Laser ablation of Type 304 stainless steel contaminated with Co^{2+}, Cs^{+}, and Eu^{3+} ions at 532 nm

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1. Introduction

A series of laser decontamination tests by a second harmonic generation of a Q-switched Nd:YAG laser with 532 nm, 450 mJ/pulse and 5 ns pulse width was employed to assess the decontamination performances for metal surfaces contaminated with the Co^{2+}, Cs^{+}, Eu^{3+} ions. The test results investigated by EPMA are presented in this paper.

2. Methods and Results

2.1 Specimen Preparation

Type 304 stainless steels were cut into a rectangular form to prepare the experiment specimens. They were polished, with abrasive papers, and washed with water and ethyl alcohol. The experimental specimens were prepared as follows: Eu_2O_3 powder (Aldrich Chemical Company, Inc.) diluted with distilled water was slowly dropped onto the surface of stainless steel specimen by injection and then dried in a room temperature. Two kinds of $Co(NH_4)_2(SO_4)_2$ and $CsNO_3$ solutions were also dropped onto the specimen surfaces, respectively and then dried for the test. The relative atomic molar percent of surface elements before laser irradiation was analyzed by EPMA.

2.2 Laser irradiation

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

2.3 Test results

To determine the optimum laser shot numbers for the removal of Co^{2+}, Cs^{+}, and Eu^{3+} ions, removal portion (C_s/C_o) was evaluated as the function of laser shot number at 13.26 J/cm^2 for the 3 kinds specimens and shown in Fig.2. Where, C_o is the atomic molar percent before laser irradiation and C_s is atomic molar percent after laser irradiation.

For the three kinds of specimens, as shown in Fig.2, the removal portion of Cs^{+}, Co^{2+} and Eu^{3+} ions were decreased to less than 0.01 during the first 8 of shots. And the Eu^{3+} ion was decreased to less than 0.015 during the first 8 of shots. The order of removal efficiency to Cs^{+}, Co^{2+} and Eu^{3+} ions on the contaminated specimens by laser was $CsNO_3 > Co(NH_4)_2(SO_4)_2 > Eu_2O_3$.

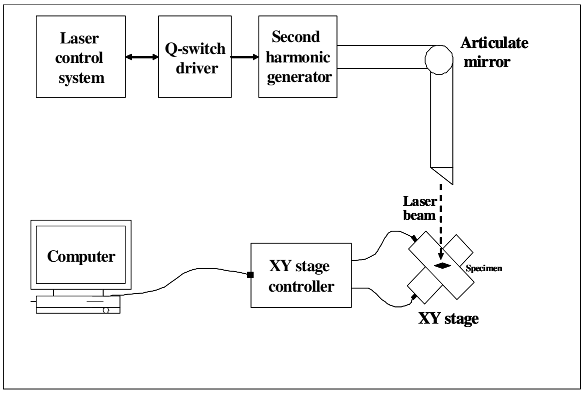

Fig.1. Schematic diagram of experimental apparatus.

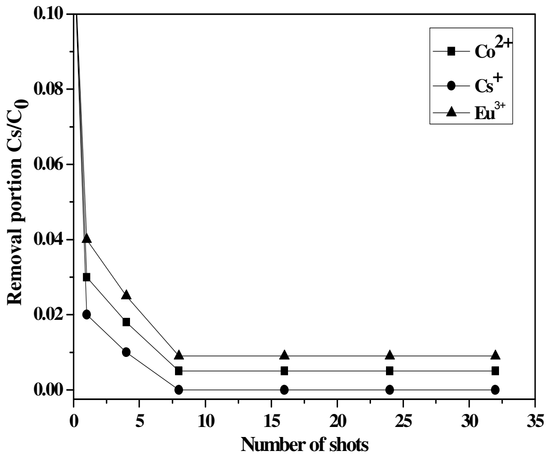

Fig.2. Removal portion of Cs^{+}, Co^{2+} and Eu^{3+} ions against the number of laser shots (13.26 J/cm^2 and 10 Hz).

Baigalmaa et al. [1] reported that the contaminants were effectively removed during 100 laser shots at a wavelength of 1064 nm. The spot diameter was smaller than 0.1 mm, and irradiated surface was coarse. Comparing with the former study, we found that decontamination at 532 nm wavelength was more efficient.

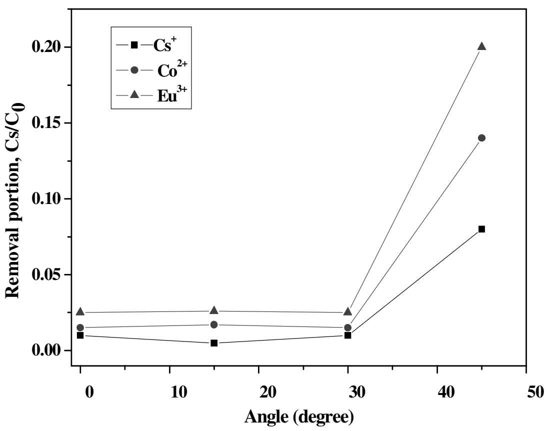

Fig.3. Removal portion of Cs^+, Co^{2+} and Eu^{3+} ions against the irradiation angle.

Fig 3. shows the removal portion of Co^{2+}, Cs^+, Eu^{3+} on the stainless steel at various irradiation angle. The specimen was irradiated by changing the irradiation angle at 8 laser shots. The angle of 0^o means the irradiation of laser beam is perpendicular to the specimen. The angles of 15^o and 45^o mean that the laser beam is inclined at 15 and 45 degree from the perpendicular of laser beam, respectively. It is seen from this figure that the 3 kinds of specimen were effectively removed between 0^o and 30^o.

3. Conclusion

A second harmonic generation Q-switched Nd:YAG laser operating at 532 nm was used to evaluate the ablation performance on the surrogate specimens contaminated with Cs^+, Co^{2+}, and Eu^{3+} ions. Cs^+ and Co^{2+} ions on the type 304 stainless steel specimens were removed satisfactorily by the laser ablation method. In the experimental range, a small portion of metal oxide was remained on the specimens treated with the Eu^{3+} ions and it suppressed the removal efficiency. Finally, the present method also has a possibility to decontaminate the equipment in hot cells or to reduce the volume of radioactive wastes generated from nuclear facilities with a small occupational exposure to workers

Acknowledgement

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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. Isotopes*, Vol. 67, pp.1526-1529, 2009.