Laser Processing of Plasma Sprayed Coatings†

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1. Introduction

Plasma sprayed coatings are widely used as the coatings of functional components. However, there exist some defects in coatings, such as micro-porosities, microcracks and nonbonded area between lamellae, which decrease the properties of coatings, such as resistance to wear, corrosion, impact and so on. Therefore, improvement of the properites of coatings is necessary in order to make greater use of coatings. On the other hand, the laser beam processing is an attractive process, because laser beam has a great potential for surface modification due to the characteristics of its own. And then, coatings with new characteristics are expected to be able to form by hybridizing of plasma spraying with laser beam irradiation.

In present study, as a first step of the program, phenomena which occurred were examined to clarify the possibility to improve the properties of plasma sprayed coatings by laser beam irradiation.

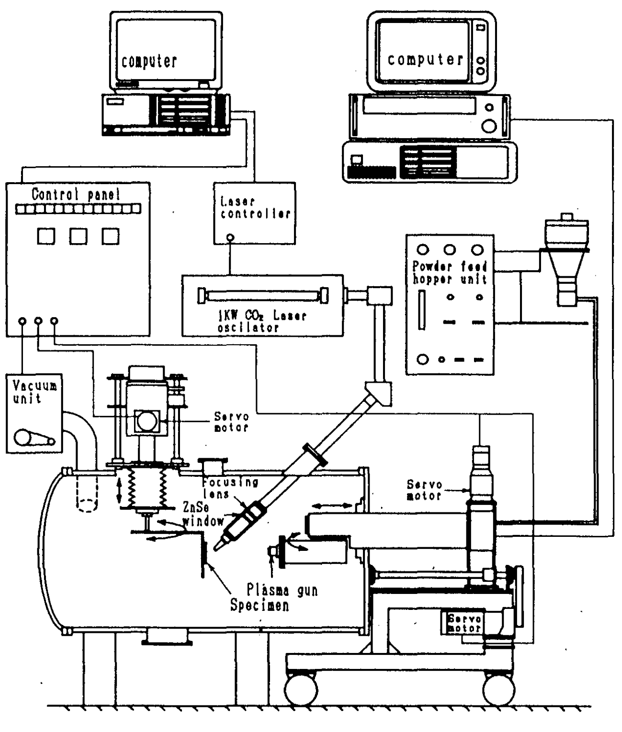

Fig. 1 Schematic diagram of laser-plasma spraying apparatus.

2. Experimental Equipment

Figure 1 shows the laser-plasma spraying system used in this study. Plasma spraying gun (METCO 9MB; maximum power 80kW) and working table are installed inside of a chamber equipped with exhaust systems. The laser source used is a CO_2 gas laser (MITSUBISHI 10C; maximum power 1 kW). Spraying is carried out in a low pressure chamber, the pressure of which can be adjusted from 1 to 760 Torr. The working table can be moved in horizontal, perpendicular and round directions. The nozzle, for flowing gases, equipped with the focusing lens inside, is at an angle of 45 degrees to the surface of the specimen. We can use a gas jet to cover the focusing lens or to cause chamical reactions.

3. Materials and Experimental Procedures

Three kinds of spraying powder used in this experiment were commercially available Al_2O_3, Mo, WC-17%Co powders. The coatings were sprayed onto sand-

Table 1 Conditions of plasma spraying and laser irradiation

	Spray material	Al_2O_3	Mo	WC-17%Co
Plasma	Plasma power [kW]	40	40	40
	Spray distance [mm]	520	450	450
	Traverse speed [mm/s]	95	95	95
Laser	Laser power [W]	300	600	600
	Defocus(F=380) [mm]	+100	±0	±0
	Traverse speed [mm/s]	95	6~20	17

