Inhomogeneous Distribution of Ni and Si atoms in Solute Clusters in Irradiated Stainless Steels

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The inhomogeneous distribution of solutes in clusters may give hints to the formation of solute clusters on dislocation loops. In this work, attempts were made to develop methods for solute distribution analysis in Ni-Si clusters in atom probe tomography (APT). The formation of Ni-Si clusters on dislocation loops was better recognized via this method.

Keywords: Stainless steel, Ni-Si clusters, Atom probe tomography.

1. Introduction

Maximum separation method (MSM) is a popular method to extract information from atom probe tomography (APT) data, such as the number density and size distribution of solute clusters, as well as the average composition of each cluster [1]. In the case of stainless steels, Ni-Si solute clusters may grow to ~10nm or even larger when irradiation dose is high, and it was found that Ni and Si solutes are not homogeneously distributed in these large clusters [2]. The inhomogeneous distribution of solutes in clusters may give hints to the formation of solute clusters on dislocation loops. Furthermore, the understanding of solute distribution in clusters can improve the current prediction model of irradiation hardening, which ignores solute distribution in clusters.

In this work, attempts were made to develop methods for solute distribution analysis in clusters. Irradiated stainless steel with large size of Ni-Si clusters were taken as an example to assess the method. The results were compared with the loop size and orientation results by transmission electron microscopy (TEM).

2. Experimental

In order to create large Ni-Si clusters for analysis, 316L model alloy of stainless steel was irradiated to 5dpa at 450ºC by 3MeV Ni^{2+}. Atom probe specimen was prepared by focused ion beam (FIB) technique. The distribution of solutes in clusters was analyzed by tuning the parameters (such as d_{max}) of MSM in atom maps.

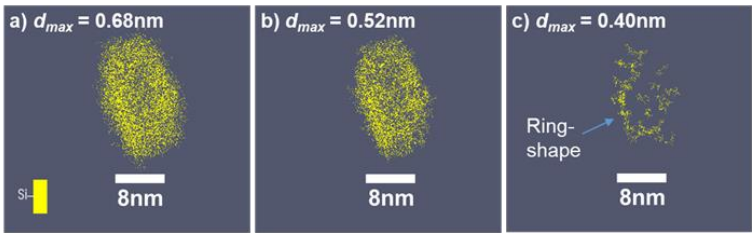

Fig.1 Anisotropic distribution of Si in a disk-shape cluster analyzed by maximum separation method (MSM). Si was selected as the atom for MSM, and d_{max} was tuned.

3. Results and discussions

Fig. 1 shows the Si distribution in a disk-shape cluster in irradiated 316L model alloy. By tuning the d_{max} value of Si atoms to be smaller, the locations with higher Si concentrations in the cluster were extracted. In Fig. 1(c), when d_{max} was as small as 0.40nm, a ring-shape distribution of Si was revealed. Combining with the crystallographic orientation of the disk-shape cluster, it indicates that this solute cluster formed on a dislocation loop. It was also found that in a given cluster, the location of peak concentration can be different between Ni and Si atoms.

References

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