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Diamond deposition on Mo with thermal stress buffer layer coated mild steel substrate by combustion flame CVD

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A B S T R A C T

In order to develop wear resistance diamond/molybdenum (Mo) hybrid coating process can be conducted in open air. Diamond deposition on the molybdenum with thermal stress buffer layer coated mild steel substrate by the combustion flame chemical vapor deposition (CFCVD) was carried out. As the thermal stress buffer layer, atmospheric plasma sprayed Mo/Fe mixture coating was deposited between Mo top coat and mild steel substrate. Consequently, crack generation and peeling off of the coating occurred due to thermal influences on the condition of Mo coated mild steel substrate in our previous study, diamond particles could be created on the Mo coating without fracture and peeling off. Besides, an additional Mo coating after diamond deposition increases the adhesion force between the diamond coating and the initial Mo coating. This encapsulation of the diamond particles between two Mo layers dramatically improves the resistance of the global coating making it strong enough to resist to the wearing test. These results demonstrate the high potential of thermal sprayed coating for the wear resistance improvement.

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1. Introduction

Thermal spray coatings have been widely used for various structures such as automobiles, buildings, bridges and so on. Above all, in the automotive industry, since a car consists of many sliding parts such as piston ring, crank shaft, and so on, wear resistant materials are required. As for the surface modification processes, wet plating and dip coating have been utilized for a long time. However, since these are wet processes, they have some disadvantages such as the high cost of the apparatus and the limitation of the sample size due to apparatus like plating baths. Therefore, recent dry processes like CVD [1,2], PVD [3,4], thermal spray [5,6] and so on have been developed and utilized. Above all, since the atmospheric thermal plasma spray (APS) can be conducted in ambient air, this process comes to supplant wet plating for the surface modification for some parts of ship engines. In the case of wear resistant coating for automobiles, Mo, Cr and TiN coatings are mainly used. However, since more resistant coating is demanded even in this field, hybrid coatings like MMC (metal matrix composites) coating, glass dispersed metal coating [7] and PTFE infiltrated porous metal coating [8] have been developed and successfully used. But, since these coating require long duration heating in a furnace, which is expensive. Hence, easier hybrid coating process is hoped.

Previously, diamond was selected as the dispersed particle for wear resist improvement of the coating, and a Mo/diamond hybrid coating process was proposed by depositing diamond on APS molybdenum (Mo) coated mild steel substrate under combustion flame CVD [9]. Consequently, since diamonds could be deposited on the APS Mo coating, it was confirmed that Mo/diamond hybrid coating could be deposited by dry process at atmospheric pressure. However, fracture and peeling off of the hybrid coating due to thermal shock occurred during diamond deposition. Bad to worse, since adhesion strength between diamond and Mo coating was very week, diamond particles delaminated at the beginning of the wear testing.

In this study, in order to obtain wear resistant Mo/diamond hybrid coating without peeling off and fracturing, a diamond coating was deposited at atmospheric pressure on an APS Mo coated mild steel substrate using a combustion flame CVD process. Besides, by additional APS Mo coating on the diamond deposited substrate, improvement of adhesion strength between diamond and Mo coating was conducted.

2. Experimental apparatus

Schematic diagram of the experimental apparatus for the diamond deposition is shown in Fig. 1. This apparatus consists of

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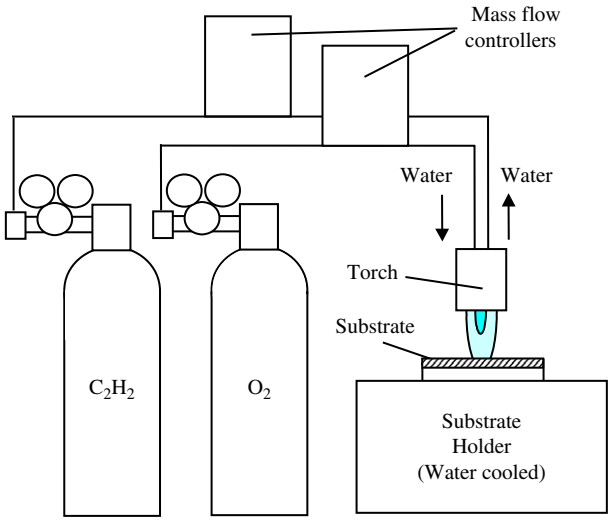

Fig. 1. Schematic diagram of the combustion flame CVD equipment.

acetylene/oxygen combustion flame welding torch, a gas supply system including mass flow controllers and a water cooled substrate holder. The sample was put on the substrate holder and cooled by cooling pipe located on the substrate surface as well as the substrate holder. Inlet pressure of C_2H_2 and O_2 was 2.5 kg/cm^2 and 3.5 kg/cm^2, respectively. The O_2 mass flow was fixed at 1.25

