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Decontamination Characteristics of Stainless Steel Surface Contaminated with Cs^+ Ion by Light Ablation

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1. Introduction

The characteristics of decontamination method by light ablation are the remote operation, a short application time, and the high removal efficiency. Furthermore, the generation of the secondary waste is negligible. The radioactivity of hot cells in DFDF (Dupic Fuel Development Facility) is presumed to be very high and the predominant radionuclide is Cs-137. A series of laser decontamination studies by the fabricated Q-switched Nd-YAG laser system were performed on the stainless steel specimens artificially contaminated with Cs^+ ion. Decontamination characteristics of the stainless steel were analyzed by SEM and EPMA.

2. Methods and Results

In this section some of the experimental methods, procedures and results are described.

2.1 Specimen Preparation

Type 304 stainless steel specimens were polished, washed with ethyl alcohol, dried and photographed. They were dipped into an ultrasonic cleaner for 30 minutes and dried. For an artificial contamination, a small amount of Cs^+ ion solution was thrown on a specimen surface. After all of the specimens were fully dried, they were analyzed by SEM and EPMA.

2.2 Laser irradiation

Q switched pulse type Nd:YAG laser fabricated in KAERI was employed. A pulse duration of Q-switched Nd:YAG laser was 14 ns. Maximum applied repetition rate was 17 Hz. The system emits fundamental wavelength at 1064 nm, and specimen was irradiated for 200 shots. A JSM-6300 scanning electron microscope (SEM) was employed to examine any laser induced alterations to the original surface. EPMA analysis was used to identify the chemical composition. A block diagram of the fabricated Q switched Nd-YAG laser system is shown in Fig. 1.

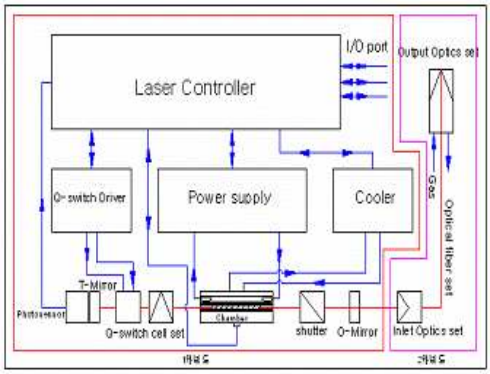

Fig.1. A block diagram of the fabricated Q-switched Nd-YAG laser system.

2.3 Test results

Fig. 2 shows the SEM photograph of the prepared stainless steel surface before laser irradiation. The chemical composition at five points of the stainless steel surface as shown in Fig. 2 is listed in Table 1. The Cs^+ ion content at S1 is 37.7, S3 is 28.9 and S5 is 8.2 atomic percent, respectively. However Cs^+ ion is not shown at S2 and S4.

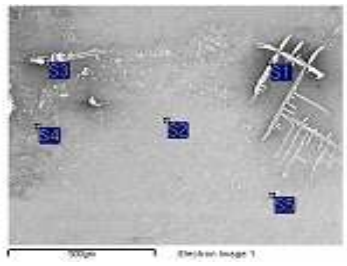

Fig. 2. SEM photograph of stainless steel surface contaminated with 1% $CsNO_3$ solution(before decontamination).

Table 1: Chemical composition of stainless steel surface (before decontamination).

	N	O	Si	Cr	Fe	Ni	Cs	Total
S1	18.6	39.8	0.0	1.4	2.2	0.3	37.7	100.0
S2	0.0	0.0	1.2	20.3	70.5	8.0	0.0	100.0
S3	0.0	61.5	0.0	2.4	6.6	0.6	28.9	100.0
S4	19.4	3.3	1.3	19.2	48.6	8.2	0.0	100.0
S5	0.0	34.0	0.8	11.9	40.5	4.6	8.2	100.0

Fig. 3 shows the SEM photograph of stainless steel surface after laser irradiation. The diameter of the spot size is approximately 0.5mm and the irradiated surface is clean and smooth. The chemical composition at five points of the stainless steel surface as shown in Fig. 3 is listed in Table 2. Contrary to the Cs^+ ion content of stainless steel specimen surface before laser irradiation, Cs^+ ion is not found after laser irradiation. This means that all Cs^+ ion was ablated by laser application. This can be explained by two reasons. 1) As Cs^+ ion is a semi volatile element, Cs^+ ion evaporated at high temperature during the laser application. 2) Fe, Ni, and Cr which are main elements of stainless steel were ablated thermally by laser irradiation[1]. Cs^+ ion was ablated concurrently.

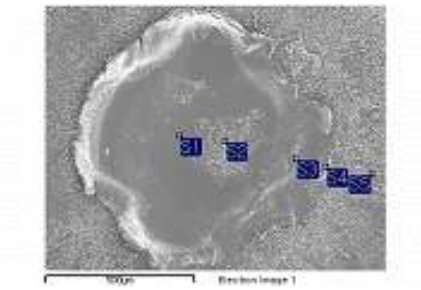

Fig. 3. SEM photograph of stainless steel surface(after decontamination).

Table 2: Chemical composition of stainless steel surface (after decontamination).

	N	O	Si	Cr	Fe	Ni	Total
S1	0.0	0.0	0.5	17.1	73.5	8.9	100.0
S2	0.0	1.7	0.0	15.6	73.8	8.9	100.0
S3	5.20	4.8	0.6	7.6	69.4	12.4	100.0
S4	0.0	1.2	0.0	13.0	78.7	7.1	100.0
S5	0.0	33.8	0.5	14.4	45.8	5.5	100.0

3. Conclusion

Q switched Nd-YAG laser decontamination tests were performed on the stainless steel specimen artificially contaminated with Cs^+ ion. For the tested specimens, it was found that Q switched Nd-YAG laser system satisfactory applied. The surface contaminated with Cs^+ ion was successfully removed by laser irradiation.

Acknowledgement

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