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Erosion Characteristics of Electroless Deposited Ni-Fe-P Alloys in 5% NaOH Slurry

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Abstract: Amorphous Ni-Fe-P alloy coating was prepared on thecopper substrate by electroless deposition. Silicon carbide particles were added into the suspension containing 5wt% NaOH to carry out erosion experiments on the coatings with the self-made erosion tester. The experimental results show that, due to the corrosion of the solution on the coating and the impact of SiC particles on the corrosion film and matrix metal, the maximum loss of coating quality occurs when the SiC particle size is 120 μm at different impact angles. With the increase of impact angle, the mass loss of coating tends to increase. With the increase oftheslurry flow rate, the mass loss of coating increases.

1. Introduction

Erosion is the joint action of metal material surface and corrosive fluid washing, which causes local metal corrosion. There are suspended hard particles in the fluid. Under the action of shear stress between the fluid and the metal, the degree of damage to the metal is increased. Erosion wear has become one of the important reasons for material damage or equipment failure, and research on erosion has also been paid attention [1-3]. Electroless deposited Ni-Fe-P alloy has good corrosion resistance and wears resistance. You yanqun et al. [4] studied the CO_2 corrosion resistance of electroless deposited Ni-Fe-P alloy on N80 steel surface. It was found that Ni-Fe-P plated sample had better CO_2 corrosion resistance than N80 steel. Wang Yanzhi [5] studied the composition, structure and corrosion resistance of electroless Ni-Fe-P alloy plating on aluminum alloy surface, and obtained amorphous structure coating, which had good corrosion resistance in 10% NaOH solution. Chen Chuanqi et al. [6] systematically studied the technological conditions of electroless deposited of Ni-Fe-P alloys. The results show that electroless deposited of Ni-Fe-P alloys havebetter corrosion resistance than electroless deposited of Ni-P alloys. The erosion characteristics of electroless deposited Ni-Fe-P alloy coatings in sodium hydroxide solution are studied.

2. Methods and test materials

The substrate material is pure copper, and the sample size is 20mm×20mm×0.5mm.The samples has been electroless plated for two hours. After the samples are plated, they are washed and dried. The morphology of electroless deposited Ni-Fe-P alloy coating is observed by a scanning electron microscope (SEM) typed JSM-7500F.The composition of the coating is tested by energy dispersive spectrometer (EDS). The structure of the coating is analyzed by X-ray diffractometer typed TD-3500A. The schematic diagram of erosion test equipment is shown in Figure 1. Silicon carbide is added to 20g/l and the particles size are as follows 250μm,120μm,80μm, and 60μm respectively. The impact angles are controlled from 45ºto 90º. The fluid medium is 5 wt% sodium hydroxide solution. The flow velocity of the slurry is between 40ml/s to 70ml/s. After an hour of erosion test, the samples are washed with deionized water and then dried. The difference of sample mass before and after erosion test is the sample's mass loss during erosion. The surface morphology of the samples after erosion test is observed by SEM typed JSM-7500F.

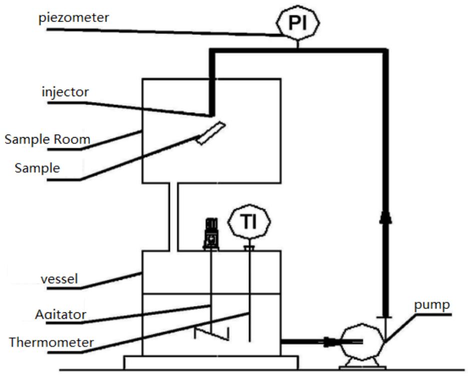


Figure 1.Schematic diagram of an erosion test device

3. Results and analysis

3.1. Electroless deposited Ni-Fe-P alloy coating

Sample preparation is described in document [6]. Figure 2 shows the surface morphology of the coating. It can be seen that the cellular structure of the coating is uniform in the as-plated state. The energy dispersive spectrometer test showsthat the content of phosphorus in the coating is 14.15% and iron content is 4.25%. Fig. 3 is the X-ray diffraction spectra of as-plated coatings. There is a broad "steamed bread" peak near the diffraction angle of 45º, which indicates the existence of amorphous phase in as-plated coatings.There is a sharp diffraction peak near 50º. The analysis shows that this diffraction peak is produced by the copper matrix.

