The Effect Of Electroplating A Ni-Sic Alloy On The Hardness Of A Copper Sample

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Abstract:

Used electroplating to deposit Ni-SiC on a sheet of brass and studied the impact of current density on the particles deposited on the surface of the brass. The deposited layer was studied using X-ray diffraction thin film Vickers micro hardness, and SEM was used to examine the deposit surfaces.

It was discovered that the composite electrolyte's cathodic polarization potential increased more than the brass substrates. Furthermore, the microhardness of the Ni–SiC matrix was improved by the uniform dispersion of co-deposited SiC nanoparticles.

Keywords: electroplating, brass, SEM, X-ray, Composite coatings

1. Introduction

It is appropriate to describe electroplating as the technique by which a (typically) thin layer (of metal) is deposited electrolytically upon a substrate.

Generally speaking, its goal is to change a surface's properties to offer:

- Better appearance (decorative finishing).
- Resistance to abrasion and corrosive conditions.
- -Modify the surface properties, such as solder ability, Increased hardness, reflectivity…. etc. It is also possible that electroplating may provide a combination of these properties.

The desired mechanical qualities in the deposits are the main determinant of the bath mixture. Engineering has turned to electrodeposition to solve fabrication or salvage problems because the mechanical properties of electrodeposited metals can often be varied over more comprehensive limits than those of the same metals by conventional means [1].

1.1 Composite coatings

Composite materials are becoming a necessary class of novel materials. To build new composite materials that meet a variety of applications, many materials with different properties can be combined.[2] Fine inert particles from an electrolytic or electroless bath are co-deposited into a metal matrix to create composite coatings. More emphasis is being paid to this procedure because of its ability to produce films with better mechanical properties, such as lubrication, wear resistance, and corrosion resistance. The form of the inert particles within the composite covering determines these properties. Metal matrix nano-composite coatings are also interesting

materials for micro-devices because of their distinct magnetic, mechanical, and optical capabilities. Studies pertaining to their nano-metric nature may benefit from the deposition of nano-composite materials. Research on the electrodeposition-based creation of composite coatings has increased significantly in the past several years, mostly concentrating on coatings produced by direct current (DC) or pulse current (PC) electrodeposition methods.[3] Currently available electrodeposited composite coatings, such as Ni–SiC or Cu–SiC coatings, are typically composed of copper or nickel. Compared to pure nickel or copper, these coatings have a superior wear resistance. Electroless plating yields another type of composite coatings, such as Ni-P-SiC or Ni-B-SiC coatings. These coatings can be heat-treated appropriately to increase their hardness to 1100–1200 Hv and to increase their wear resistance. But they also have low wear resistance because the covering is typically just 50–70 μm thick. These coatings can have their hardness and wear resistance increased to 1100–1200 Hv with the right heat treatment. Nevertheless, their wear resistance is likewise restricted, and their coating thickness is often only between 50 and 70 μm. [4]

2 -Experimental work
2.1 Introduction
This chapter deals with the experimental work carried out in this study. The experimental work includes the surface pretreatment of the Cu-alloy specimen used as a substrate for the electroplating bath. The condition of the electroplating bath on the Cu-alloy specimen will be given.

2.2 Substrate Materials
A brass specimen with dimensions 3.0 x 3.0 x 0.6 cm was used as substrate. A commercial brass specimen was used.

2.3 Chemicals
Every chemical was of the analytical variety:
- Sulfuric acid (NiSO4), obtained from PROLABO-France.
- sodium citrate (Na), a GDR Germany product.
- SiC powder from 600 mesh (22 μm). [5]

2.4 Preparation of the specimen
The specimen was prepared as follows:
- Solvent degreasing in ethanol (C2H5OH) 95% for 60 seconds.
- Rinsed in distilled water.
- Pickling in 10% HCl for 30 sec.
- Rinsed in distilled water.
- Anodically polarized in H3PO4 concentration for 2 min. At 4 V for electropolishing.
- Rinsed in distilled water [6]

2.5 Cell construction
The cell used in electroplating consisted of brass substrate to be pure nickel plate served as the anode and was plated as the cathode. The cell was connected to a DC power supply (MUNK-PSP-VARI-PULS, USA) between the anode and cathode. The current density was measured using a digital ammeter.

2.6 Bath for Electroplating
Nickel sulphate, which functioned as the Ni source, and sodium citrate were added to the plating bath to prevent the anode from passivating. Bath composition and factors are shown in table (1).

Table 1 explains the characteristics and content of the bath.

