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Laser Decontamination of Type 304 Stainless Steel by the String Type Beam at 532 nm

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1. Introduction

Laser decontamination is a relatively new technique for removing pollutants from surfaces that is currently finding various applications in a nuclear industry. Laser beam is generally a circular type. To apply to the larger area during a same application time, use of the string type laser beam was considered. The objective of the study is to investigate the removal characteristic of the string type laser beam on the Type 304 stainless steel artificially contaminated with Cs^+, Co^{2+}, Eu_2O_3 and CeO_2, respectively.

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 Cs^+, Co^{2+}, Eu_2O_3 and CeO_2 containing solutions were thrown on specimen surfaces. After drying, they were analyzed by SEM and EPMA (JEOL Ltd. Model: JSM-6300) and used for the tests. The chemical composition of Type 304 stainless steel surface is listed in Table 1.

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

Element	N	O	Ni	S	Cr	Fe	H	Eu	Cs	Ce	Co
$Co(NH_4)_2(SO_4)_2$	2.0	10.7	6.9	0.2	18	59.2	trace	-	-		3.0
Eu_2O_3	-	30.6	7.7	-	10.1	45.6	-	6	-		-
$CsNO_3$	4.5	25.4	5.9	-	13.6	45.6	-	-	5.0		-
CeO_2	-	11.6	6.0	-	17.1	58.3	-	-	-	7.0	-

2.2 Laser irradiation

A Q-switched Nd:YAG laser (Quentel Co. Model: Brilliant b) with a second harmonic generation was employed. The pulse energy determined from the energy meter was 400 mJ/pulse at 532 nm. The repetition rate was 10 Hz and pulse duration was 5 ns. The specimen was mounted on a stage that allowed the specimen holder to move by 25 mm x 25 mm in the X and Y directions. Fig. 1 shows the schematic diagram of the experimental apparatus. The specimens were irradiated for 80 shots.

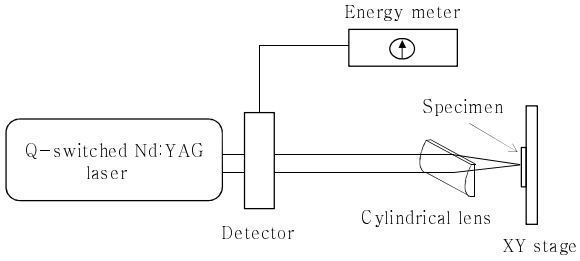

Fig.1. Schematic diagram of experimental apparatus.

2.3 Test results

Fig. 2 shows the photographs of the Type 304 stainless steel irradiated with string type laser beam.

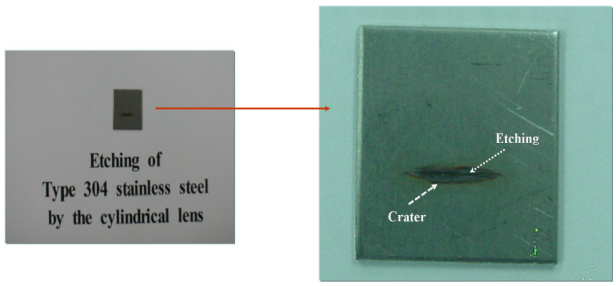

Fig. 2. Photographs of Type 304 stainless steel after irradiation by string type laser beam (10shots).

It is shown that etching happened during the laser irradiation and the area of rectangle is 8.0 mm x 0.5 mm. It can be shown that crater was formed during the laser irradiation. Rafique et al. [1] reported that the hydro-dynamic effects were apparent with a liquid flow which formed a recast material around the periphery of the laser focal area.

Fig. 3 shows the SEM micrographs of Type 304 stainless steel contaminated with CeO_2 particles. As the increase of the irradiation number, contaminants are removed satisfactorily. Contrary to the bare metal surface, crater was not formed during the laser irradiation.

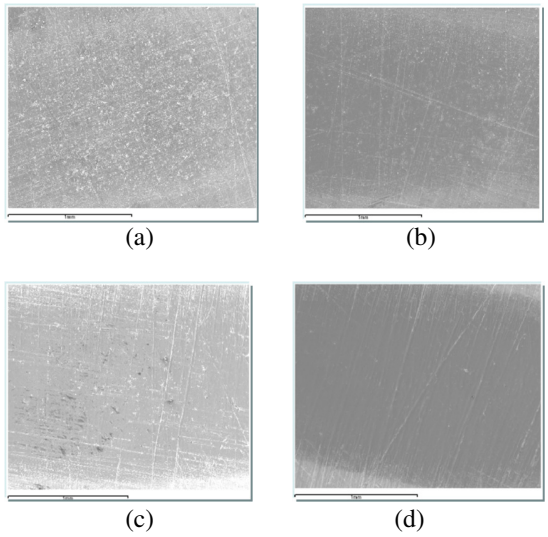

Fig. 3. SEM micrographs of the Type 304 stainless steel surfaces contaminated with CeO_2 particles after (a) 1shot, (b) 2shots, (c) 5shots and (d) 10shots, 100X, 13.26 J/cm^2 .

Fig. 4 shows the change of the relative atomic molar ratio of 4 kinds of contaminants on Type 304 stainless steel against the number of shots.

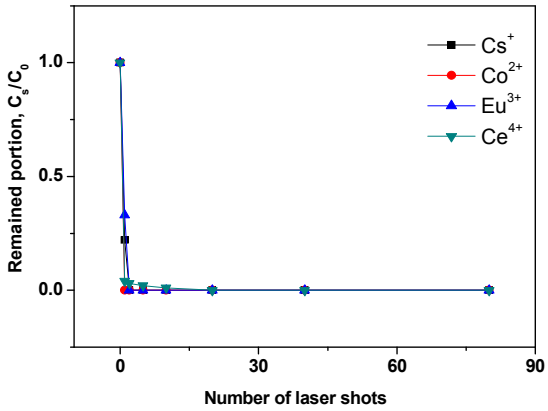

Fig. 4. Remained portion of contaminants against the number of laser shots.

The contaminants were satisfactorily decontaminated by Q-switched Nd:YAG laser during the first 10 laser shots.

3. Conclusion

Q-switched Nd:YAG laser decontamination tests were performed on stainless steel specimens artificially contaminated with Cs^+, Co^{2+}, Eu_2O_3 and CeO_2. For the tested specimens, it was found that the string type laser beam at a wavelength of 532 nm effectively removed contaminants. Comprehension of ablation mechanism and optimization of process parameters are required.

Acknowledgement

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REFERENCES

[1] M.S. Rafique, R. M. Khaleeq-ur, T. Firdos, RD and SEM analysis of a Laser Irradiated Cadmium, Laser Physics, Vol. 17, No. 9, p.1138, 2007.