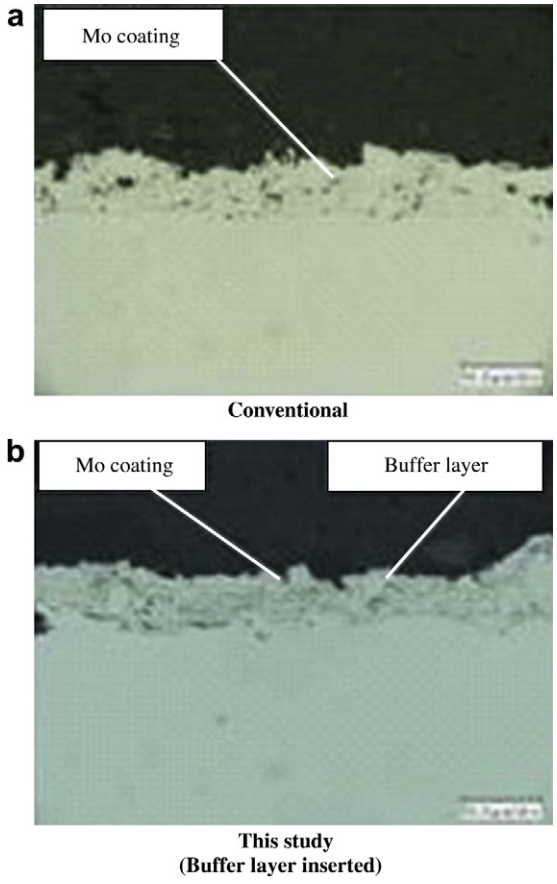

Fig. 2. Optical micrographs of the cross-sections of the substrates. (a) Conventional and (b) this study (buffer layer inserted).

Table 1
Experimental condition

Working gas	C_2H_2/O_2
C_2H_2 flow rate (SLM)	1.4
O_2 flow rate (SLM)	1.25
Deposition distance (mm)	10
Total deposition time (min)	20
Deposition temperature (K)	1200–1723
Substrate	Mo coated SS400 mild steel

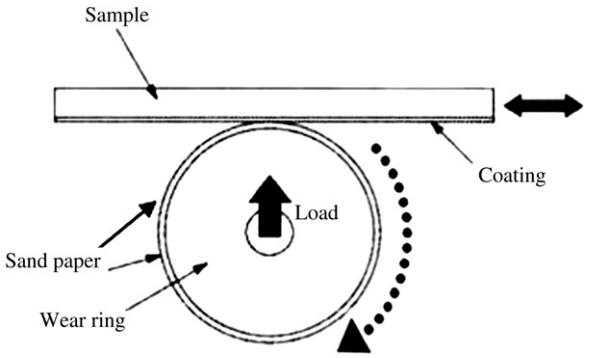

Fig. 3. Schematic diagram of the wear testing equipment.

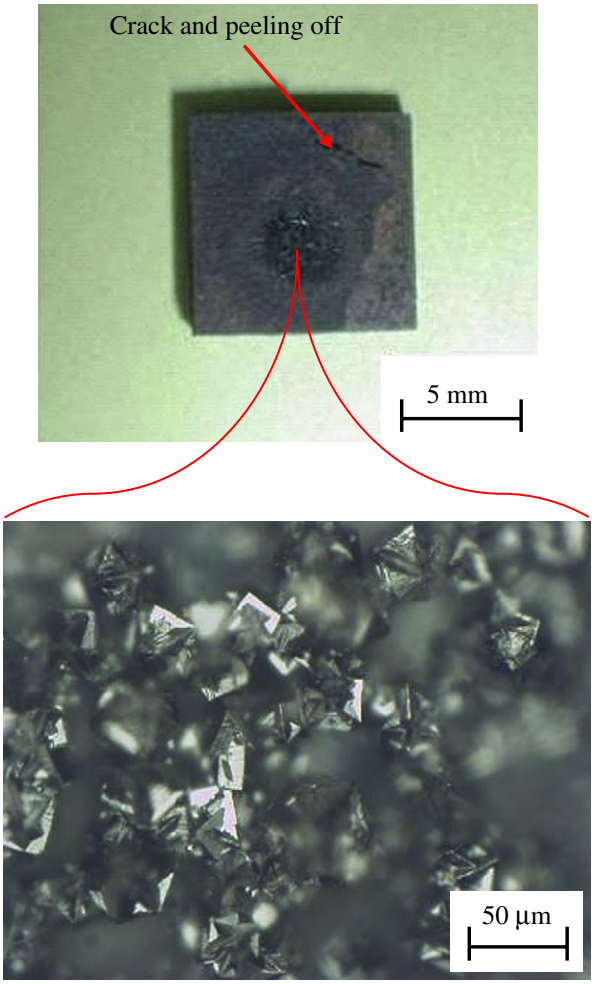

Fig. 4. Appearance of the diamond deposited substrate without thermal buffer layer.

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