Behavior of Perovskite Phase in Irradiated Nuclear Fuel

YangHong Jung, HeeMoon Kim, ByungOk Yoo, YongSun Choo, and ChangJe Park
Irradiated Materials Examination Facility, Korea Atomic Energy Research Institute, Ducjin, Yusung, Taijeon, Korea,305-353 (nyhjung@kaeri.re.kr)

A specimen of spent PWR fuel was irradiated at HANARO research reactor as much as 3,300 MWd/tU of burn-up at the condition of 36 kW/m of maximum linear power. This study shows some results for the EPMA (Electron Probe Micro-Analyzer) characteristics of grey phase of oxide precipitates of fission product of irradiated fuel, which has white inclusions and Perovskite of barium-zirconate phase.

Around barium and zirconium, perovskite phase develops depending on the oxygen concentration. The average size of precipitates of perovskite phase is about 0.1 ㎛ and it was found that the barium zirconite-type perovskite phases are distributed uniformly in the fuel.[1]

In general, the barium zirconite-type perovskite precipitates are difficult to find in the spent fuel of which burnup is about 33,000 MWd/tU using EPMA[2].But we could found perovskite precipitates in this Irradiated Fuel. The precipitates of the phase are distributed between 0.2 and 0.5 of the relative position(r/r_0) and the sizes are distributed from 4 to 10 ㎛. Fig. 1 depicts a precipitates of perovskite phase of the irradiated fuel. The centerline temperature of the pellet were estimated about 2,000 K. The relative position of phase is 0.3 and the width and height of the precipitates are 5 ㎛ and 10 ㎛, respectively.

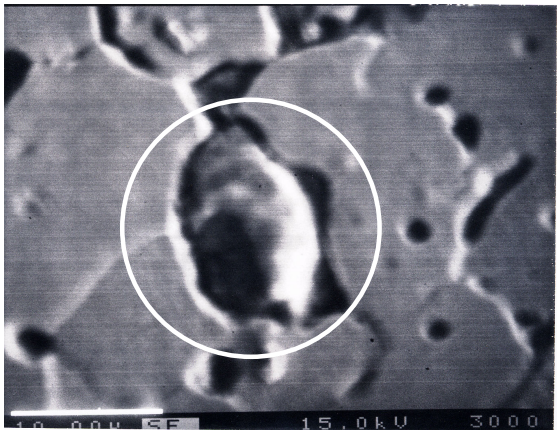


Fig 1. A precipitates of perovskite phase on the irradiated fuel

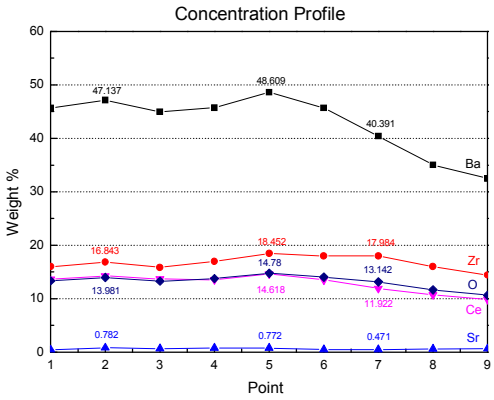
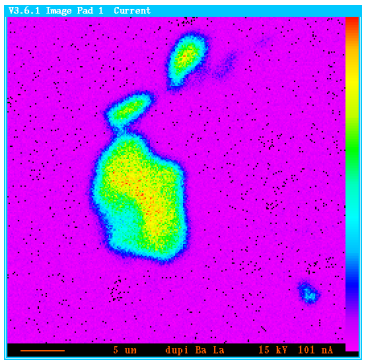


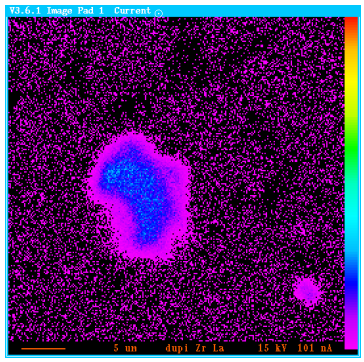
Fig.2. Barium zirconite-type perovskite phase concentration profile on the irradiated fuel.

Fig. 2 shows the quantitative analysis for the precipitates of barium zirconite-type perovskite phase. Samples are taken from the nine points in

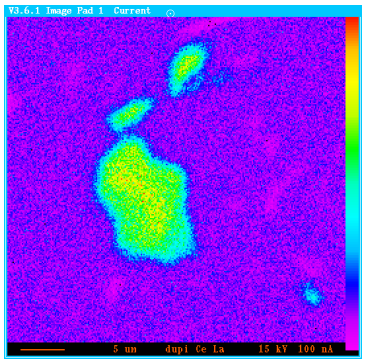
the diagonal direction of the precipitate and the distance is about 1 ㎛ at each point. There is uneven distribution for each sample due to roughness of the surface.



Ba X-ray photographs



Zr X-ray photographs



Ce X-ray photographs

Fig.3. Characteristic X-ray photographs for barium zirconite-type perovskite phase.

In general, the chemical formula of barium zirconite-type perovskite phase is known to be $BaZrO_3$[3]. but from the above results, Ce should be added to the chemical formula of the phase. the weight percent of Ce is 12.86 and normalized atomic percent is 6.46, which is enough high to take an effect on the phase.

From the quantitative analysis of the simulated fuel, Ba, Zr and O, and their concentrations were found as 18.96 at.%, 17.27 at.%, 60.17 at.%., respectively. Combining the ratio of those elements of the perovskite phase, the corresponding chemical formula is $BaZrO_3$. However, the irradiated fuel, the compositions of Ba, Zr, Ce, Sr, O were analyzed as 21.94 at.%, 12.98 at.%, 6.46 at.%, 0.50 at.%, and 58.10 at.%, respectively. Neglecting the effect of Sr, the chemical formula of the perovskite phase may be expressed as $Ba_4Zr_2CeO_{10}$.

References

1. C. Sari, C.T. Walker and G. Schumacher, J. Nucl. Mater. 79 (1979) 255.

2. D.R. O'boyle, F.L. Brown and J.E.Saneckl, J. Nucl. Mater. 29(1969)27-42.

3. M. Koizumi and M. Satoh, J. Nucl. Mater. 51(1974)90-94.

1 : nyhjung@kaeri.re.kr

Tel : 82-42-868-8459

Fax : 82-42-868-8420