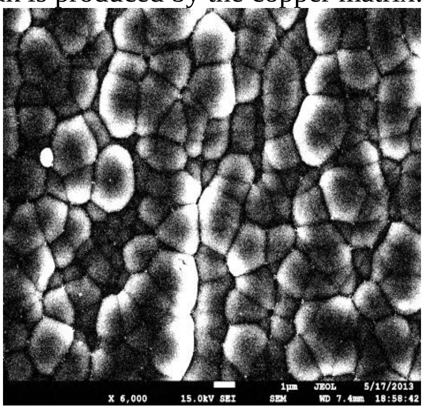


Fig.2 Coating morphology

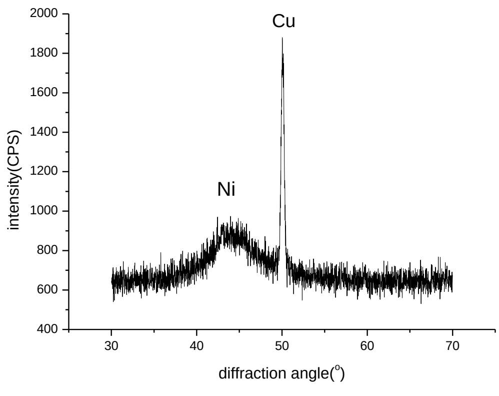


Fig.3 X-ray Diffraction Analysis of Coating

3.2. Effect of particle size on mass loss of the coatings

Fig.4 shows the effect of SiC particle size on mass loss of the coatings in 5wt% NaOH slurry. From Fig.4, it can be seen that, under different impact angles, the maximum mass loss of coating occurs when the SiC particle size is 120μm. When Ni-Fe-P alloy coating contacts with the slurry, on the one hand, it is affected by OH^- ions to form an oxide film of metal. On the other hand, SiC particles in the slurry have a shearing effect on the oxide film, which makes the oxide film peel off, and the coated alloy is quickly exposed to the corrosive medium and re-generates oxide film. With the increase of SiC particle size, the damage caused by large particles is greater than that caused by small particles at the same flow rate. Therefore, with the increase of SiC particle size, the mass loss of coating increases.

Because the total mass of SiC particles in the slurry is certain, when the SiC particle size is large, the number of SiC in unit volume decreases greatly, and the damage caused by this condition decreases, so the mass loss decreases. Therefore, when the particle size of SiC is 250μm, the mass loss of coating decreases.

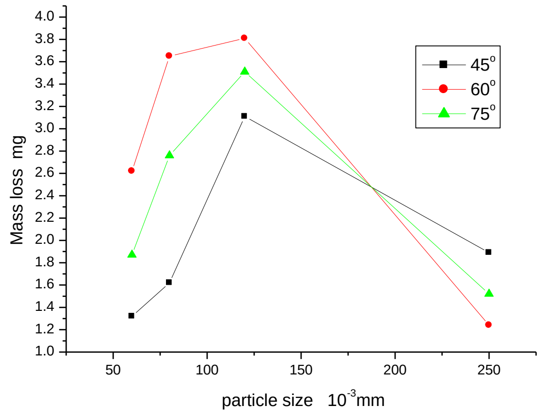
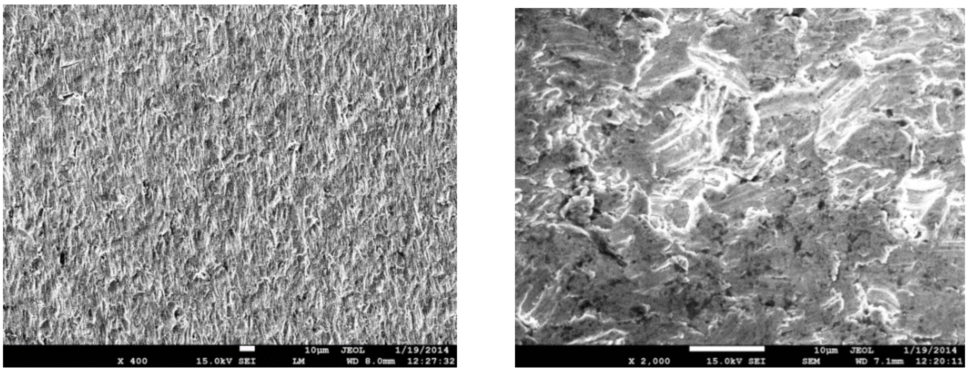