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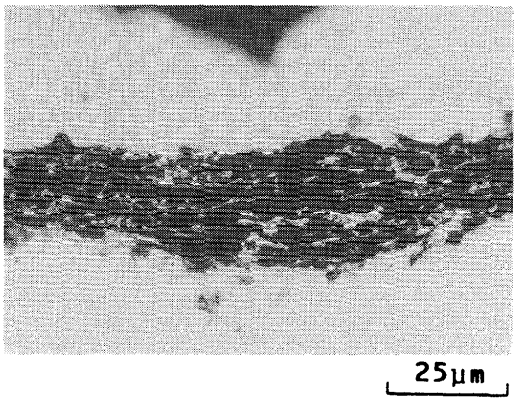
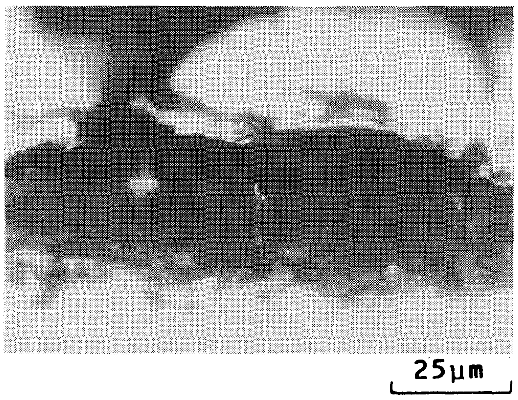
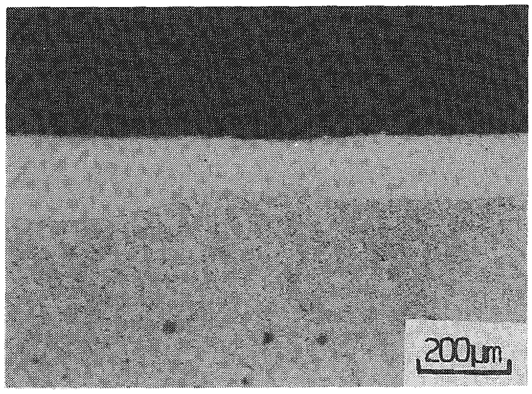


(a) As-coat

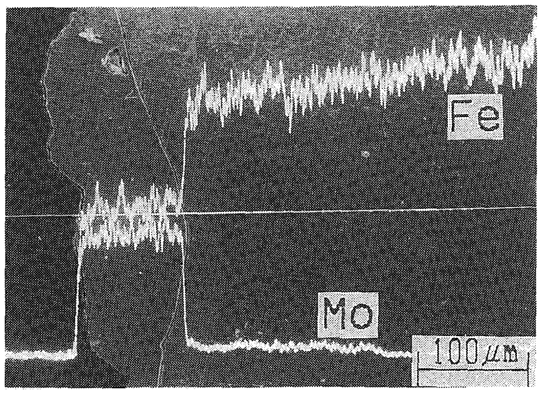


(b) Laser treatment

Fig. 2 Micrographs of cross sections of Cu elecrtoplated Al_2O_3 coatings.



(a) Optical micrograph



(b) SEM and EDX analysis

Fig. 3 Micropraph and EDX analysis of laser treated Mo coatings.

blasted SS41 steel of a size of 60 X 100 X 3 mm. Before spraying the chamber is evacuated to about 1 Torr and then purged to 100 Torr with Ar gas. During spraying, a pressure of 100 torr is maintained in Ar atmosphere. Immediately after spraying, laser treatment was carried out. **Table 1** shows the plasma spraying and laser irradiation conditions.

4. Results and Discussion

4.1 Al_2O_3 coating

Figure 2 shows cross sections of Al_2O_3 coatings before and after laser treatment respectively. Copper electroplating to the coating was carried out in order to reveal exactly the existence of micro-porosities, microcracks, nonbonded area between ceramic lamellae in the coating. Porosities can be recognized by the existence of a white areas just like some shown in **Fig. 2(a)**. After Cu electorplated into an as-sprayed coating, it is recognized that the microstructure of coating consists of the flattened particles and nonbonded interfaces. However, as shown in **Fig. 2(b)**, the laser treated Al_2O_3 coating showed a dendritic microstructure, and porosities almost disappeared. It was recognized that it is effective to obtain dense coating without cracking by laser irradiation to coatings.

4.2 Mo coating

Figure 3 shows the micrographs of a cross section and EDX analysis of laser treated Mo coatings. **Figure 4** shows a micro Vickers hardness distribution with depth from the surface of the laser treated Mo coating. There formed the alloying layer composing of the elements of Mo coating and Fe in SS41 substrate materials, and the hardness of the alloying layer is larger than as-coated one.

