EFFECT OF BATH TEMPERATURE ON PROPERTIES OF ELECTRODEPOSITED NICKEL-COBALT ALLOY THIN FILMS

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ABSTRACT

Electrodeposition in different bath temperatures was used to prepare nanostructured thin films of NiCo. Films deposited with NiCo have a texture that favors the FCC process. The structural properties of thin films observed experimentally for different temperatures were compared. The addition of cobalt (Co) to nickal thin films will improve their structural and mechanical properties. Electrodeposited NiCo films were prepared at various temperatures (30, 50, 70, and 90 degrees Celsius) and morphological, structural, and mechanical characterization were performed on them. At 90°C, the nickel concentration reached its peak of 71.93 wt%. As the temperature of the electrolytic bath was raised, the nickel content rose. NiCo films were bright and evenly coated. NiCo film deposits were also nanoscale, with an average crystalline size of about 71 nm. High saturation magnetization and low coercivity were observed in thin films prepared at high temperatures. At 30°C, NiCo had a micro hardness of 268 VHN.

***Keywords**: **SEM, Electrolytic bath, Crystalline size, VHN, Ni-Co, X-ray diffraction, VHN**.*

1. INTRODUCTION

NiCo electrodeposits are a good substitute for traditional Ni electrodeposits because of their higher resilience, strength, and wear resistance. These enhanced properties result from cobalt's position in microstructure refinement, which reduces the need for organic grain refiners[1-4]. Soft magnetic thin films made of NiCo alloy films are well-known as a soft magnetic material [5-7]. Since NiCo films have a low resistivity, eddy current loss occurs when they are used in microwave applications. Because of their low coercivity and strong saturation magnetization, Ni–Fe, Ni–Co, and Co–Fe alloys have been widely used. Since the magnetic properties of Ni–Co alloys are primarily influenced by their crystal structure, a thorough investigation of this engineering substance is essential for its application areas [8-12]. In recent

years, scientists have conducted numerous experiments on the effects of various deposition parameters on magnetic properties of Ni–Co films. Nickel and its alloys have many benefits, including excellent wear and corrosion resistance [13-17]. Electrodeposition is a surface structure alteration procedure that uses an electrochemical mechanism. In the MEMS, NEMS, communication, optical, and sensor industries, the electrodeposition approach is commonly used. In MEMS and NEMS, the most widely used magnetic thin film compounds are NiCo, NiCoW, and NiW. To obtain enhanced soft magnetic characters, unique optical properties, and increased corrosion resistance, NiCo thin film electroplating is used [18-20].

2. EXPERIMENTAL PART

Temperatures of 30, 50, 70, and 90 o C were used to prepare electroplated NiCo alloy films. The deposition process took 15 minutes to complete. Copper and stainless steel substrates with dimensions of 1.5 cm x 7.5 cm were used as cathode and anode in this study [21-23]. Cobalt sulphate (15 g/l), Nickel sulphate (30 g/l), Ammonium sulphate (40 g/l), Boric acid (10 g/l), and Saccharin (10 g/l) were used to make NiCo thin films [20-21]. By adding ammonia solution, the pH of the electrolytic solution was set to 6.0, and the electroplating procedure was carried out with a current density of 3 mA/cm2. After 15 minutes, the copper or cathode was gently removed from the bath and dried for a few minutes [24-25]. Scanning Electron Microscope was used to describe the surface nature of NiCo films. Energy-dispersive X-ray spectroscopy was used to look at the atomic composition of film deposits, and X-ray diffraction was used to look at the crystal structure of the deposits. Vickers Hardness Test was used to determine the micro hardness of the films.

3. RESULTS AND DISCUSSION

3.1 COMPOSITION OF NiCo FILMS

The elemental composition of deposits is determined using an energy-dispersive X-ray analyser (EDAX). EDAX study reveals the weight percentage of Co and Ni at various electrolytic bath temperatures in Table 1. According to the findings, films prepared at 90°C have a high nickel content. At an electrolytic temperature of 30°C, the maximum cobalt content of 42.73wt% was found. The content of cobalt decreases as the electrolytic temperature rises.

