PULSE FREQUENCY EFFECT ON MICROSTRUCTURE, MORPHOLOGY, MICRO HARDNESS AND WEAR RESISTANCE OF ELECTRODEPOSITED Ni-SiC COMPOSITE COATINGS

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Abstract: This paper describes the work on Ni-SiC composite coatings produced by pulse electrodeposition on copper substrate. XRD analysis was done for the coated layer and confirms the presence of SiC in the coating. It has been found that SiC was engulfing in Ni matrix so that microhardness and wear resistance property improved. SEM (scanning electron microscopy) and EDS(energy dispersive spectroscopy) were done to investigate microstructure, morphology and SiC (vol.%) reinforcement in Ni-SiC metal matrix composite(MMCs) coatings.

Keywords: Pulse electrodeposition, Ni-SiC, composite coatings, microhardness, wear rate.

1. Introduction

Metal matrix composites (MMCs) coatings by electrodeposition technique have been generating significant interest in surface and coatings technology. Electrodeposited nickel is the most widely used coating as it shows good mechanical properties, excellent corrosion resistance, high electrical and thermal conductivity and good magnetic property. Nickel composite coatings are deposited with SiC, Al_2O_3, ZrO_2, TiO_2, La_2O_3, and CeO_2 particles [2]. Electrodeposition of Ni-SiC composite in which matrix made by Ni metal and SiC ceramic reinforced in that matrix having very good mechanical properties used in engineering application like automobiles, electronic, textile, ceramic, paper industries, energy sector etc. These composite coatings not only depend on the concentration, size, distribution and nature of the reinforced particles but also on type of solution used and parameters like current density, temperature, pH value, etc [1,3]. Entrapment of the particulate in composites depends on suspension and parameters like current density, pH, temperature etc gave appreciable effect on hardness and COF [3]. Pulse current can produce deposits with more uniform particle distribution and better surface morphology compared to direct current because it provides T_{off} time to cathodic substrate during which particulate SiC got enough time to well reinforced in between the Ni matrix and enhanced the composites property [3, 4]. In pulse current compare to dc having lower porosity and improved corrosion resistance[1, 2].

Microhardness for pulse current plated samples was higher than the direct current plated sample and internal stress was lower for it [2, 4, 6]. Also pulse electrodeposition method plays a crucial role because it is more efficient in fabrication of metals and alloys due to its independently controllable parameters and higher instantaneous current densities compare to other electrodeposition [4]. The properties of metals and alloys can be controlled and improved by modifying their microstructure when using pulse current. It shifted the polarization curve and greatly affected the composition of alloy deposits [2].Pulse current can produce deposits with more uniform particle distribution and better surface morphology compared to direct current. In pulse current compare to dc having lower porosity and improved corrosion resistance [1, 2]. Microhardness for pulse current plated samples was higher than the direct current plated sample and internal stress was lower for it [2,4].Also pulse electrodeposition method play a crucial role because it is more efficient in fabrication of metals and alloys due to its independently controllable parameters and higher instantaneous current densities compare to other electrodeposition [4]. The properties of metals and alloys can be controlled and improved by modifying their microstructure when using pulse current.

SiC particulate role was crucial in this deposition so can't ignore physical ... ies of the solute. Purpose of this experiment was to electrodeposits Ni-SiC composite by pulse current method at various frequency between (10-100) Hz and investigate SiC content, microstructure, morphology, grain size, wear rate and microhardness of composite coatings at different frequency.

2. Experimental

Basic bath composition consisted of $NiSO_4.6H_2O$ 300g/l, $NiCl_2.6H_2O$ 35g/l, H_3BO_3 40g/l, SiC 20g/l, Temperature 50^0c, pH 4.0, Current density 0.05A/cm^2, Pulse duty cycle 50% and Pulse frequency (10-100)Hz.

The plating electrolyte was Watts type bath and SiC powder having particle size 400 mesh (37μm or .0015 inch-) w... deposition with nickel. Before the deposition electrolyte solution were stirred for 12 h and then subjected to ultrasonic vibration for 15 ... single side surface area was used as cathode and other surface are blocked with the help of PVC adhesive tape. Here pure Ni plate used as anode. Before electrodeposition the substrate were mechanically polished with emery paper E1/0 and cleaned by acetone before going for electodeposite. During the co-deposition process, the bath was slowly stirred by a magnetic stirrer in order to keep the particles dispersed and prevent sedimentation in the electrolyte suspension and with the help of temperature bath electrolyte maintained constant temp. After depositing for 3h, the composite coating was washed in running water and it was cleaned ultrasonically in distilled water for 10 min. and specimen was cleaned by acetone again so that loose particles was removed and it was ready for microstructure and mechanical properties measurement. Three identical Cu substrate (1.4x1.4cm^2) were taken and electrodeposited separately at 10Hz, 50Hz and 100Hz frequency in front of Ni anode.