Chemicals	Composition (g/l)
Nickel sulfate	30
Sodium citrate	84
Ammonium chloride	10
SiC	10
Variables	
Temp.	50 – 53 Cº
Current density	2-6 A/dm^2
pH	8.5
Plating time (min)	15, 30, 45, 60, 75, 90
Stirring speed (rpm)	250 - 300

High-purity nickel with an adequate 100 X 50 X 10 mm area served as the anode. SiC powder with a size of 22 µm was combined with the plating bath. It was anticipated that the agitation would evenly distribute SiC particles throughout the electroplating bath to improve the electroplating composite's particle content and dispersion.[7]

2.7 Surface investigation
2.7.1 Coating thickness
Using an optical microscope, the coated layer was measured, and a cross-section of the plated specimen was used to measure the obtained coating thickness. (neophot 21, Germany). [8]

2.7.2 Surface morphology

Utilized was a scanning electron microscope (SEM). to determine the microstructure of the deposited Ni-SiC by analyzing the coated layer's surface morphology and crystal structure.[9]

Fig 1: SEM, Jeol-5410, Japan

2.7.3 Composition and structure of coated sample
Using X-ray diffraction, the Ni-SiC coating was examined (XRD). Each lattice phase has a distinct X-ray radiation diffractive index, and each phase's measured interatomic distances are described. XRD was used to keep an eye on the different samples' phase changes and surface structures. Using a Selected sample of each group were recorded using an X-ray diffractometer equipped with a nickel filter and copper target. XRD data were based on Bragg's equation. $\lambda n = 2 d \sin \theta$ Where: n = integral number λ = wave length θ =diffraction angle.[10]

Figure 2: Panalytical, Germany, XRD, XPert PRO

2.8 Hardness Measurements
The deposit underwent a Vickers microhardness test, with a 50g stress applied for 15 seconds. The diamond's depression is shaped diagonally. A hardness tester automatically determined the microhardness value in HV0.05. The length of the diagonal is calculated by averaging its two diameters. [11]

Figure 3: Hardness testing machine, HWDM-7, Japan

3.1 Surface morphology

Fig.4. The illustration shows that irregular polyhedral crystals have been observed in the pure nickel deposit. Bright spherical particles are the visible form of the SiC agglomerates. The morphological transformation can be associated with the shift from randomly oriented composite deposits to preferred orientation composite deposits. Using EDX analysis, it was possible to see that SiC was distributed uniformly throughout the composite.
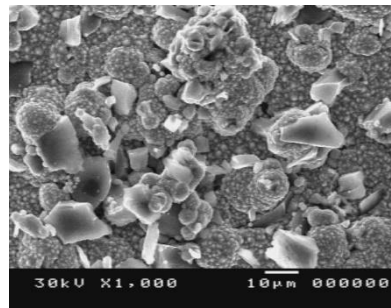
Figure 4. a: The Ni-SiC composite's surface morphology at current density 2A/dm^2

The appearance of the Ni-SiC coatings is a homogeneous fine globular structure, with approximately 38% of the SiC particles discernible as white spots.
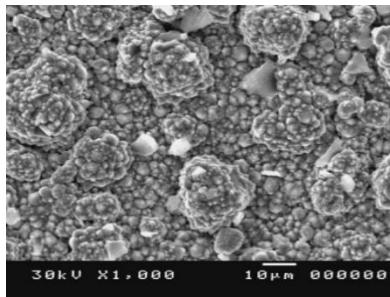

Figure 4. b: The Ni-SiC composite's surface morphology at current density 3A/dm^2

The Ni-SiC coatings have a homogenous fine globular structure, and around 36% of the SiC particles are visible as white dots.
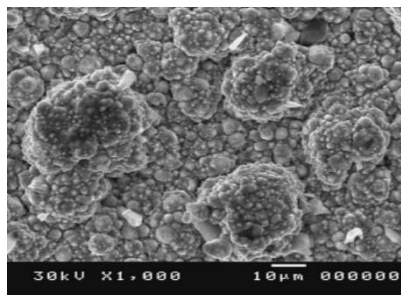

Figure 4. c: The Ni-SiC composite's surface morphology at current density 4A/dm^2

The morphology of the Ni-SiC coatings shows white patches, which correspond to approximately 32% of the SiC particles present in the uniform fine globular structure.
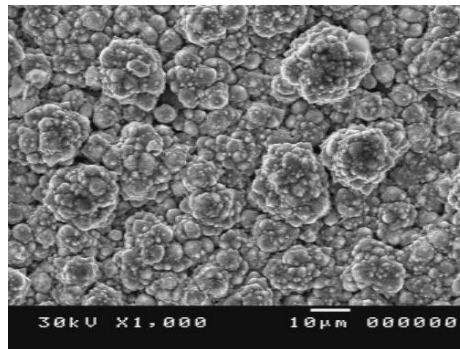

Figure 4. d: The Ni-SiC composite's surface morphology at current density 5A/dm^2

The morphology of the Ni-SiC coatings shows white spots, which correspond to approximately 28% of the SiC particles, which are seen in a uniform fine globular structure.

