Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 29-30, 2009

Laser Decontamination of Type 304 Stainless Steel Contaminated with Co^{2+} and CeO_2

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1. Introduction

The merits of laser decontamination are a remote operation, a short application time, and the high removal efficiency. And also, generation of the secondary waste is negligible. A series of laser decontamination test by Q-switched Nd:YAG laser at 532 nm were performed on stainless steel specimens artificially contaminated with the Co^{2+} and CeO_2, respectively. Test results were examined by SEM and EPMA.

2. Methods and Results

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 Co^{2+} and CeO_2 containing solutions were thrown on a specimen surfaces. After all of the specimens were fully dried, they were analyzed by SEM and EPMA.

2.2 Laser irradiation

Q-switched Nd:YAG laser was employed. Fig. 1 shows the schematic diagram of experimental apparatus.

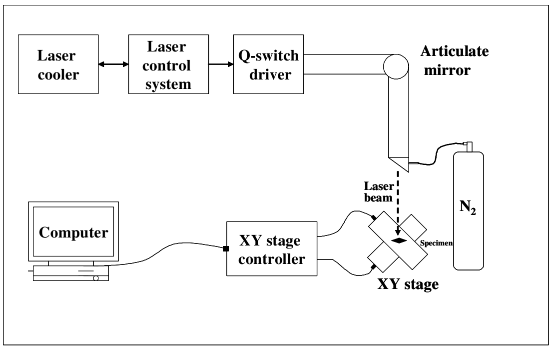
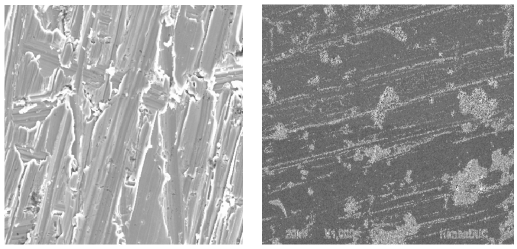


Fig.1 Schematic view of the experimental apparatus.

Pulse energy of the system at 532nm wavelength was 150 mJ/pulse. Pulse duration was 8 ns and the maximum repetition rate was 14 Hz. The specimens were irradiated for 42 shots. A JSM-6300 SEM was employed to examine any laser induced alterations to the original surface. EPMA analysis was used to identify the chemical composition.

2.3 Test results

Fig. 2 shows the SEM photographs of the prepared stainless steel surfaces before a laser irradiation. The chemical composition of the stainless steel surfaces as shown in Fig. 2 is listed in Table 1. The Co^{2+} and Ce^{4+} content is 3.0 and 7.0 atomic percent, respectively.



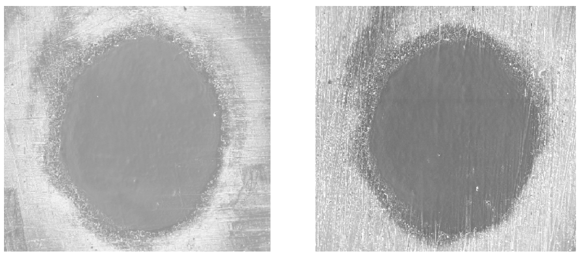
(a) 1000X (b) 1000X

Fig. 2. SEM photographs of the stainless steel surfaces contaminated with Co^{2+} and CeO_2 containing solutions (before decontamination).

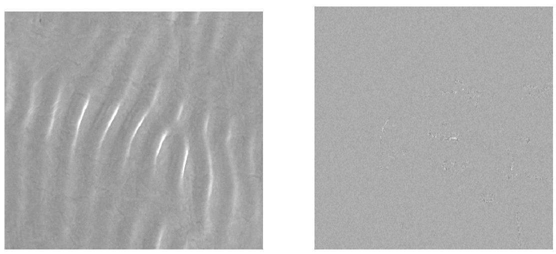
Table 1. Chemical composition of the stainless steel surfaces (before decontamination).

	O	Si	Cr	Ni	Fe	Co	Ce
A	10.5	1.6	18	6.7	60.2	3.0	−
B	11.3	0.3	17.1	6.0	58.3	−	7.0

Fig. 3 shows the SEM photographs of stainless steel surfaces after 42 laser shots. The spot diameter is approximately 1.5mm. The average fluence calculated from the diameter is 8.5 J/cm^2. The irradiated surface is clean and smooth. The chemical composition of the stainless steel surfaces as shown in Fig. 3 is listed in Table 2. Contrary to stainless steel specimen surfaces before laser irradiation, the Co^{2+} ion is not found after laser irradiation. But, negligible amount of Ce^{4+} ion is found after laser irradiation. Baigalmaa et al.[1] reported that the contaminants were effectively removed during the 100 laser shots at 1064 nm wavelength. The spot diameter was smaller than 0.1 mm and the irradiated surface was coarse. Comparing with the former study, we found that the decontamination at 532 nm wavelength is more efficient.



(a) 50 X　　(b) 50 X



(a) 1000X　　(b) 1000X

Fig. 3. SEM photographs of the stainless steel surfaces (after decontamination).

Table 2. Chemical composition of 50X stainless steel surfaces (after decontamination).

	O	Si	Cr	Ni	Fe	Co	Ce
A	7.5	0.7	16.3	9.9	65.6	0.0	-
B	7.6	0.3	18.2	10.1	63.6	-	0.2

3. Conclusion

Q-switched Nd:YAG laser decontamination tests were performed on stainless steel specimens artificially contaminated with Co^{2+} and CeO_2. For the tested specimens, it was found that the Q-switched Nd:YAG laser system at 532 nm wavelength was more effectively removed contaminants compared with 1064nm system. The surface contaminated with the Co^{2+} ion was successfully removed. But, a little portion of the contaminated Ce^{4+} was remained after 42 laser irradiations.

Acknowledgement

This work has been carried out under the Nuclear R & D Program funded by the Ministry of Education, Science and Technology.

REFERENCES

[1] B. Baigalmaa, H. J. Won, J. K. Moon, C.H.. Jung, and J. H. Hyun, "A comprehensive study on the laser decontamination of surfaces contaminated with Cs^+ ion", *Appl. Radiat.. Isotope*s, Vol. 67, pp.1526- 152 9, 2009.