Table 1: EDAX analysis of thin films

S. No	Temperature	Nickel Wt%	Cobalt Wt%
1.	30˚C	57.27	42.73
2	50˚C	61.05	38.95
3	70˚C	66.32	33.68
4	90˚C	71.93	28.07

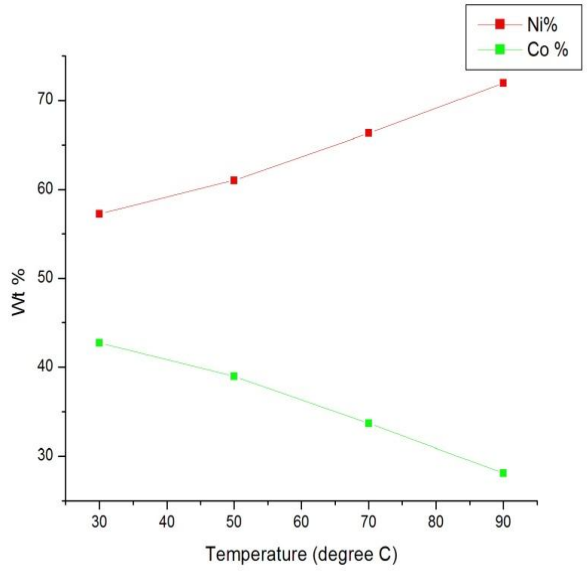
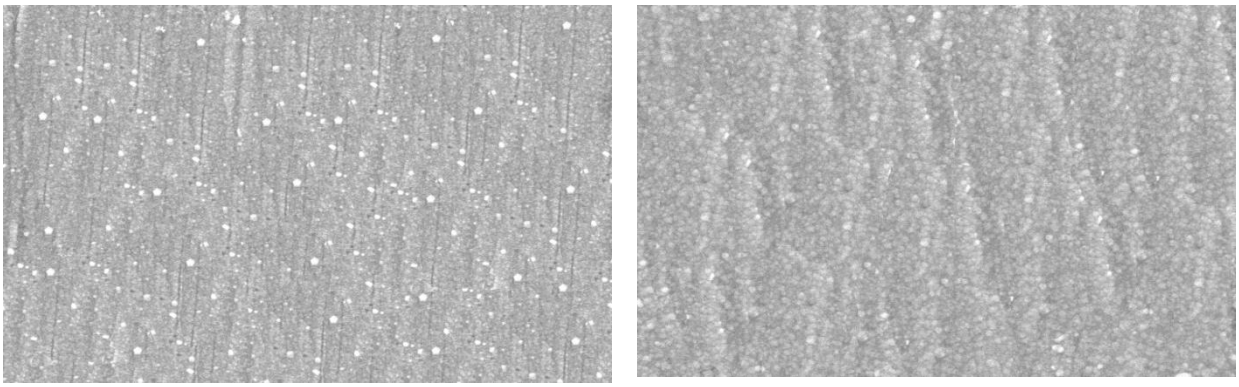


Figure 1. Variation of Weight percentage with different electrolytic bath temperature

3.2 MORPHOLOGICAL STUDY OF NiCo FILMS

Scanning Electron Microscope (SEM) images of the surface structure of NiCo thin films at temperatures of 30, 50, 70, and 90 o C were analyzed, and the results are shown in Fig 2. On the result, the thin films are bright and uniformly coated. They appear to be crack-free.