3.2 Composition of the coated film

X-ray diffraction analysis (XRD), as shown in Fig. 6, was used to determine the coated film's composition. SiC particles were indeed present in the nickel matrix, as indicated by the XRD signals.
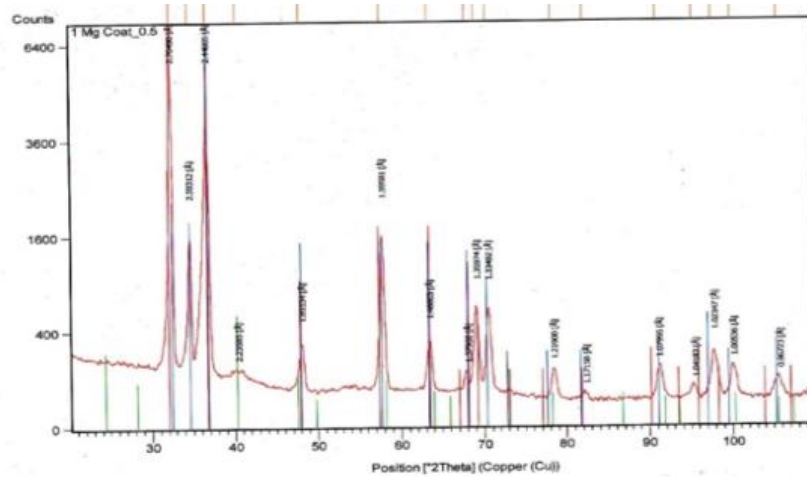

Figure 5. a: Ni/SiC deposit X-ray diffraction patterns produced at (2 A/dm2).
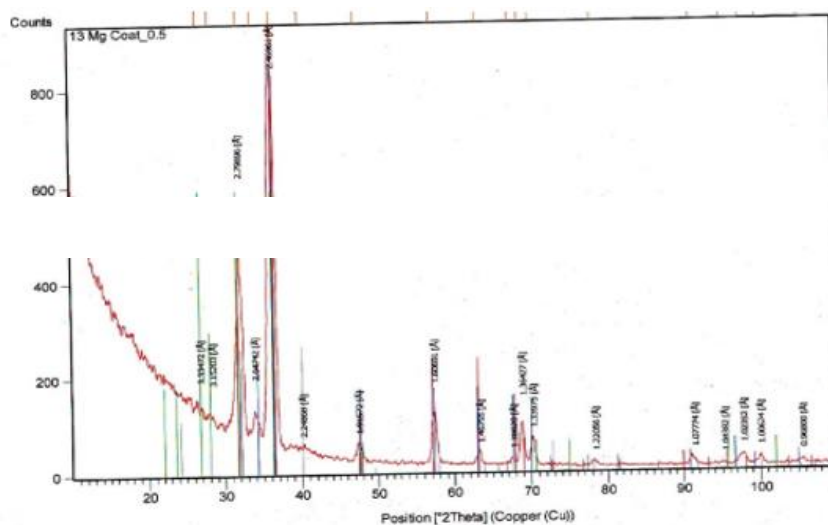

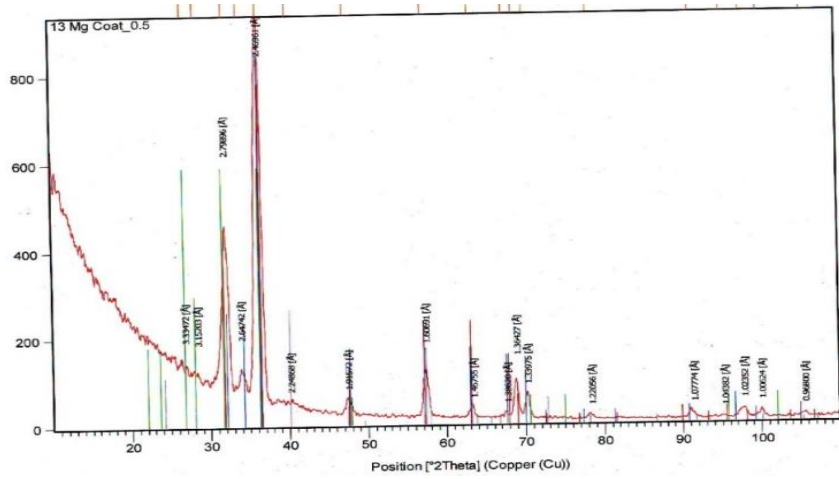**Figure 5.b:** Ni/SiC deposit X-ray diffraction patterns produced at (3 A/dm^2).

