PREPARATION TECHNOLOGY OF NI-SIC COMPOSITE COATING IN CENTRIFUGAL FIELD

MA HUANMING, JIN XIAOQIU, MENG YONGHONG, CHU JUNZAI

Using self-made centrifugal high-speed electroplating equipment, we studied the effect of technological parameters on SiC content in SiC-Ni composite coating, such as temperature, pH value, current density, SiC content in bath, and rotation speed of cathode. Experimental results show that temperature, current density, SiC content in bath, and rotation speed influence SiC codeposition volume. PH value has little affect on it.

1. Introduction

The method of adding inert powders to bath electrolyte and electrodepositing them with metal to prepare metal-based coating, that is, coelectrodeposition, has been greatly developed in recent years. However, there are the following defects in normal coelectrodeposition technology: Low deposition speed; Low eutectoid amount of powders; Increasing of powder concentration in electrolyte has little effect on powder content in composite coating; Powders are easy to lose from matrix for the matrix is porous. Thus, application of the technology is limited in many fields.

The method of centrifugal electroplating shows advantages for composite electrodepostion on inner surface of tube-shaped workpiece. Centrifugal electroplating powders in bath would accelerate towards inner surface of the workpiece driven by centrifugal force, which would greatly increase powder eutectoid amount. As a result, amount of the powder added into the electrolyte is considerably reduced, which would do favor to the coating quality and the equipment working life. At the same time, deposition rate is increased greatly in such condition for the electrolyte flowing through the workpiece surface at very high speed.

2. Experiment

2.1 Experiment equipment

Self-made centrifugal high-speed electroplating equipment is shown as Fig.1.

Anode is a round titanium plate with platinum plated on it. It is fixed onto a titanium tube and faces just to the workpiece surface so as to get parallel electric lines. Bath solution is pumped via the titanium tube, sprayed to the workpiece inner surface, and flows away from the workpiece inner surface tangentially.

Cathode (the workpiece) is driven by a motor and rotates at very high speed. Laminar flow layer will form near inner surface of the cathode. Powders entering the layer rotate with the cathode together. The closer powders are to the cathode inner surface, the faster they rotate. Powders rotating with cathode receive a centrifugal force pointing to the cathode inner surface vertically, which is the driven force of powders moving towards cathode inner surface.

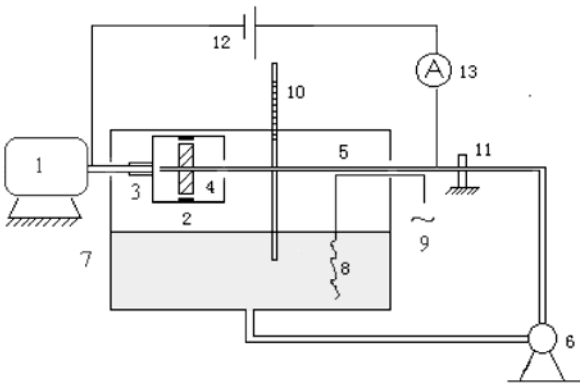

Fig.1. centrifugal high-speed electroplating equipment:
1.Motor 2.Workpiece 3.Canode 4.Anode 5.Titanium tube 6.Pump 7.Bath 8. Heater 9.power

2.2 Bath composition and experiment condition

The composite coating is obtained from the Watts bath. $Ni(OH)_2 \cdot H_2O$ is added to bath solution to compensate the consumed nickel ion and to regulate pH value. Bath composition and plating conditions are as follows:

$NiSO_4 \cdot 7H_2O$:	300g/L
H_3BO_3:	35g/L
$NiCl_2 \cdot 6H_2O$:	25g/L
SiC:	0~2g/L
Temperature :	30°C~60°C
pH:	2.3~3.7
Current density:	10~40A/dm^2

All chemicals used are EP grade.
Average diameter of SiC particle is 3.5μm.

