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ANNEALING EFFECT ON CHARACTERISTICS OF NICKEL-FERROUS ALLOY THIN FILMS

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ABSTRACT

Ni-Fe alloy thin films were created via electroplating at ambient temperature. After that, the Ni-Fe thin films were electroplated and annealed at 200 degrees Celsius. In the FCC phase, the microstructure of Ni-Fe deposited films is orientated. They were characterised morphologically, structurally, and mechanically. Ni-Fe films were bright and uniformly covered on the surface. The deposition of Ni-Fe films was also nanoscale, with an average crystalline size of 92 nm. Ni-Fe has a micro hardness of 138 VHN after annealing.
Keywords: Electroplating, electrolytic bath, crystalline size, VSM, Ni-P, X-ray diffraction, VHN, SEM.

1. INTRODUCTION

Because NiFe films have a low resistivity, they suffer from eddy current loss when utilised in microwave applications. Soft magnetic thin films consisting of NiFe alloy films, which are well-known as a soft magnetic material[1-4], make up the material. NiFe electrodeposits are a good substitute for traditional Ni electrodeposits because of their better durability, strength, and wear resistance. The involvement of cobalt in microstructure refining improves features, lowering the demand for organic grain refiners [5-9]. Because of their low coercivity and high saturation magnetization, Ni–Fe, Ni–Co, and Co–Fe alloys have been frequently used.Because NiFe alloys' crystal structure has the largest impact on their magnetic characteristics, a detailed investigation of this engineering substance is necessary for its application areas[10-14]. This study looked into the effects of annealing on NiFe films.

2. EXPERIMENTAL PART

Using electrolyte baths containing ferrous sulphate (15 g/l), nickel sulphate (30 g/l), ammonium sulphate (40 g/l), boric acid (10 g/l), and saccharin (10 g/l) and working at temperature, Ni-Fe alloy sheets were electrodeposited (30ºC). It took 15 minutes to conclude the deposition. The cathode and anode in this investigation [6-8] were copper and stainless steel substrates with dimensions of 1.5 cm x 7.5 cm. The pH of the electrolytic solution was adjusted to 6.0 by adding ammonia solution, and the electroplating technique was carried out at a current density of 3 mA/cm^2.The copper or cathode was carefully withdrawn from the bath after 15 minutes and dried for a few minutes [10-14]. The Ni-Fe thin films were then electroplated and annealed at 200 degrees Celsius. The surface nature of Ni-Fe films was described using a scanning electron microscope. The atomic composition of film deposits was studied using energy-dispersive X-ray spectroscopy, and the crystal structure of the deposits was studied using X-ray diffraction. The micro hardness of the films was determined using the Vickers Hardness Test.

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3. RESULTS AND DISCUSSION

3.1 ELEMENTAL COMPOSITION OF Ni-Fe THIN FILMS

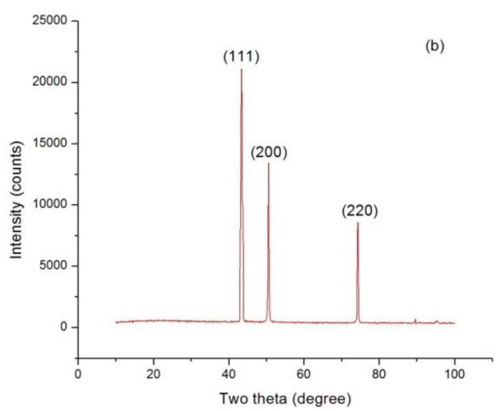
The elemental composition of Ni-Fe films was determined by EDAX analyser. The obtained data by this analyser are shown in Table 1. From result, after annealing , ferrous increased and nickel decreased .

Table 1: EDAX analysis of thin films

S. No	Condition	Ni Wt%	Fe Wt%
1.	Ni-Fe (30°C)	64.34	35.66
2	Ni-Fe (Annealed 200°C)	60.89	39.11

3.2 MORPHOLOGICAL OBSERVATION

Surface appearance of Ni-Fe thin films at 30°C and annealed thin film were analysed by Scanning Electron Microscope (SEM) images and they are shown in Fig 1. The thin films are bright and uniformly coated on the surface. They are crack free by appearance.



(a) **(b)**

Figure 1. SEM images of thin films (a) Ni-Fe (30°C)**(b)** Ni-Fe (Annealed 200°C)

3.3 STRUCTURAL CHARACTERS

Structural characteristic (from XRD Data) results of deposited materials prepared with temperature 30°C and annealed thin film are shown in figure 2. From XRD pattern of Ni-Fe, crystal formation of deposits can be concluded. The size of crystals of can be determined by formula

$$\text{Crystal Size (D)} = (0.955\ \lambda) / \beta \cos \theta$$

Where, β is FWHM at 2θ, λ is wavelength of incident light. The XRD results of Ni-Fefilms have shown face centred cubic phase with three diffraction peaks. The nano crystallite deposits was obtained

