Phase stability under ion-irradiation in ODS ferritic steels strengthened by different sorts of oxide particles

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Abstract

The phase stability in ODS ferritic steels with different oxide forming elements addition were investigated by the ion irradiation at 200 ºC up to the nominal damage levels of 10 dpa. After the irradiation, both the averaged sizes and number densities of oxide particles decreased continuously with the local damage level increasing.

Keywords: phase stability, oxide particle, ODS steels, ion irradiation

1. Introduction

An ultrahigh density of oxide particles and fine grains provide ODS ferritic steels with high tensile, creep and fatigue strength at elevated temperatures, as well as excellent radiation tolerance. The Ti-addition to FeCr-ODS steels refined oxide particles by forming the nano-sized (Y, Ti, O) particles, which were dominated by $Y_2Ti_2O_7$ pyrochlore and Y_2TiO_5. However, the Al-addition to FeCr(Y, Ti)-ODS steels altered the dominated particles from fine (Y, Ti) oxide particles to larger $YAlO_3$ (YAH and YAP) or $Y_4Al_2O_9$ (YAM) in FeCrAl-(Y, Ti)-ODS steels, and a small addition of Zr to FeCrAl-(Y, Ti)-ODS steels altered the majority of oxide particles from (Y, Al) ones to (Y, Zr) ones, mainly $Y_4Zr_3O_{12}$, where the latter oxide particles have smaller size and higher number density. Considering the difference in chemical compositions and structures of the three types of oxide particles, we aimed to investigate their stability in ODS ferritic steels by means of ion irradiations.

2. Experiment

Three ODS ferritic steels with Y, Ti co-addition (named by Y-Ti-ODS), Y, Ti, Al co-addition (named by Y-Al-ODS), Y, Ti, Al and Zr co-addition (named by Y-Zr-ODS) were irradiated with 6.4 MeV Fe^{3+} at 200 ºC up to the nominal damage levels of 10 dpa. After ion-irradiation, radiation defects and nano-sized oxide particles were observed by transmission electron microscope (TEM). The lattice structure and chemical compositions of oxide particles were characterized by high-resolution TEM (HRTEM) and energy-filtered TEM (EFTEM), respectively.

3. Results

Under the 200 ºC irradiation, the averaged sizes and number densities of (Y, Ti), (Y, Al) and (Y, Zr) oxide particles decreased continuously with the local damage level increasing. However, the number densities of (Y, Ti) oxides particles were decreased faster by ion-irradiation than those of (Y, Al) and (Y, Zr) oxides, possibly ascribed to the smaller size of (Y, Ti) oxides particles.