The Unfaulting of Frank Loops Influenced by Loop Size in Heavy Ion Irradiation

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Abstract: Stainless steel model alloy was irradiated at 350~450°C to study the effects of loop size on the unfaulting process of Frank loops. Post-irradiation analysis was preformed via relrod and dark field imaging. The size distribution between Frank loops and perfect loops were compared, and the hardening coefficient of perfect loops in heavy ion irradiation was discussed.

Keywords: Frank loop, perfect loop, unfaulting, irradiation hardening, stainless steel.

1. Introduction

When irradiated to high dose, Frank loops in stainless steels unfault and turn into perfect loops, which is an important process for the ageing degradation of stainless steel components in reactors. As loops are biased sinks for point defects, the unfaulting process may also influence the evolution of precipitates and cavities. A Frank loop can unfault either by the impingement of adjoin Frank loops [1], or by absorbing two Shockley partial dislocations nucleated inside the Frank loop [2]. Besides, it is supposed that a critical loop radius may exist, beyond which the Frank loop tends to unfault [3]. The dominant mechanism is unclear so far, while loop size seems to be a key factor. In this work, the extent of loop unfaulting under different irradiation conditions was analyzed by transmission electron microscopy. The size distribution between observed Frank loops and perfect loops were compared. Additionally, the contribution of perfects loops to irradiation hardening in heavy ion irradiation was quantitatively discussed.

2. Experimental

The HIT facility of The University of Tokyo was utilized for heavy ion irradiation. For simplification, stainless steel model alloy without Si was used to avoid the formation of Ni-Si precipitates. Bulk samples were irradiated by 3MeV Ni ion at 350, 400 and 450°C, which is the boundary condition for unfaulting phenomenon. The dose at damage peak depth was ~8dpa.

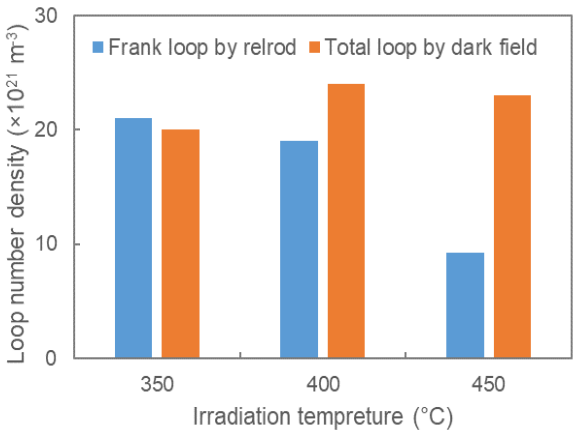

Fig.1 Frank loop and total loop number density in the damage peak region (800~1000nm depth)

3. Results and discussions

The formation of Frank loops was analyzed by relrod technique, whereas the total loop density was analyzed by dark field images. Loops formed at different depth were compared, corresponding to different irradiation doses. As shown in Fig. 1, the unfaulting of Frank loops at damage peak region was not observed at 350°C, but was clearly seen in 400°C and 450°C irradiation. By the Orowan model, the hardening coefficient of perfect loops was calculated.

References

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