Nucleation and Growth of Defect Clusters during In-situ Irradiation of Stainless Steels with Considerations of Surface Effects

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In-situ transmission electron microscopy (TEM) is a powerful tool to analyze defect nucleation and growth during irradiation; however the surface effects cannot be neglected. In this work, in-situ irradiation is performed on stainless steels with different Si content, and the influences of surface on observation results are discussed with stereo imaging technique.

Keywords: in-situ, TEM, irradiation, surface effects, stainless steel.

1. Introduction

To predict component ageing in reactors, the evolution process of irradiation-induced defects needs to be quantitatively clarified. However, since defect production and evolution could be rapid, especially in low dose regime (e.g. dose<0.5dpa), in-situ analysis technique is necessary. Despite of its advantages, in-situ TEM analysis has its limitations in using thin foil samples for irradiation [1]. The existence of surface may sufficiently alter the microstructure observed, and may influence the conclusions drawn from the analysis. In this preliminary work, Si effects on defect production in stainless steels is studied by in-situ TEM, and the influences of surface on the results are discussed with stereo imaging technique.

2. In-situ TEM analysis

The HIT facility of The University of Tokyo was utilized for in-situ irradiation [2]. The beam profile of 2MeV Fe ion beam was tested by a Faraday cup at TEM specimen position. Low Si (<0.001wt.% Si) and high Si (0.95wt.% Si) type of 316L stainless steel model alloys were used, and thin foil TEM specimens were prepared by focused ion beam followed by electro-chemical polishing.

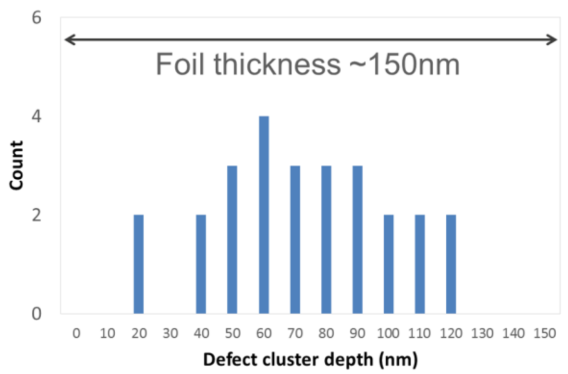

Fig.1 Depth distribution of defect clusters by stereo-imaging (Low Si, 400ºC, 0.2dpa)

3. Results and discussions

In in-situ irradiation at 400ºC, the observed number density and average size of defect clusters in high-Si sample is much lower than those in low-Si sample. Meanwhile, the depth distribution of black dots and loops was analyzed by stereo imaging technique. The surface denuded zone was found to be approximately ~20nm in the low-Si sample, as shown in Fig.1. However in the high-Si sample, the thickness of the denuded zone would be much larger. Therefore, the addition of Si had resulted in a thicker denuded zone, which is one of the major contributors to the low number density of defect clusters observed in the high-Si sample.

References

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