Creation of Diamond/Molybdenum Composite Coating in Open Air

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Abstract

For improvement of wear resistance property of atmospheric thermal plasma sprayed molybdenum (Mo) coating, diamond deposition on the atmospheric plasma sprayed molybdenum coating by the combustion flame chemical vapor deposition (CFCVD) has been operated. In this study, to diminish the thermal damage of the substrate during operation, a thermal insulator was equipped between substrate and water-cooled substrate holder. Consequently, diamond particles could be created on the Mo coating without fracture and peeling off. From these results, it was found that this process had a high potential in order to improve wear resistance of thermal sprayed coating.

Keywords : Chemical vapor deposition, Combustion flame, Diamond, Thermal spray, Wear resistance

1. Introduction

As the wear resistive coating for piston of reciprocal engine, molybdenum (Mo) coating has been widely used. Recently, in order to improve its wear resistance, glass particle dispersed [1] and/or PTFE infiltrated [2] Mo coating was developed and its merit for wear resistance was confirmed. However, these fabrication processes demand long duration time and expensive equipment and so on. Therefore, a process without these problems should be developed. On the other hand, since diamond can be deposited on Mo coating by combustion flame CVD (CFCVD), diamond dispersed Mo coating can be fabricated easily in comparison with above mentioned Mo coatings. In this study, in order to develop the process for diamond/Mo composite coating without fracture and peeling off of Mo coating, a thermal insulator was inserted between substrate and water-cooled substrate holder in advance and diamond deposition by CFCVD was carried out.

2. Experimental and Results

Fig. 1 shows schematic diagrams of the experimental apparatus for the diamond deposition and substrate holder, respectively. This apparatus consists of acetylene/ oxygen combustion flame welding torch, gas supply system including mass flow controller and sample holder with substrate cooling system. A sample was deposited on the stage of the substrate holder and cooled by cooling pipe located on the substrate surface as well as the substrate holder. An alumina thermal insulator was inserted between substrate and substrate holder in order to prevent from the thermal shock due to shut down of combustion. As a substrate, 12 mm x 10 mm x 1mm^t molybdenum plate was used. The substrate was polished by #400 water resist sand paper before operation in the case of diamond deposition on polished Mo coating. The deposition temperature during operation (T_d) was observed by a radiation thermometer.

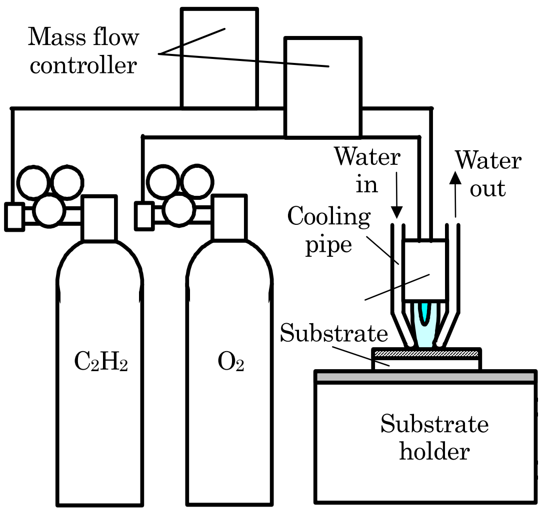


Fig. 1 Schematic diagram of CFCVD equipment.

After diamond deposition, investigation of the micro-structure of the diamond deposited substrate was carried out using optical microscope and X-ray diffraction. Table 1 shows experimental conditions.

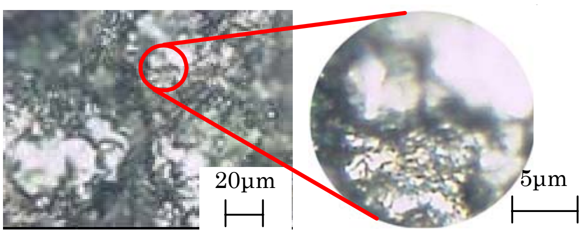
In the case of fabrication of CFCVD diamond/ thermal spray Mo composite coating, additional thermal spray coating of Mo after diamond deposition is necessary

Table 1. Experimental condition

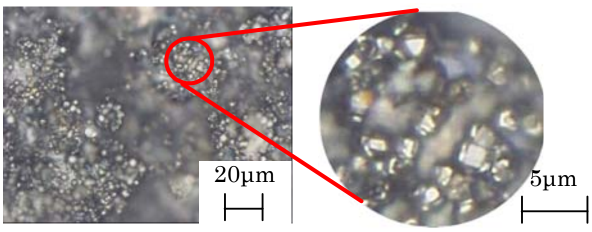
Working gas	C_2H_2/O_2
C_2H_2 flow rate	1.4 l /min
O_2 flow rate	1.25 l /min
Deposition distance	10 mm
Total deposition time	20 min
Deposition temperature	1200-1723K
Distance between cooling pipes	8 mm
Substrate	Mo coated SS400 mild steel

because of weak adhesion strength between diamond and Mo. Therefore, diamond deposition on the as-deposit Mo coating is practical rather than that on the polished Mo coating.

Figs.2-3 show optical micrographs and XRD patterns of Mo coatings before and after diamond deposition on the condition of Td =1373K. Although scratching is generally demanded in order to make stagnation area for nucleation in the case of CVD, diamond particles could be created without scratching because of its rough surface in this case. From the results of XRD, molybdenum carbide was created as well as diamond on the Mo coating during diamond deposition. According to some papers on diamond deposition [6], molybdenum carbide is said to effective for nucleation and crystal growth of diamond and reduction of residual stress at Mo/ diamond interface. So, the effect of molybdenum carbide on diamond deposition and optimum deposition condition of molybdenum carbide should be taken into account.



a) Before diamond deposition (Mo coating)



b) After diamond deposition

Fig. 2 Optical micrograph of the sample surfaces in the case of as-deposit Mo coating.

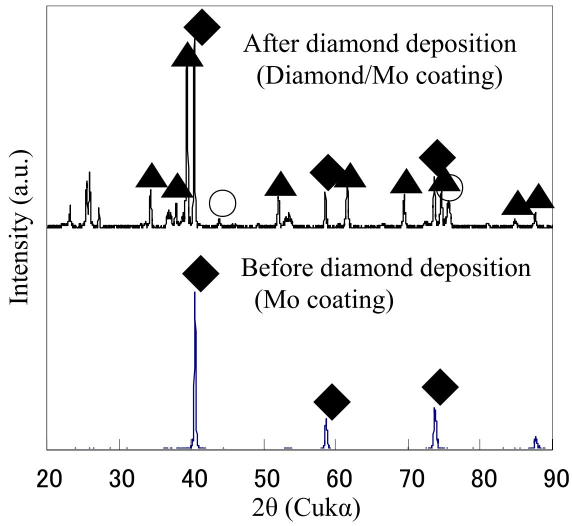


Fig. 3 XRD patterns of sample surfaces in the case of as-deposit Mo coating. (○: Diamond, ◆: Mo, ▲:Mo_2C)

3. Summary

By inserting a thermal insulator between substrate and water-cooled substrate holder, diamond particles could be deposited on the Mo coated SS400 mild steel without fracture and peeling off of the coating even by CFCVD. Besides, it was proved that diamonds could be deposited on the as-deposit Mo coating as well as the polished one. From these results, this process was found to have high potential for diamond/ Mo composite coating and improvement of wear resistance of Mo coating.

4. References

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