3. Results and discussion

3.1 Characterization of Ni-SiC coatings

With the help of XRD data compare the peaks of SiC powder and coating surface. Coating peaks match with the peak of SiC confirms presence of SiC reinforcement in Ni matrix composites.

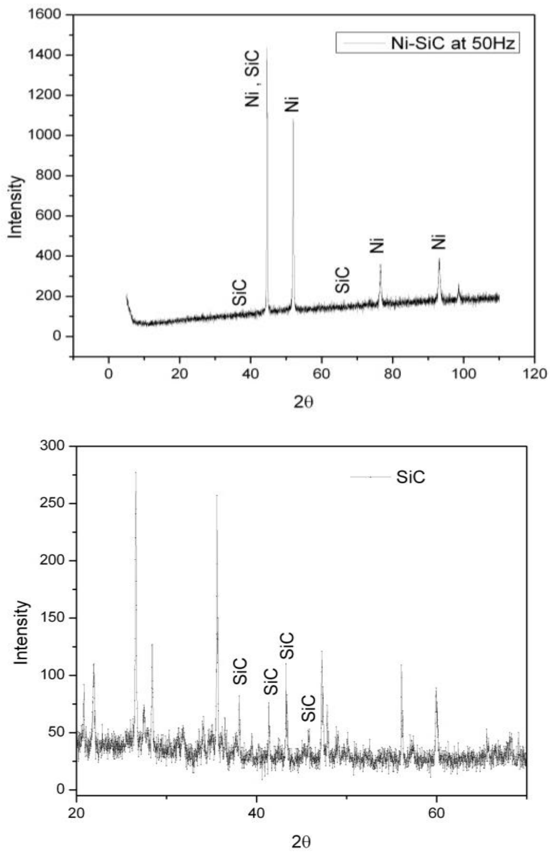

Fig. 1 (a). XRD of Ni-SiC composite coatings at 50Hz 1(b). XRD Of SiC powder.

3.2 Microstructure and morphological change due to frequency

Compare to direct current in pulse current electrodeposition method Ni crystallites were small in grain size because SiC engulfed in the nickel matrix so Ni sustained compressive force and hence its grain size decreased from the normal one and Ni grain structure changes from columnar to equiaxial. Ni deposited by pc method gave cauliflower structure formed by microcrystalline summation but on the other hand dc method give well arranged comparably bigger grain size crystallites.Presence of SiC in the Ni matrix in engulf form modify the microstructural defect which enhanced the mechanical properties of coatings.

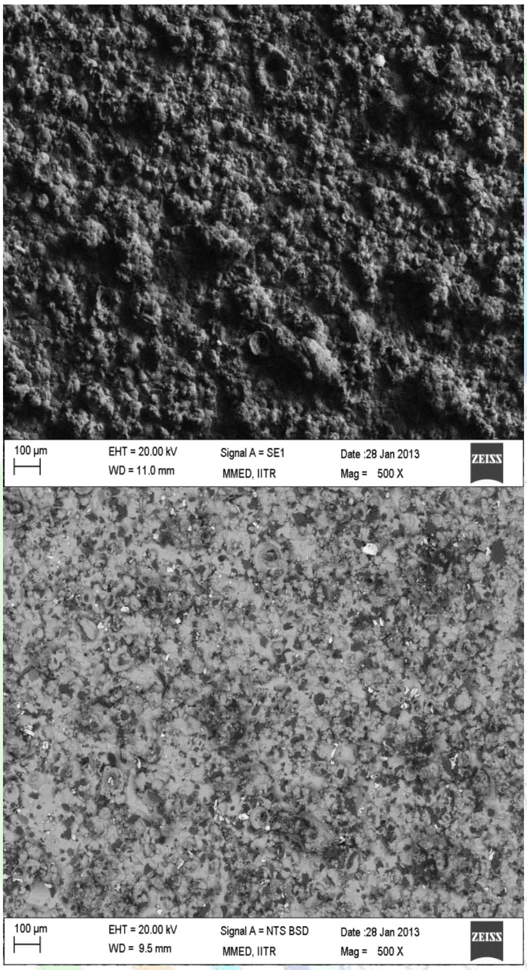

Fig. 2 SEM image of unworn surface (a) at 10Hz (b) at 50Hz.

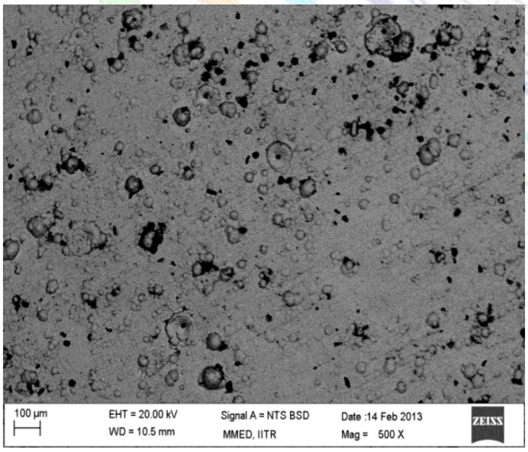

Fig. 2 (c) SEM image of unworn surface at 100Hz.

