He/dpa ratio and high post-irradiation testing temperature. This effect, however, was small at fusion-relevant He/dpa ratio(~7) as shown in Fig. 2.

Acknowledgements

This work was supported by the Japan-USA Fusion Cooperation in "Fundamental Studies of Irradiation Effects in Fusion Materials Utilizing Fission Reactors" sponsored by Monbusho, the Japanese Ministry of Education, Science and Culture.

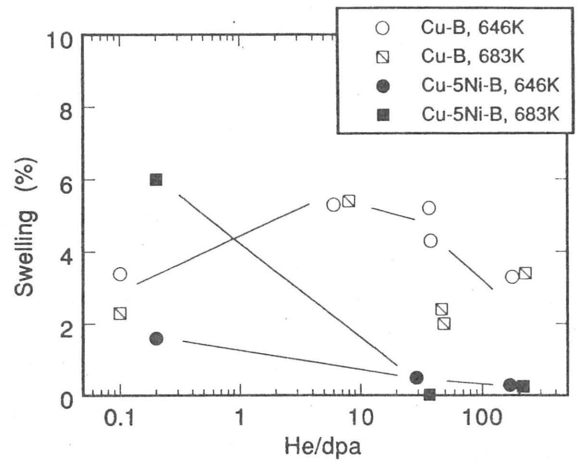

Fig. 1. Summary of void swelling with He/dpa.

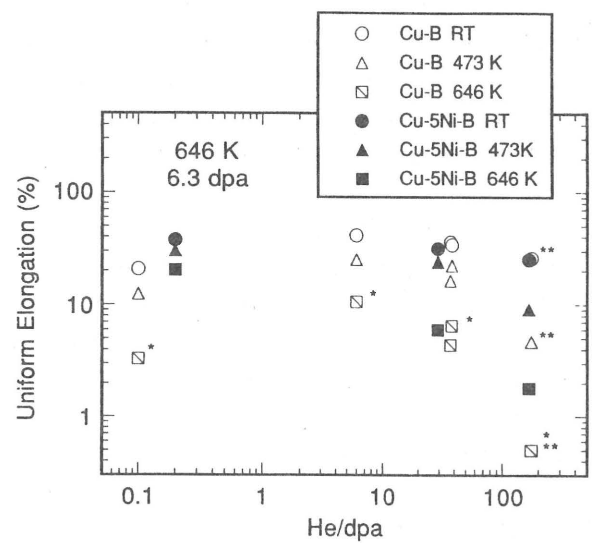

Fig. 2. Uniform elongation with He/dpa.

Reference

1) Muroga, T. and Yoshida, N., J. Nucl. Mater. 212-215 (1994) 266.