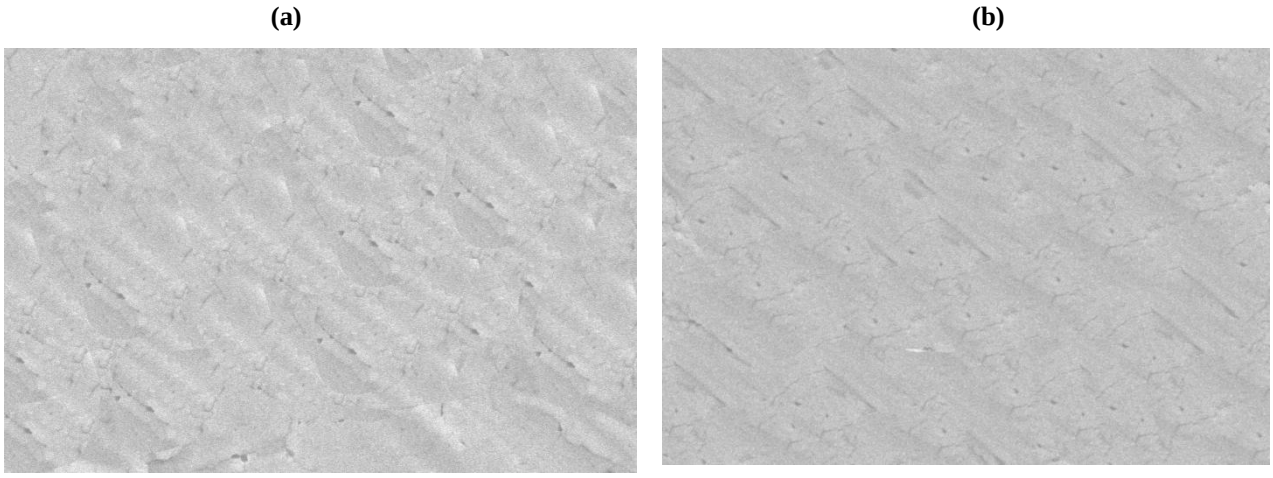


Figure2.NiCo films –SEM imagesat (a) 30˚C (b) 50˚C (c) 70˚C (d) 90˚C

3.3 STRUCTURAL ANALYSISOF NiCo FILMS

Powder X-ray diffraction was used to examine the crystal structure of NiCo alloy films (XRD). Diffraction patterns of NiCo films prepared at various temperatures are seen in Fig 2. The presence of sharp peaks in the X-ray diffraction pattern indicates that the deposits are crystalline. The XRD patterns of all samples deposited at 30, 50, 70, and 90 ˚C shows (111), (200), and (211) peaks. In addition, the XRD results show the presence of an FCC form crystal. NiCo deposits have particle sizes of 89.65 nm, 79.54 nm, 66.34 nm, and 49.05 nm for bath temperatures of 30, 50, 70, and 90 ˚C, respectively. As a result, increasing the electrolytic temperature reduces the crystal size of thin film deposits. Also deposits ofthin films reveals nano scale andaverage crystalline size is around 71 nm.

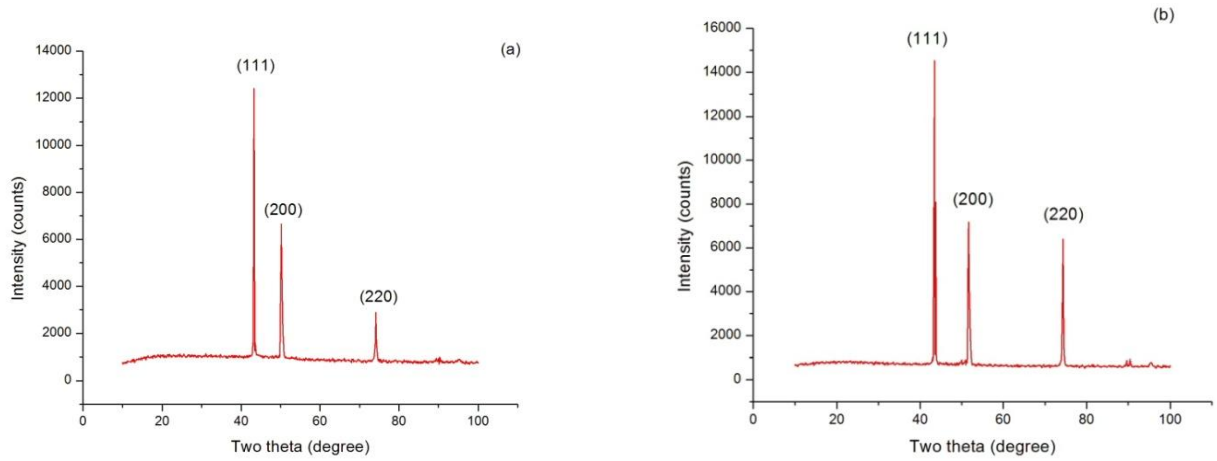


Figure.3NiCo films-XRD patterns at (a) 30^0C (b) 50^0C (c) 70^0C (d) 90^0C

Table 2 shows the crystal dimension of NiCo alloy films. If the bath temperature rises, the crystalline size of the deposits reduces owing to the start of crystal orientation. Figure 4 illustrates how crystal size decreases as bath temperature rises.