4.3 WC-17%Co coating

Figure 5 shows the micrographs of cross sections of WC-17%Co coatings before and after laser treatement, and micro Vickers hardness. As shown in Fig. 5(a) in laser treated coating, WC particles disperse uniformly in

Co matrix, and the hardness varies less. Therefore, by laser irradiation, the dense coating with uniform hardness can be obtained.

5. Conclusion

As follows, it is effective to obtain dense, uniform and alloying coatings by laser-plasma spraying.

(1) The open porosities in Al_2O_3 coating almost disappeared without cracking.

(2) The alloying layer consisting of the elements of Mo and Fe was formed, and the hardness of the layer was larger than as-coated one.

(3) WC particles dispersed uniformly in Co matrix, therefore the dense coating with uniform hardness can be obtained.

References

1) Y. Arata, A. Ohmori and C-J. Li; JWRI 1987 2(16) 259-265.

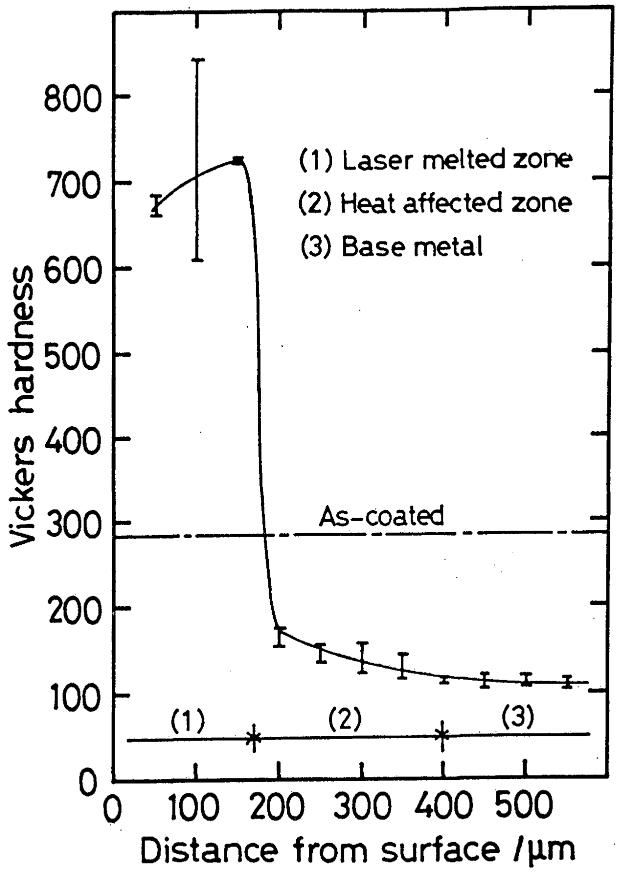


Fig. 4 Microhardness distribution of laser treated Mo coating.

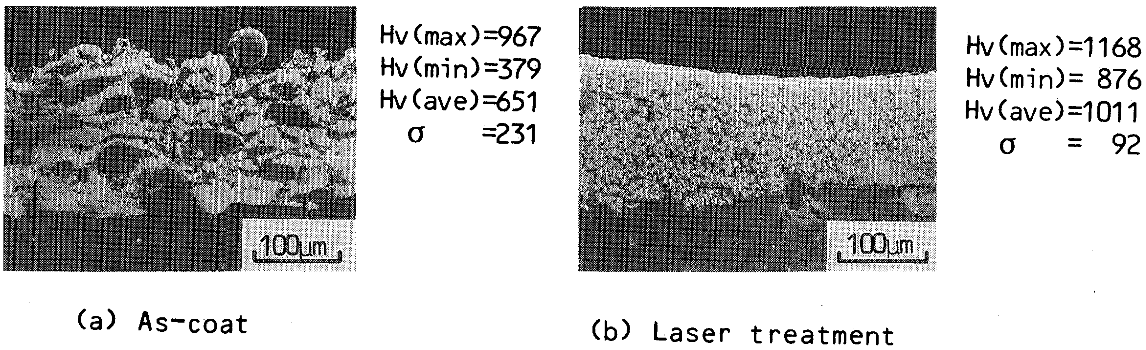


Fig. 5 Micrographs of WC-17%Co coatings and micro Vickers hardness.