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Study of Annealing Effect on Characteristics of Nickel Boron Alloy Thin Films

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Abstract: Alloy thin films of NiB were prepared using electroplating at room temperature. Then electroplated NiB thin films was annealed at 200 o C . NiB deposited films are textured with FCC phase preferred orientation. They were subjected to morphological, structural, and mechanical characterization analysis. NiB films were bright and uniformly coated on the surface. Also, the deposits of NiB films were in nano scale and the average crystalline size was around 61 nm. The micro hardness of NiB was 112 VHN after annealing .

Keywords: Electroplating, electrolytic bath, crystalline size, VSM, Ni-B, X-ray diffraction, VHN, SEM.

INTRODUCTION

Several physical and chemical processes, such as thermal decomposition method, co-precipitation, spray pyrolysis, and electro deposition, can be used to make NiB alloy thin films [1-3]. Electro deposition is a surface structure modification technology that uses an electrochemical process. Electro deposition, when compared to other deposition processes, is one of the most promising due to its precise control, low cost, simple setup, and potential compatibility [4-7]. The use of nickel boron alloy sheets in MEMS would allow for more efficient sensing, storage, and transduction capabilities, as well as increased adaptability and performance of present MEMS [8-10]. Nickel is a well-known soft magnetic substance that contains boron [11-13]. Transformers, inductors, magnetic amplifiers, magnetic shields, and memory storage devices all use NiB alloy thin films, which offer the best soft magnetic characteristics. The effects of annealing on NiB films were investigated in this work.

EXPERIMENTAL PART

Electrodeposition of NiB alloy films were prepared with electrolyte baths consisting Borox (15 g/l), Nickel sulphate (30 g/l), Ammonium sulphate (40 g/l), Boric acid (10 g/l), and Saccharin (10 g/l) and operating at temperature (30 o C). 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 [14-16]. 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 [17]. Then electroplated NiB thin films was annealed at 200 o C. Scanning Electron Microscope was used to describe the surface nature of NiB 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.

RESULTS AND DISCUSSION

Elemental Composition of NiB Thin Films

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

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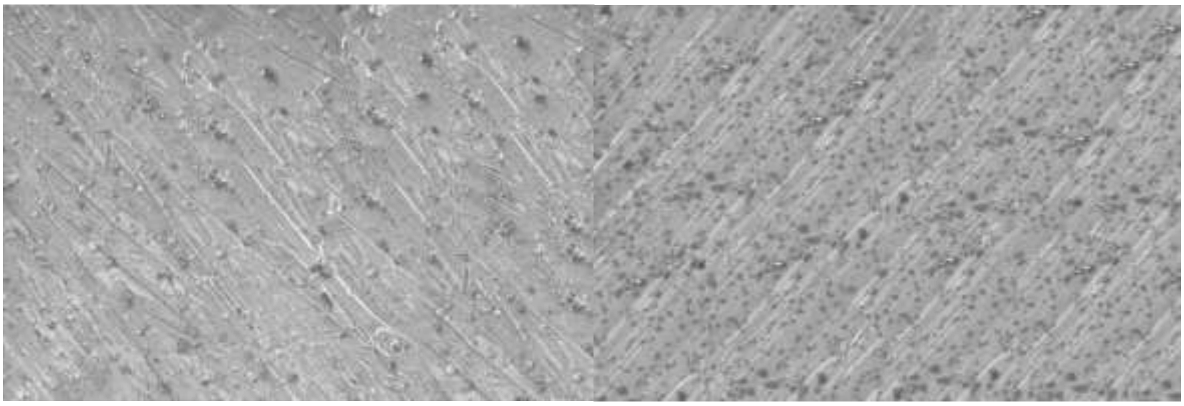
Table.1: EDAX analysis of thin films

S. No	Condition	Ni Wt% Wt%	B Wt%
1	NiB (30°C)	73.23	26.77
2	NiB (Annealed 200°C)	69.81	30.19

Morphological Observation

Surface appearance of NiB 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)**