Fig. 4 The influence of particle size on mass loss of the coating

During the erosion process, the SiC particles in the slurry not only exert shear stress on the sample but also form compressive stress on the surface of the sample. The existence of compressive stress will destroy the oxide film and cause micro-deformation of the metal matrix. The accumulation of micro-deformation will cause micro-pits on the surface of the coating and accelerate the mass loss of the coating. Therefore, under the experimental conditions, it can be seen that with the increase of impact angle, the loss of coating quality tends to increase.

Fig.5 is the surface morphology of the sample after the erosion test. Compared with the morphology of as-plated coating, the cellular structure of the coating surface has been destroyed (Fig. 5a), and a large number of pits appear on the coating surface. The surface of the coating shows plough grooves caused by the impact of hard particles on the matrix, and plastic deformation occurs in the local area (Fig. 5b).



（a）400 (b)2000

Fig. 5 Surface morphology of the sample after the erosion test

3.3. Effect of slurry velocity on mass loss of coating

Fig.6 shows the effect of flow rate on the mass loss of coatings in a suspension containing 5wt% NaOH. As shown in Fig. 6, with the increase of flow rate, the loss of coating mass increases under various SiC particle sizes. When the SiC particle size is 120μm, the mass loss of coating is the largest, and when the SiC particle size is 60μm, the mass loss of coating is the smallest. With the increase of slurry flow rate, the impact of liquid medium and hard particles on the coating increases, the damage to the oxide film and matrix metal increases, and the mass loss of the coating increases.

At the same flow rate, the scouring effect of the liquid medium on the coating is the same.ButSiC particle size in the slurry is different, so the exten ofdamageto the coating is different. With the increase of SiC particle size in the slurry, the damaging effect of SiC particle on the coating increases, and the damage of the coating increases. Because the mass of particles added into the slurry is the same, the number of particles per unit volume of slurry decreases when the particle size is larger. Therefore, when the particle size is 250μm, the damage of a single particle to the coating is stronger, but the overall damage is weaker. When the particle size of SiC is 120μm, the particle size is moderate, which has a great impact on the surface of the coating, and the mass loss of the coating is the greatest.

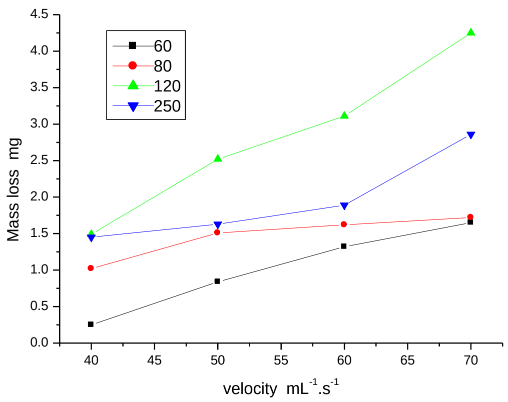


Fig 6 The influence of velocity on the plating quality loss

4. Conclusion

Amorphous Ni-Fe-P alloy coating was prepared on a copper substrate by electroless deposition. Silicon carbide particles were added into the suspension containing 5wt% NaOH. Due to the corrosion of the solution on the coating and the impact of SiC particles on the corrosion film and matrix metal, the maximum mass loss of the coating occurred at 120μm SiC particle size at different impact angles. With the increase of impact angle, the mass loss of coating tends to increase. With the increase of the slurry flow rate, the loss of coating quality increases.

Acknowledgments

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