§87. The Effect of Solid Transmutant Production in Copper Studied by Mixed-Spectrum Neutron Irradiation

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Since neutronics calculations showed that nickel and zinc will be produced in copper as a result of transmutation by fusion neutrons, the role of those elements in copper during irradiation has attracted attention. Response of Cu-Ni, Cu-Zn and Cu-Ni-Zn alloys to fast neutron, electron and ion irradiations were investigated for this purpose. However, the effect of nickel and zinc, whose concentrations continuously increase during irradiation, has not been studied yet.

In the present study, microstructures of Cu, Cu-5Ni, Cu-3.5Zn and Cu-5Ni-2Zn alloys were observed after irradiation with mixed spectrum neutrons. During the irradiation, the production rates of transmutant nickel and zinc from copper are higher than those in the fusion condition. The results were compared with those by fast neutron irradiation, in which the transmutation rate was much lower than the fusion condition.

Irradiation was carried out at the PTP position of the High Flux Isotope Reactor (HFIR) at 573 K to 9.2 dpa and 673 K to 10.4 dpa. Post irradiation chemical analyses showed that 2.8-3.2%Ni and 3.1-3.4%Zn were produced from pure copper during the irradiation. The results were compared with those by fast neutron irradiations with Fast Flux Test Facility (FFTF).

Voids were formed in all specimens. In alloys containing nickel, high density of small bubbles were observed, which is considered to be the influence of transmutant helium produced from nickel. In Cu-3.5Zn, the void density was high and the size was small in the case of the mixed spectrum neutron irradiation relative to those in the fast neutron irradiation. In pure copper, however, significant difference in the microstructure was not observed between the two cases. The void density and swelling were summarized in Figs. 1 and 2, respectively.

The effect of Ni and Zn on void nucleation and growth during irradiation was qualitatively understood by fast neutron irradiations of Cu-Ni and Cu-Zn alloys and heavy ion irradiations. The present results are consistent with those data taking the increasing concentration of nickel and zinc into account.

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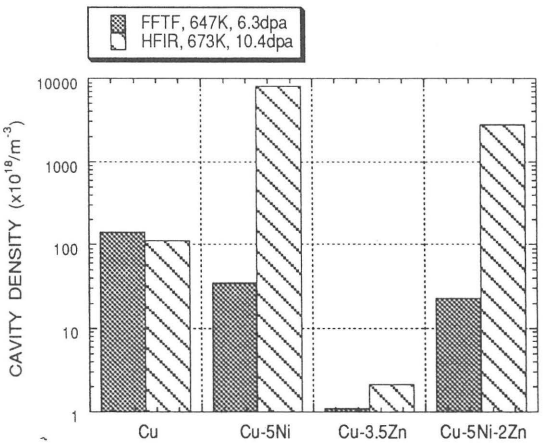

Fig 1. The densities of cavities formed by irradiation with FFTF and HFIR.

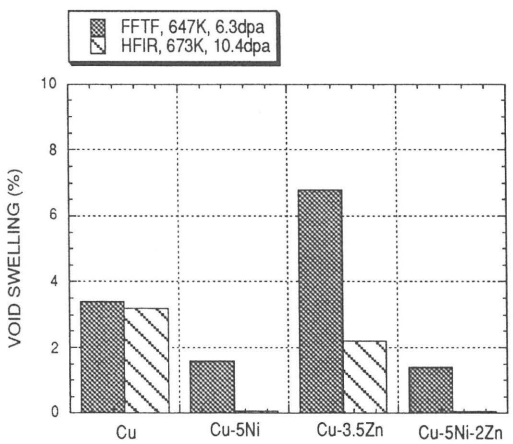

Fig.2. The void swelling by irradiation with FFTF and HFIR.