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CHARACTERIZATION OF ELECTROLESSLY DEPOSITED NICKEL - PHOSPHORUS - SILICON CARBIDE COMPOSITE COATINGS

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An attempt is made to describe some aspects of incorporation of SiC with the electroless Ni-P coating. Electroless deposited coatings have some advantages over electroplated coatings, in that autocatalytic processes provide a means of applying coatings of uniform thickness to complex shaped articles without the need for an elaborate jigging system. When the electrolessly plated articles are heat treated, materials having good hardness and wear resistance characteristics can be produced. In this present work a suitable bath based on nickel - phosphorus - silicon carbide system has been prepared to study the characteristics of electrolessly composited coating. SEM studies confirm the crystalline structure as well as the incorporation of the SiC particles in the coatings.

Keywords: Electroless plating, composite coatings, characterization of coatings

INTRODUCTION

Electroless nickel is normally used as an engineering coating because of excellent corrosion and wear resistance, as well as other specific properties. Electroless deposited coatings have some advantages over electroplated coatings in that the autocatalytic processes provide means of applying coatings of uniform thickness to complex shaped articles without the need for an elaborate jigging system. In the past ten years, major progress in the field of electroless nickel has been nickel poly alloy deposits and electroless composite coatings being tailored more closely to the customer and environmental requirements. As more and more applications are developed researchers have studied composite electroless deposits such as Ni-P-SiC, Ni-P-WC, Ni-P-MOS_2, Ni-P-BN and Ni-P-TiO_2 in the search for coatings with enhanced physical properties [1-6]. In the earlier paper [8], the developments of Ni-P-SiC composite coatings and the effect of *p*H, temperature on rate of deposition and corrosion resistance of composite deposits have been reported.

In this paper the authors have studied the effect of hardness and wear resistance on the structure of electroless Ni-P-SiC composite coatings.

EXPERIMENTAL

The electroless nickel bath contained 25 gl^{-1} hydrated nickel sulphate, 20 gl^{-1} sodium hypophosphite, 50 gl^{-1} of a complexing agent and was operated at 355 ± 275 K, the solution *p*H being kept in the range of 4.8 to 5.0. The bath was agitated using a mechanical stirrer at a constant speed of 360 rpm.

Coatings were deposited on stainless steel substrate and dissolved in nitric acid for analysis of the silicon carbide and phosphorus content in the deposit. The phosphorus content in the deposits was analysed by UV method using the standard procedure. The silicon carbide in the bath was varied from 0-25 gl^{-1} and the particle size was 25 μm. Micro hardness and wear resistance were tested on brass specimens (100mm x 6.7mm x 100mm). Micro hardness was measured under a load of 50g by Vicker's hardness method.

Wear was determined by measuring the weight loss in 1000 cycles by Taber Abraser using an abrading wheel made of steel containing 1.25 to 1.42% carbon, 0.4% manganese, and 0.35% silicon. The wheel was pressed against electroless coated samples with a load of 1000g. Deposits prepared for hardness and wear measurements had a thickness of 20 to 30 μ m. Microstructure was studied using a scanning electron microscope at a magnification of x 10000.

RESULTS AND DISCUSSIONS

Effect of silicon carbide on the hardness of the deposit

Table I shows the effect of heat treatment on the hardness of deposits obtained from the bath containing different concentrations of silicon carbide particles. It is seen from the table that the hardness of the composite coating increases with silicon carbide content in the bath. Heat treatment of the deposits further enhances the hardness of the composite coating.

There is no appreciable change in the hardness value of the coating in the bath containing more than 10 gl^{-1} of silicon carbide. The higher hardness is caused by the additive effects of the normal precipitation hardening mechanism and the dispersion hardening effect of silicon carbide particle will also be a contributing factor [8-9].

TABLE I: Effect of silicon carbide on hardness of coating

Silicon carbide (gl^{-1})	Hardness (VHN), load 50 g	
	As plated	After heat treatment
0	424	555
1	466	582
5	475	600
10	543	655
15	550	680
25	584	715

TABLE II: Effect of silicon carbide on abrasion resistance of coating

Wheel	Weight applied	Taber wear index (in mg)		
		SiC (gl^{-1})	As plated	After heat treatment
CSIO	1 Kg	0	10	9
		1	10	8
		5	5	4
		10	3	2
		15	3	2
		25	2	1

Effect of silicon carbide content in the bath on the abrasion resistance of the deposit

Table II shows the abrasion resistance of the composite coating with and without heat treatment. It is seen from the table that there is a considerable improvement in wear resistance of the coating upto a concentration of 10 gl^{-1} silicon carbide in the bath.

Further additives of silicon carbide only helps in the inclusion of silicon carbide in the coating and not in the furtherance of the abrasion resistance.

