Monte Carlo Simulation of Quantitative Electron Probe Microanalysis of the PWR Spent Fuel with a Pt Coating

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1. Introduction

The PWR spent fuel sample should be coated with conducting material in order to provide a path for electrons and to prevent charging. Generally, the ZAF method has been used for quantitative electron probe microanalysis of conducting samples. However, the coated samples are not applicable for the ZAF method [1]. Probe current, primary electron energy and x-ray produced by the primary beam are attenuated within the coating films.

The electron and X-ray depth distributions for a quantitative electron probe micro analysis were simulated by the CASINO Monte Carlo program [2] to evaluate the x-ray attenuation within the Pt coating films. The target samples are the PWR spent fuels with 50 GWd/tU of burnup , 6 years of cooling time and a Pt coating film (3, 5, 7, 10 and 15 nm thickness).

2. Methods and Results

In this section some of the theories and results of Monte Carlo simulation are described.

2.1 PWR Spent Fuel

The spent fuel includes almost all the elements of the periodic table as named in the fission product and trans-uranium. The Origen-S[3] code was used for concentrations of the PWR spent fuel enriched to 4.5% U-235. Six years was selected for the decay time and its burnup was 50 GWd/tU. Chemical compositions and densities of target materials used in the simulation are listed in the Table I.

Table I: Parameters used for PWR spent fuel sample

Sample	*Atom*	*Mass (%)*	*Density (g/cm^3)*
Spent fuel	*U*	*81.47*	*10.2*
	Nd	*0.64*	
	Xe	*0.87*	
X-ray line	*X-ray energy, keV*	*Atomic Number*	*Atomic Weight*
Nd La	*5.229*	*60*	*144.24*
Xe La	*4.109*	*54*	*131.29*

2.2 Monte Carlo Simulation

Montel Carlo simulation was carried out for the PWR spent fuel, Nd and Xe. The primary electron energy is 25 keV, the numbers of trajectories 200,000 and the x-ray take-off angle 40.0^o from the sample surface. We selected a Pt coating with 3, 5, 7, 10 and 15 nm. A Pt coating reduces the surface damage by electron bombardment due to the high thermal conductivity.

In this study, we used the Rutherford model for total cross-section, the Casnati model for effective section ionization and the Joy-Luo model for ionization potential in the CASINO Monte Carlo code. Figure 1 shows electron trajectories within SF sample with 15 nm Pt coating.

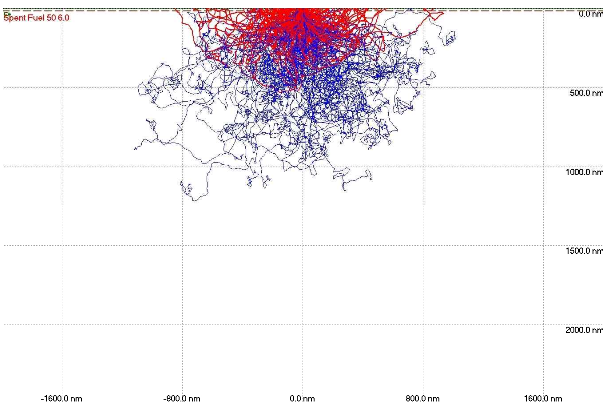

Fig. 1. Electron trajectories of SF sample with 15 nm Pt coating.

2.3 Effect of a coating film

A coating film has an effect on the matrix correction procedure to distort the depth distribution of generated X-ray. Figure 2 and 3 show the $\phi(\rho z)$ curves of SF samples with non-coating and 15 nm Pt coating. These X-ray depth distributions are applicable for the matrix correction. Kato[4] insisted that this distortion of the depth distribution by the coating film is mainly the result of the incident angle of electrons.

When the matrix correction factor of the uncoated SF sample applied to Pt coated samples, the results of the quantitative analysis are shown in figure 4.

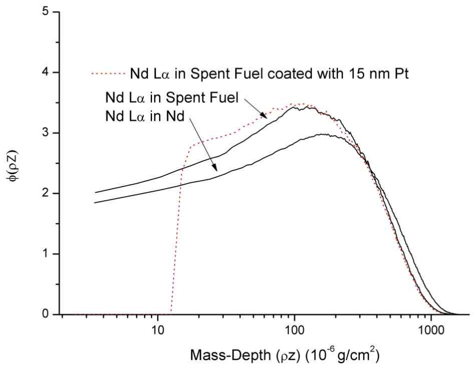

Fig. 2. The depth distributions of generated Nd La line intensities.

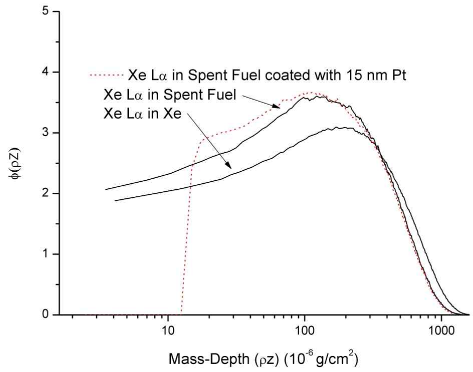

Fig. 3. The depth distributions of generated Xe La line intensities.

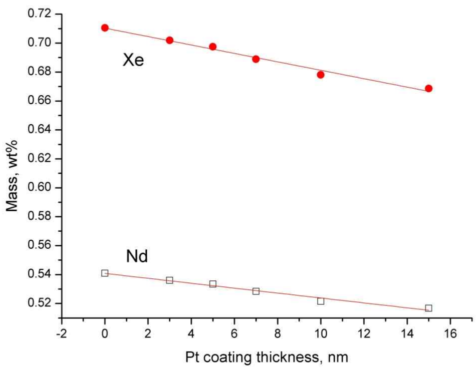

Fig. 4. Quantitative analysis results of SF samples with Pt coating.

3. Conclusions

The effect of a Pt coating on the quantitative electron probe microanalysis was evaluated by Monte Carlo simulation. 15 nm Pt coating decreased the analyzed weight percent of Nd and Xe of SF samples in compared with the uncoated condition.

REFERENCES

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