Figure 5.c: Ni/SiC deposit X-ray diffraction graphs created at (4 A/dm^2).
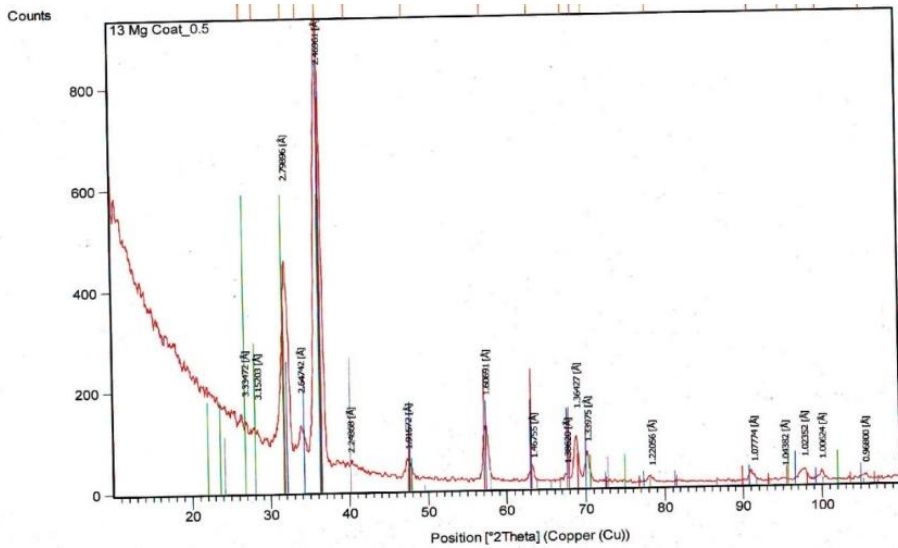

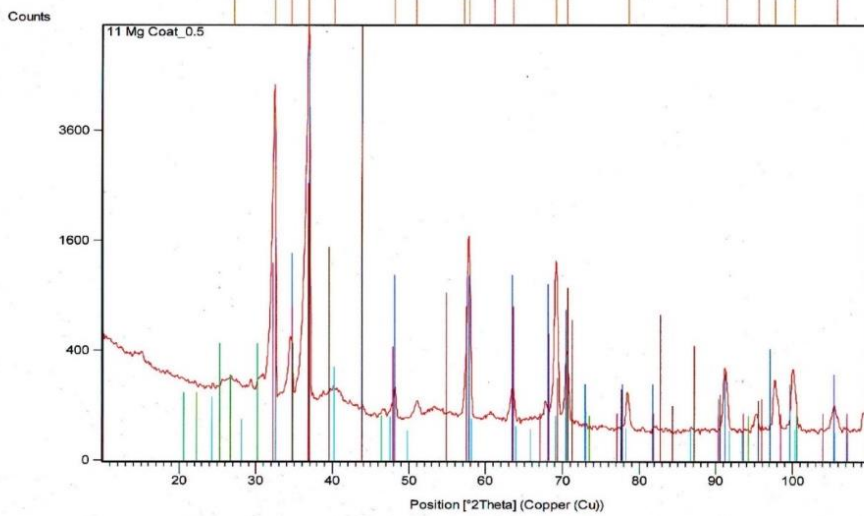**Figure 5.d:** Ni/SiC deposit X-ray diffraction graphs created at (5 A/dm^2).

Figure 5. e: Ni/SiC deposit X-ray diffraction patterns produced at (6A/dm^2).

3.3 Hardness Measurements

Figure 6 illustrates how the coated materials' microhardness varies with current density. The bath's pH was kept at 8.5, its temperature was kept at 50 °C, and its current density increased from 2 to 7 A/dm2 for 45 minutes. The surface underwent the microhardness test, with an average of five measurements representing the surface. The surface hardness of the brass has grown from 130 HV (brass substrate) to 490 HV after Ni-SiC coating. According to Fig., surface harness at current density equals 4 A/dm^2, while surface hardness at current density equals 2 A/dm^2. As current density increased, the surface harness dropped. Fig.7. It is clear that the coatings' micro-hardness has decreased as the current density has increased for a fixed SiC concentration.

