Atom probe tomography analysis of anisotropic distribution of solute elements (Mn, Ni) on irradiated Fe-based model alloy

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Abstract

Atom probe tomography (APT) results show that Mn and Ni atoms in irradiated Fe-based model alloy are distributed close to the habit planes of interstitial loop, <111> and <100> plane families. This anisotropic distribution may be considered as a proof of irradiation induced segregation of solute atoms to the dislocation loops.

Keywords: ion irradiation, atom probe tomography, solute elements, orientation calculation, dislocation loop decoration.

1. Introduction

Mn and Ni-rich precipitates (MNP) is a critical concern in the embrittlement of reactor pressure vessel (RPV) materials. Numerous studies have observed MNPs in irradiated RPV steels. Meslin [1] has reported that the distribution of solute atoms was heterogeneously precipitated on the planar object, suggesting a dislocation loop or a grain boundary. To clarify this anisotropic distribution of solute, the orientation of plane, on which solute elements distributed, is identified.

2. APT analysis

Fe-1.4Mn-0.6Ni (wt.%) model alloy was irradiated by 2.8 MeV Fe^{2+} ions at 400 ^{0}C up to 2 dpa. APT measurements were conducted using the LEAP3000XHR. Reconstruction parameters were carefully selected to optimize the length of z-axis. Based on the coordinates of the polar points from field ion microscope (FIM) image, crystal orientation of specimen in z-direction was determined.

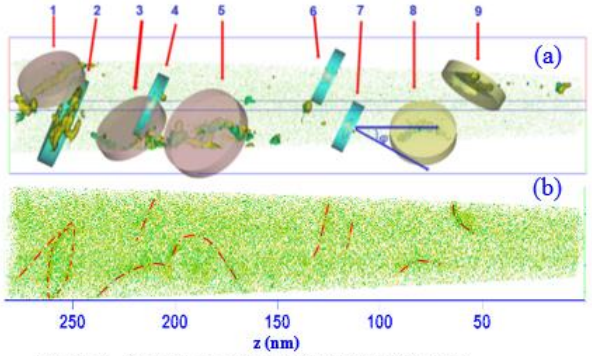

Figure 1. Atom map of irradiated FeMnNi alloy
(a) angle φ of solute enriched plane with z- axis
(b) dislocation line in 3D-AP

From 3-dimensional APT image, the angle φ of solute enriched plane with z-axis was measured as shown in Figure 1 (a). At the same time, theoretical calculation of the inter-planar angles φ' between <111> and <100> family orientations and z-direction was done. The matching of φ and φ' was recognized that the solute clusters are segregated to two types of habit planes of dislocation loop in bcc structure. Considered the dislocation line as a part of dislocation loops as shown in Figure 1(b), the number density of dislocation loop was calculated. The order of 10^{21} (m^{-3}) in number density of dislocation loop is similar with our work using TEM observation. This is an addition evidence that anisotropic distribution of solute elements in bcc Fe alloy is decorated along with the dislocation loop.

3. Conclusion

Irradiation induced segregation of solute atoms (Mn and Ni) to both types of habit planes of dislocation loop, <111> and <100> has been confirmed by applying pole figure analysis as well as geometrical calculation.

References

[1] Meslin E., *et. al.*, Acta Materialia 61 (2013) 6246–6254.