3.3 Hardness

Vickers microhardness (HV) values at low frequency at constant duty cycle is more as compare to higher pulse frequency deposition. At 50% duty cycle electrodeposition were done at different frequency shown variation in micro hardness.

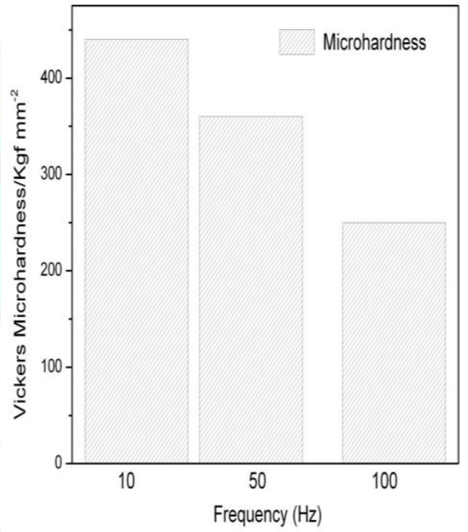

Fig. 3. Microhardness variation with respect to frequency.

3.4 Wear resistance

Wear test (ball on disk) were perform on tribometer (TR-201E-M2 Ducom, Bangaluru, India) at temp. 15 -18^{0}c and relative humidity 55-65% under dry condition having constant track dia. 6mm, load 1N, sliding speed 55mm/sec and steel ball dia. 3mm use as a counter body against the coating surface.Wear rate measured in terms of volumetric losses which can measured with the help of profilometer (T800 Mitutoya Japan)

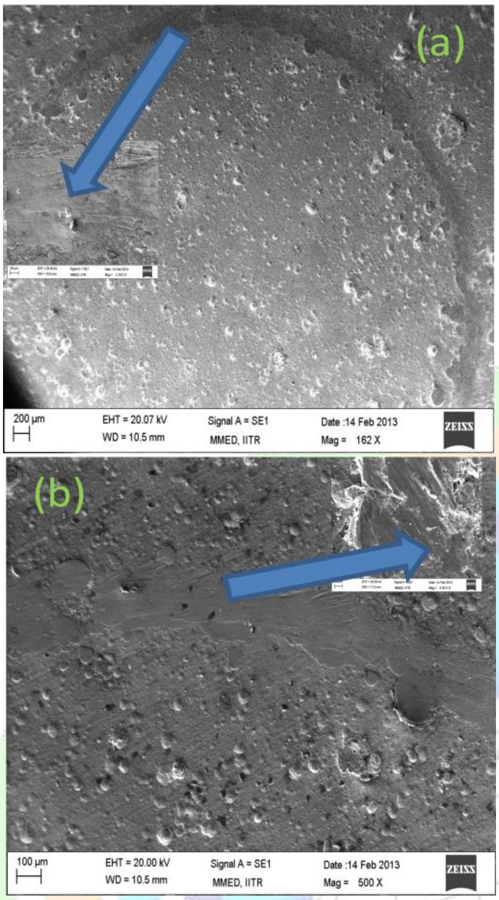

Fig. 4 SEM image of worn surface of (a) Ni-SiC at 100Hz (b) Ni-SiC at 50Hz.In inset same image at higher magnification

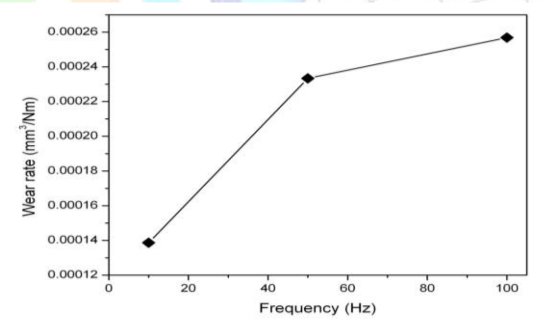

Fig. 4(c) Wear rate variation with respect to frequency.

4. Conclusions

After performing XRD, SEM, Vickers Microhardness test andsliding wear test on Ni-SiC deposites on Copper substrate at varying frequency following pertinent conclusions were drawn:

I. XRD confirms reinforcement of SiC particulate in Ni matrix.
II. SEM image shown variation in microstructure and by EDSwe get SiC (vol. %) at different frequency.
III. Low frequency electrodeposited MMCs coatings having high microhardness compare to high frequency pulse electrodeposition at constant duty cycle.
IV. Low frequency electrodeposited MMCs have low wear rate compare to higher one at same duty cycle.

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