The decrease in SiC content in the coating may be connected to this. In the EDX research, the SiC content decreased from 42 per cent to 27 per cent with an increase in current density from 1.0 to 7.0 A/dm^2. Particle entrapment by chance can be associated with the quantity of particles co-deposited. It takes longer to get the required coating thickness at a low current density (1.0 A/dm2) than it does at a high current density (7.0 A/dm2). Consequently, a harder composite covering has resulted from a higher chance of particle entrapment at lower current densities.
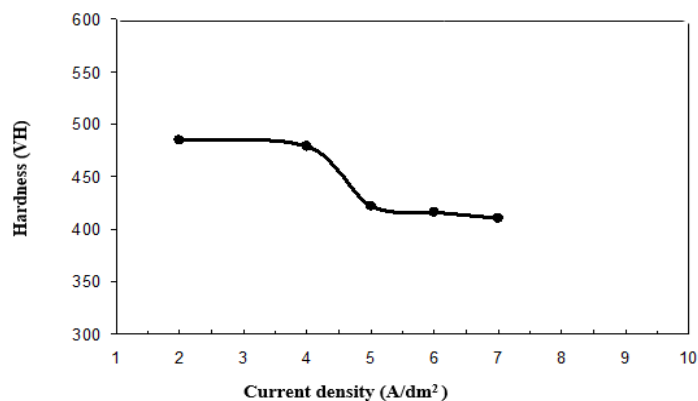

Figure 6: Current density's effect on the microhardness of the Ni–SiC composite coating.

3.4 Heat treatment's impact on hardness

Applications involving high temperatures frequently use nickel matrix composites enhanced with SiC particles. In certain applications, the interface interaction between SiC and the surrounding matrix is very important, especially for the composite's mechanical characteristics and regulated structural stability. The parameters of the bah were maintained at 50 °C, pH 8.5, 45 minutes, and 4 A/dm^2.Using a muffle furnace; the samples were heated for 20 minutes at 200, 300, 400, and 500 degrees Celsius. The entire pressure within the chamber was kept below 4×10^{-5} Mbar during the heating procedure. Following the samples' cooling period, Fig. 7 illustrates the correlation between the heat treatment temperature and the hardness of the composite covering. The micro-hardness of the coatings remains constant at a given SiC concentration due to heat treatment. Showed that the heat treatment did not affect the morphology or microstructure of these coatings.
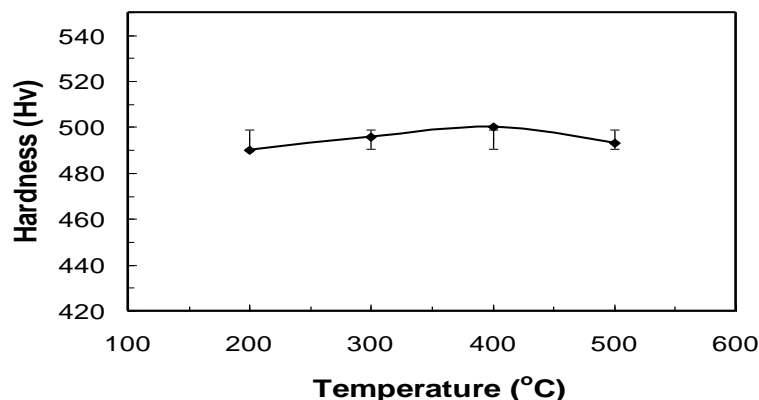

Figure 7: The correlation between the temperature of heat treatment and the composite coating's hardness.
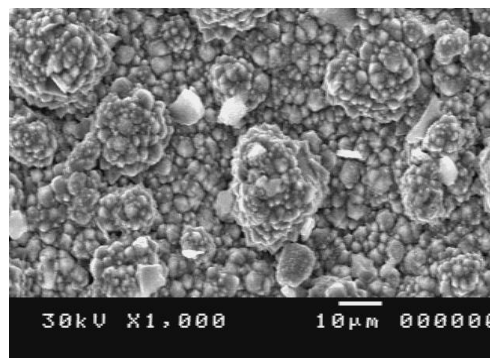
Figure 8: SiC particle distribution in as-plated composite Ni–SiC coatings that were applied following 20-minute heat treatment at 500 °C.

4. Conclusions

1. Ni-SiC composite coating is one of the techniques used as a surface protective layer with good mechanical properties
2. A Ni/SiC gradient deposit of up to 42 weight per cent can be generated with a consistent distribution of SiC content. The gradient deposit's XRD patterns show that the SiC and Ni particle diffraction peaks form independently at their respective angles. The SiC diffraction peak intensities rise with the deposit's SiC content.
3. As deposited, the Ni-SiC composite coating has a 410–480 Hv hardness
4. Ni/ SiC composite coating on the brass substrate is more wear-resistant than Ni plating.

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