Fig 1. SEM Images of thin films (a) NiB (30°C) (b) NiB (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 NiB, 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 NiB films have shown face centred cubic phase with three diffraction peaks. The nano crystallite deposits was obtained

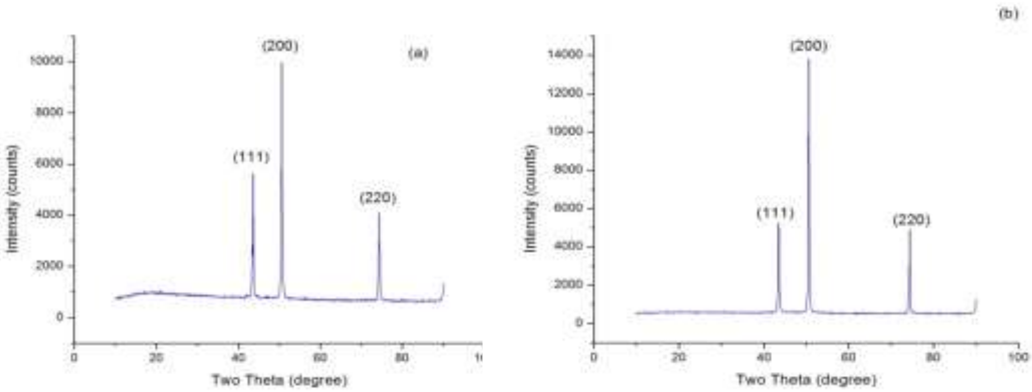


Fig 2. XRD patterns (a) NiB (30°C) (b) NiB (Annealed 200°C)

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

Table.2: NiB alloy films -Structural properties

S.No	**Condition**	**2θ (deg)**	**d (A^0)**	**Particle Size(D) (nm)**
1	NiB (30°C& without Adenine)	47.65	1.8457	65.67
2	NiB (Annealed 200°C)	48.03	1.8934	56.17

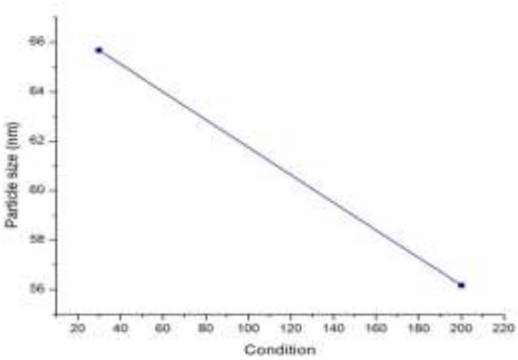

Fig 3. Particle size changes with condition

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: NiB alloy films -Hardness

S.No	**Condition**	**Hardness VHN)**
1	NiB (30°C)	93
2	NiB (Annealed 200°C)	112

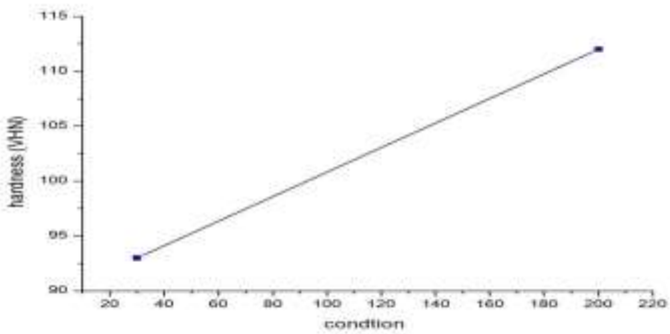

Fig 4. Hardness changes with condition

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CONCLUSION

An alloy thin films NiB has been prepared by electro deposition method. The characteristics of NiB films were observed. From EDAX result, boron increased, and nickel decreased after annealing. The XRD results of NiB films have shown face centered cubic phase with three diffraction peaks. The thin films prepared with annealing process are bright and uniformly coated on the surface. They are crack free by appearance. The hardness values of thin films after annealing process increases.

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