§64. Microstructural Evolution in a High Purity Ferritic Alloy During Steady and Varying Temperature Electron Irradiations

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The impact of negative temperature excursion during irradiation, which occurs periodically during neutron irradiation in fission reactors during start-up and shut-down procedures and is also expected to occur in fusion reactors, attracts increasing attention from the standpoints of reexamination of reactor irradiation data and simulation of DEMO operation conditions.

Some defect clusters formed during the low temperature transient period may persist and affect the microstructural evolution during the following high temperature irradiation. In ferritic steels it is known that two types of dislocation loops, Burgers vectors of a<100> and a/2<111>, are formed during irradiation. Because of the difference in bias, the fraction of these two types of dislocations is considered to influence strongly the void swelling behavior at high fluence. If the irradiation during low temperature transient period alters the Burgers vector fraction of loops to be formed during subsequent high temperature irradiation, the transient should influence microstructure at high fluence. This is the main interest of the present study.

In this study, dislocation loop formation and evolution in a high purity Fe-10Cr binary ferritic alloy and a low activation candidate feriitic alloy (JLF-5) during 1MeV electron irradiation was investigated at constant and varying temperatures.

The type of loops formed was found to be sensitive to irradiation temperature. The loops formed are mostly of a/2<111> type at 573K, and of a<100> and a/2<111> types in comparable density at 673K, respectively. At 773K, a different mechanism of a/2<111> type loop production, punching out from a small clusters, was observed. In the case of low temperature irradiation followed by high temperature irradiation, the loop type was similar to that expected by irradiation at the low temperature only (Fig.1). This rule was obeyed even when the period of the first low temperature irradiation was very short (e.g. 15 sec 0.003dpa). In JLF-5, however, higher fluence pre-irradiation is needed to affect the loop density and nature (Fig.2).

The present study showed that the fraction of Burgers vector of dislocations and, thus, void swelling behavior at high fluence would be strongly influenced by short-term negative temperature excursion in the initial period of the irradiation.

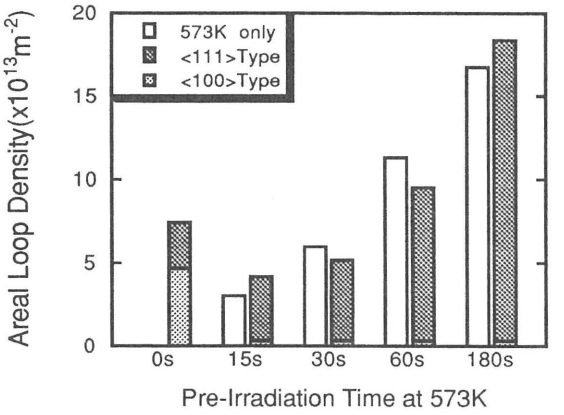

Fig 1. The change in the areal loop density at 673 K and 420 sec with pre-irradiation time at 573K in Fe-10Cr. The specimen thickness was ~450 nm. (1.6×10^{-4} dpa/s)

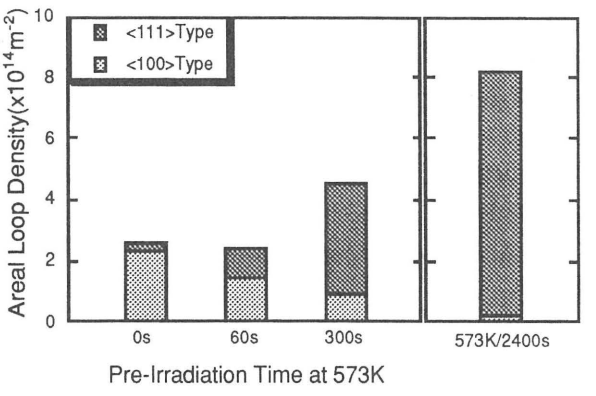

Fig.2. The change in the areal loop density at 673 K and 2400 sec with pre-irradiation time at 573K in JLF-5. The specimen thickness was ~450 nm. (1.6×10^{-4} dpa/s)