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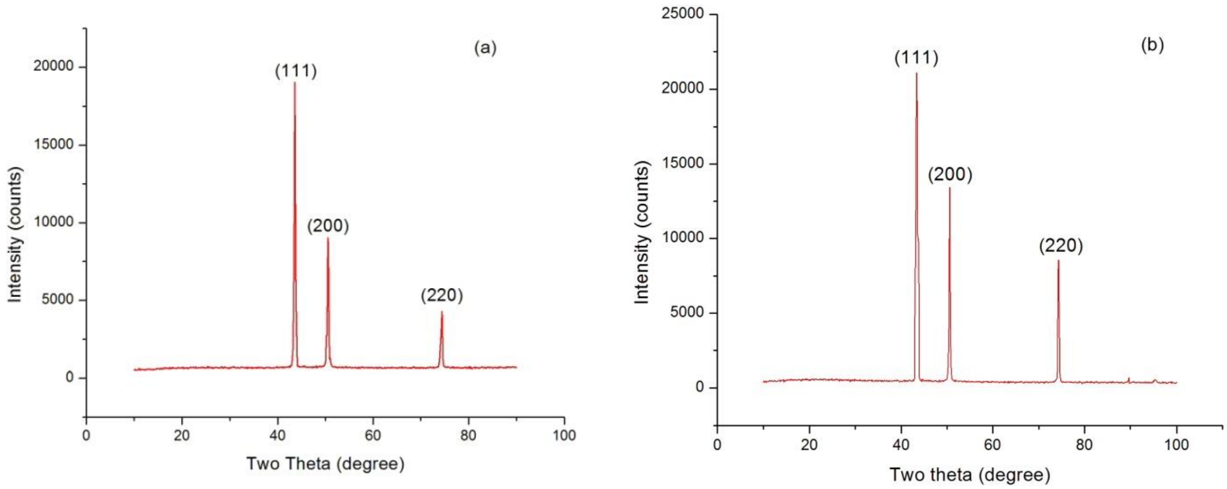

Figure.2. XRD patterns (a) Ni-Fe (30°C) **(b)** Ni-Fe (Annealed 200°C)

The crystallite sizes of Ni-Fe deposits are tabulated in table 2. Annealing process decreases the crystal size.

Table.2: Ni-Fe alloy films -Structural properties

S.No	**Condition**	**2θ (deg)**	**d (A^0)**	**Particle Size(D) (nm)**
1	Ni-Fe (30°C& without Adenine)	46.34	1.572	57.78
2	Ni-Fe (Annealed 200°C)	45.23	1.467	51.90

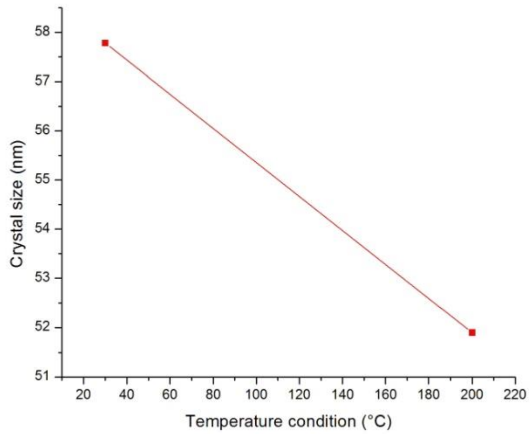

Figure.3.Particle size changes with condition

3.4 MECHANICAL PROPERTIES

Micro hardness measurement of deposits was done by Vickers hardness tester. The hardness values of thin films at room temperature 30°C and annealed thin film are shown in table 3. Annealing process increases the hardness, because of onset formation of crystal deposits during electro deposition process..

Table.3: Ni-Fe **alloy films -Hardness**

S.No	Condition	Hardness VHN)
1	Ni-Fe (30°C)	87
2	Ni-Fe (Annealed 200°C)	112

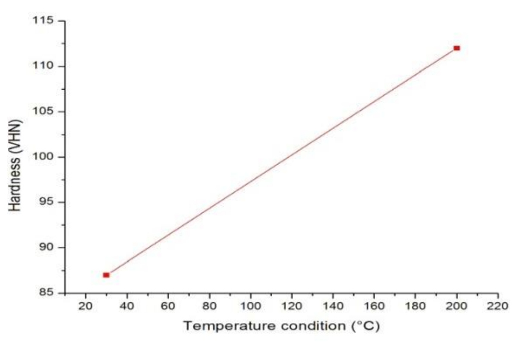

Figure.4.Hardness changes with condition

4. CONCLUSION

A thin alloy film the electro deposition process was used to make Ni-Fe. The properties of Ni-Fe films were studied. After annealing, ferrous increased and nickel decreased, according to EDAX results. The Ni-Fe films' XRD measurements revealed a face-centered cubic phase with three diffraction peaks. The annealing process produces thin coatings that are brilliant and uniformly deposited on the surface. They appear to be crack-free. After the annealing process, the hardness of thin films rises.

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