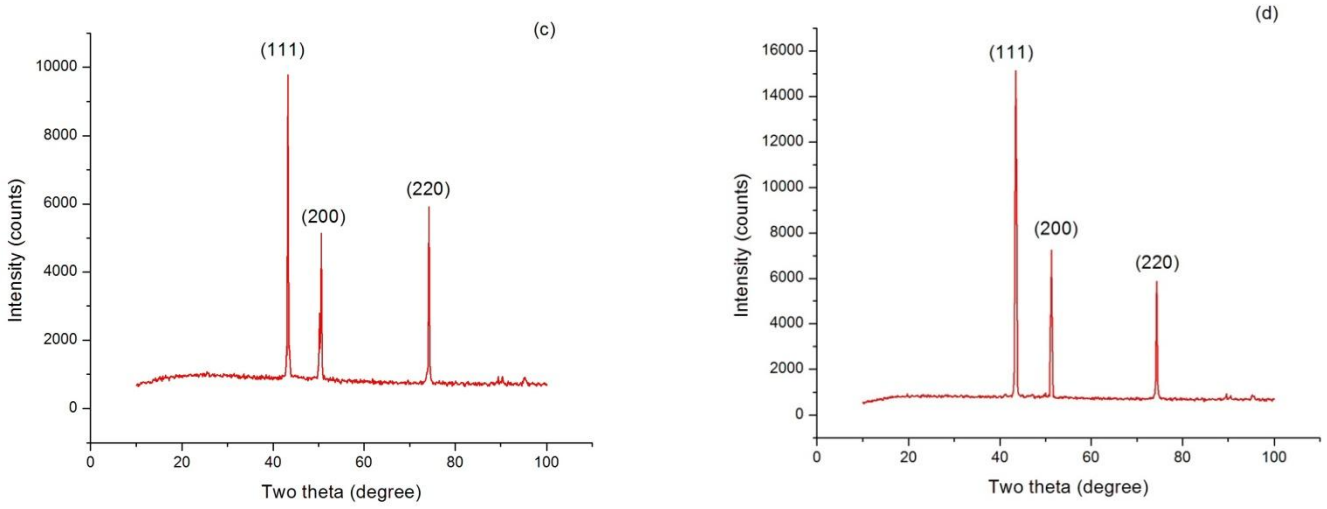


Table.2: Structural characteristics of NiCoalloythin films

S.No	Bath Temperature (˚C)	2θ (deg)	d (A^0)	Particle Size(D) (nm)
1	30	43.94	1.6832	89.65
2	50	42.67	1.4056	79.54
3	70	41.84	1.5734	66.34
4	90	45.11	1.5934	49.05

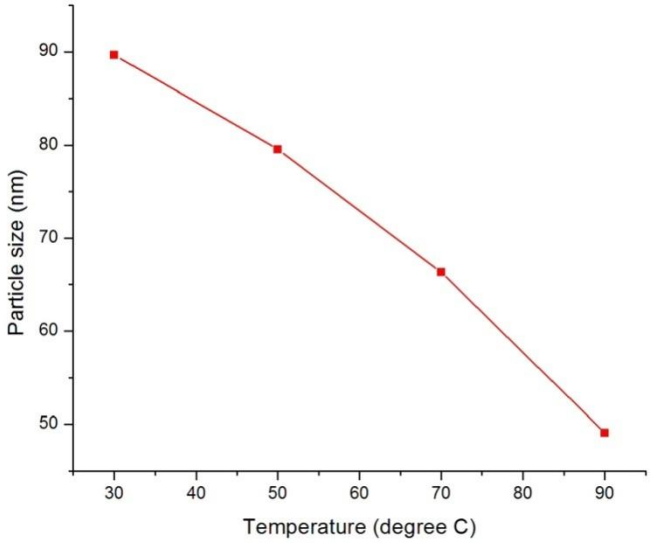


Figure 4. Variation of crystal size with different electrolytic bath temperature

3.4 MECHANICAL PROPERTIESOF NiCo FILMS

Vickers hardness tester was used to measure the micro hardness of the deposits. Thin films prepared at temperatures of 30, 50, 70, and 90oC have hardness values of 268,192, 124, and 79 VHN, respectively. As a result of the lower tension associated with thin films, the micro stiffness reduces as the electrolytic bath temperature rises. Figure 5 illustrates how hardness changes as bath temperature rises.

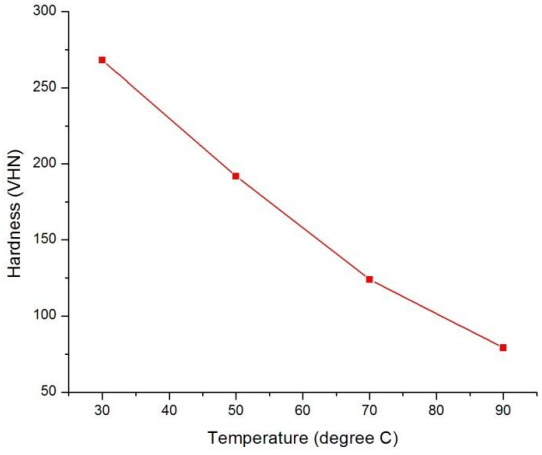


Figure 5. Variation of micro hardness with different electrolytic bath temperature

4. CONCLUSION

The NiCoalloy thin films were prepared by electrodeposition at varying temperatures while maintaining a current density of 3 mA/cm2 and a pH of 6.0 in the solutions. On the result, the thin films are bright and uniformly coated. The XRD results show that an FCC form crystal exists. If the bath temperature rises, the crystalline size of the deposits shrinks due to online crystal orientation. Due to the lower stress associated with thin films, the hardness reduces as the bath temperature rises. The particle size decreases from 89.65 nm to 49.05 nm as the bath temperature rises from 30 to 90 degrees Celsius.This is due to the deposits of nano crystalline composition. As nickel is electroplated with cobalt (Co), the mechanical and structural properties improve, and the alloy films can be used in NEMS, MEMS, and memory units.

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