2.3 Coating test method

Eutectoid amount of SiC in deposit (α_V) is determined by the gravimetric method. The composite coatings are first dissolved in 50% nitric acid, then the solution is filtered. The SiC powders left behind are weighed after firing at 600°C.

3. Result and discussion

3.1 The effect of temperature on SiC eutectoid amount

Keeping SiC concentration in bath electrolyte 2g/L, current density 10A/dm^2, pH=3±0.1, cathode rotation speed 2800rpm. Samples are electroplated respectively at 30°C, 40°C, 50°C, 60°C. Relationship between SiC eutectoid amount (α_V) and temperature is shown in Fig.2.

SiC powders are positive in Watts's bath, for they can absorb positive ions H^+ and Ni^{2+}. Thus, in double layer near the cathode, not only centrifugal force, but also electric field force pointing to the cathode surface is loaded on SiC powders. When temperature increases, the capacity of SiC powders' adsorbing positive ion decreases, then electric field force loaded on SiC powders decreases. Thus, the quantity of SiC powder approaching the cathode surface is reduced. As a result, the SiC eutectoid amount is reduced with increasing temperature.

3.2 Effect of pH value on SiC eutectoid amount

Keeping SiC concentration in bath 2g/l, temperature 50±2°C. Samples are electroplated for 30 minutes at different pH value as

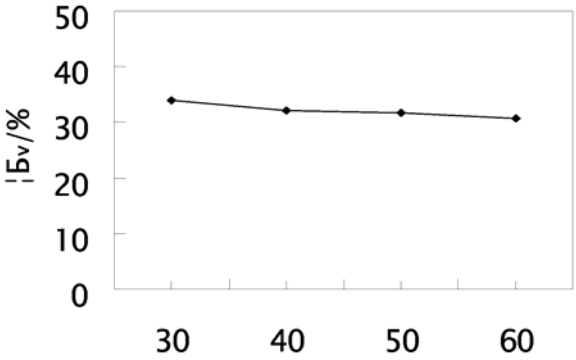

Fig.2. shows that volume fraction of SiC powders in the deposit (α_V) decreases with increasing temperature

3.7,3.1,2.9 and 2.3 respectively. The relationship between SiC eutectoid amount in the deposite (α_V) and pH value is shown in table 1.

Table 1 shows that pH value has little effect on SiC eutectoid amount. The pH value influences SiC powder codeposition process in two aspects: On one hand, increasing of pH value means decreasing of hydrogen ion concentration in electrolyte. Then the hydrogen ion quantity adsorbed onto SiC powder surface decreases. That is, effective charge density on SiC powder surface is decreased. This is unfavorable for the formation of composite coating. On the other hand, with pH value increasing, less hydrogen is produced on cathode during plating process, which is favorable for the formation of composite coating. Experimental results indicate that the two contrary aspects are comparable to each other, so the effect of pH value on SiC eutectoid amount can be neglected.

Table 1

Effect of pH value on SiC eutectoid amount (vol %)

pH value	3.7	3.1	2.9	2.3
SiC eutectoid amount (α_V)	29.8	31.7	31.9	31.8

3.3 Effect of current density on SiC eutectoid amount

Keeping pH value 3±0.1, temperature 50°C ±2°C, cathode rotation speed 2800 rpm. Samples are plated for 30 minutes at different SiC concentration and different current density. Fig.3 shows the relationship between SiC eutectoid amount (α_V) and current density for different SiC powder content in electrolyte.

It seems that α_V increases with increasing current density at the same SiC powder content in electrolyte.

Increase of cathode current density means increase of electric field force loaded on SiC powders, which accelerates the velocity of SiC powders moving to cathode surface. Thus it

becomes easy for SiC powder to concentrate on the cathode surface. At the same time, increase of cathode current density accelerates the deposition rate of nickel, then shortens the “limit time”. “Limit time” is the period from the SiC powders adsorbing on cathode to the SiC powders covered into the matrix completely. Shortening “limit time” increases the quantity of SiC powders covered into matrix in unit time, also the SiC quantity in the deposit.