The scanning electron microphotographs of an electroless Ni-P and Ni-P-SiC composite coatings obtained from the bath containing 0, 1 and 10 gl^{-1} of silicon carbide are presented in Figs. 1-3

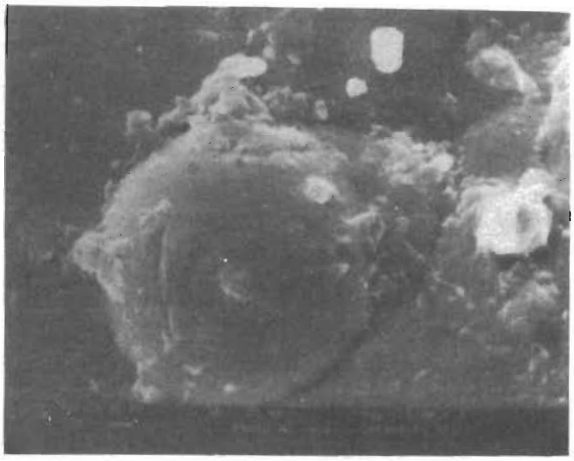

Fig. 1: SEM photomicrograph of Ni-P deposits

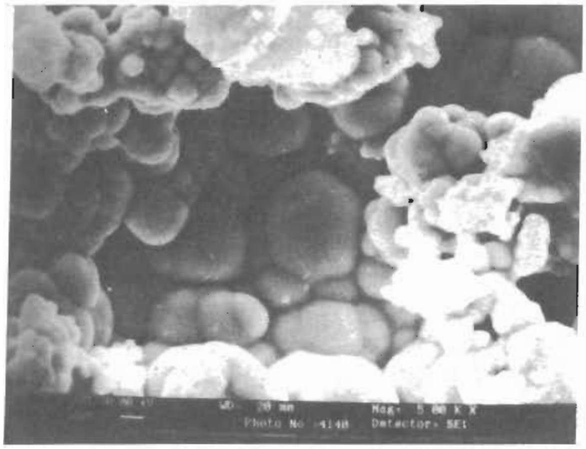

Fig. 2: SEM photomicrograph of Ni-P-SiC (1 gl^{-1}) deposits

taken at a magnification of x 10000. It is clear from Fig. 1 that the presence of relatively bigger spherical particles of nickel with some dispersed small particles of phosphorus is confirmed. Figs. 2 and 3 represent the composite coatings with 1 gl^{-1} and 10 gl^{-1} of SiC respectively. As regards the morphology of the composites, it is seen that smaller and bigger nodules of phosphorus and nickel particles embedded in a spread of cauliflower like SiC particles. Such reports have appeared in the literature about the surface texture of the composites [7]. Increasing additions of silicon carbide in the bath increases the dispersion of silicon carbide in the deposit and reduces the grain size.

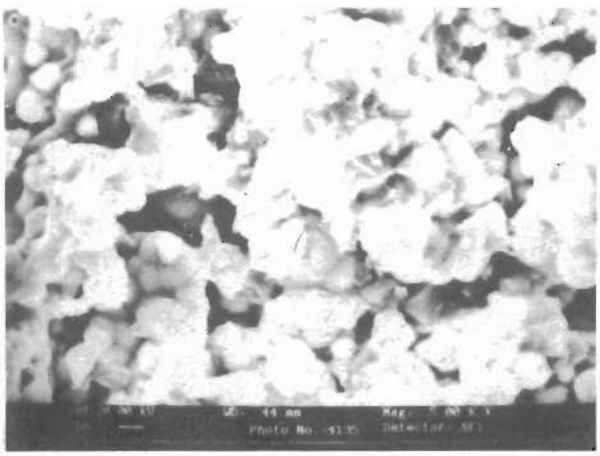

Fig. 3: SEM photomicrograph of Ni-P-SiC (10 gl^{-1}) deposits

TABLE III: Effect of Silicon Carbide in the bath on the percentage of Phosphorus, Nickel and Silicon Carbide in the deposit

SiC in the bath (gl^{-1})	Composition of the deposit		
	% of Nickel	% of Phosphorus	% of Silicon Carbide
0	83.13	16.87	—
1	80.36	6.64	13.00
5	63.23	4.37	32.40
10	61.38	3.92	34.70
15	61.10	3.02	35.00
25	55.00	1.58	43.42

The higher hardness of the composites may be due to these factors. The silicon carbide particles also resist micro cuts. All these factors play an important role in resistance to wear. It is normally found that phosphorus content improves the wear resistance of nickel deposits. Phosphorus when combined with silicon carbide is found to have a telling effect on the wear resistance of the composite of coatings. This is evident from the fact that the wear value of the nickel, 16.87%, phosphorus coating is less than that of the nickel, 3.9% phosphorus, 34.7% silicon carbide coating. Based on the above analysis, the high wear resistance of the nickel, 3.9% phosphorus, 34.7% silicon carbide can be attributed to contributions from the silicon carbide particles.

Generally, the wear resistance of the composite coatings is reported to depend on the presence of both the hard particle and a good matrix [8-10].

Effect of silicon carbide in the bath and its effect on the composition of nickel-phosphorus-silicon carbide coatings

It is seen from the Table III that the addition of silicon carbide in the bath from 0-25 gl^{-1} increases the percentage of silicon carbide in the coating from 0-43% by weight. At the same time, the percentage of phosphorus in the coating decreases with increase in silicon carbide in the bath.

An optimum concentration of 35% by weight of silicon carbide is obtained in the deposits when the bath contained 10 to 15 gl^{-1} of silicon carbide. Further additives beyond 15 gl^{-1} increases the inclusion of composite particles and reduces the percentage of phosphorus considerably [8].

CONCLUSIONS

- The co-deposition of silicon carbide produces significant changes in the structure of electroless nickel - phosphorus alloys, evident from SEM photographs.
- In comparison with nickel - phosphorus coatings, nickel - phosphorus - silicon carbide composite coatings possess greater hardness.
- At an optimum concentration of 10 gl^{-1} of silicon carbide in the bath gives a composition of the deposit with nickel 61.4%, phosphorus 3.9% and silicon carbide is 34.7% by weight.
- The wear resistance of a nickel - phosphorus - silicon carbide deposit is much higher than that of a nickel - phosphorus coating.

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