3.4 Effect of the SiC powders concentration in bath on SiC eutectoid amount

It also can be seen from Fig.3 that under a same current density, the higher the concentration of SiC powder in bath is, the higher the volume fraction of SiC powder in the deposit is.

High concentration of SiC powder in bath means more powders suspended in bath, thus more SiC powders would be transported to cathode surface by mechanic, electric and centrifugal force in unit time, which increases the opportunity of SiC powders covered into matrix.

3.5 Effect of cathode rotation rate on SiC eutectoid amount

Keeping pH value 3±0.1, temperature 50°C ±2°C, current density 20 A/dm^2. Samples are plated for 30 minutes at different SiC powder concentration 1.0g/L, 1.5g/L and 2.0g/L. Relationship between cathode rotation speed and SiC eutectoid amount is given in Table.2.

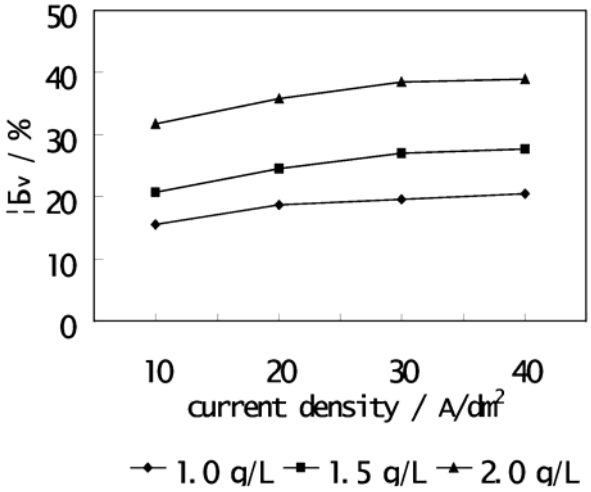

Fig. 3 Effect of current density and SiC content on SiC eutectoid amount

Table 2

Relationship between cathode rotation speed and SiC eutectoid amount

SiC powder concentration in bath (g / L)	SiC eutectoid amount (%vol)	
	1400rpm	2800rpm
1.0	17. 6	18. 7
1.5	24. 8	27. 0
2.0	30. 9	35. 9

Table.2 shows that higher cathode rotation speed means higher SiC eutectoid amount when other conditions are the same.

Electrolyte flow velocity in laminar flow layer near cathode increases with increasing cathode rotation speed. Centrifugal force is directly proportional to square of velocity; thus the centrifugal force loaded on SiC powders at cathode rotation speed 2800rpm is four times as that at 1400rpm. As a result, volume fraction of SiC powders in the deposit increases with the increasing cathode rotation speed.

4. Conclusion

1) In centrifugal force field, the SiC volume fraction in the deposit can be increased remarkably.

2) The factors affecting SiC eutectoid amount are temperature, current density, powders concentration in electrolyte and cathode rotation speed. PH value has little affect on it.

REFERENCE

1. Celis J.P, Roos L.R, Buelens C,Grasaer L. Mechanism of Electrolytic Composite Plating: Survey and Trends. Trans Inst. Metal Finish.1991,69(4):133-139.
2. Stankovic V D,Gojo M. Electrodeposition Composite Coating of Copper with inert, Semiconductive and Conductive Particles. Surface and Coating Technology. 1996, 81(2-3):225-231.
3. Zahavi J. Electrodeposited Nickel Composites Diamond Particles. Plating and Surface Finishing. 1983, 70(2): 57-61.
4. Kenteposidou A, Kiparissudes C, Kotzia F. Nickel/ Microcapsules Composite Electrocoatings: the Synthesis of Water-containing Microcapsules and Preparation of the Coatings. j. Materials science. 1996, 31(5): 175-180.

Dicastal Wheel Manufacture Co. Ltd,
Qinhuangdao, 066004, China

Article is delivered in editing 9.07.2002