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Temperature Effect on Characteristics of NiCoB Alloy Thin Films

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Abstract – *Nickel cobalt boron (NiCoB) Thin films were produced on a copper substrate using an electrodeposition technique. It was reported on the crystalline structure, morphology, and electrochemical experiments. The NiCoB films have an FCC structure, according to the X-diffraction pattern. SEM is used to observe the formation of two-dimensional growths of nanocrystalline surface morphology in NiCoB thin films. NiCoB's hardness rises as the temperature rises. It has a higher coercivity and saturation magnetization than other materials.*

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

1. INTRODUCTION

CoNi oxide thin films are ideal materials for the fabrication of super capacitors in the power electronics industry. Magnetic sensor techno format, define read/write heads, large scale integration (ULSI) devices, magnetic actuators, magnetic shielding, high performance transformer cores, micro electromechanical systems (MEMS), and nano electromechanical systems are all potential applications for Ni, Co, W, Fe, and Cr based thin films (NEMS). Thin films of CoNi, CoW, NiFe, and NiW alloys are used in modern MEMS technologies due to their exceptional magnetic characteristics. Thermal decomposition and electrodeposition methods are better suitable for the creation of these alloy thin films. The electrodeposition approach was adopted for coating NiCoB thin films in the current study.

Electrodeposition provides various advantages over other coating processes, including being easy, cost-effective, dependable, and repeatable. A number of researchers studied the characteristics of electrodeposited CoNi thin films. CoNi thin films typically have strong magne3 Fontracteristics and are used in super capacitors.

2. EXPERIMENTAL PART

Electrodeposition of NiCoB alloy films was carried out in electrolyte baths comprising borax (10 g/l), nickel sulphate (30 g/l), cobalt sulphate (15 g/l), ammonium sulphate (40 g/l), boric acid (10 g/l), and saccharin (10 g/l) at varied temperatures of 30,50,70, and 90o C. The deposition took 15 minutes to complete. Copper and stainless-steel substrates with dimensions of 1.5 cm x 7.5 cm were used as the cathode and anode in this study [14-16]. By adding ammonia solution to the electrolytic solution, the pH was corrected to 6.0, and the electroplating procedure was performed at 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]. The micro hardness of the films was determined using the Vickers Hardness Test. 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. A scanning electron microscope was used to describe the surface nature of NiCoB films.

3. RESULTS AND DISCUSSION

3.1 Elemental Composition of NiCoB Thin Films

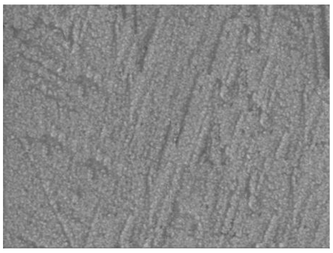
The elemental composition of NiCoB films was determined by EDAX analyser. The obtained data by this analyser are shown in Table 1. From result, when temperature increases, nickel increased, and boron decreased.

Table -1: EDAX analysis of thin films

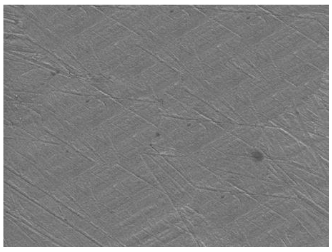
S. No	Temperature	Co Wt%	NiWt%	BWt%
1	30˚C	57.91	13.98	28.11
2	50˚C	51.18	25.38	23.54
3	70˚C	49.09	43.98	6.93
4	90˚C	45.05	44.57	10.38

3.2 Morphological Observation

Scanning Electron Microscope (SEM) images were used to analyse the surface appearance of NiCoB thin films at various temperatures, as shown in Fig 1. The thin films have a bright appearance and are uniformly coated on the surface. They appear to be crack-free.



(a)



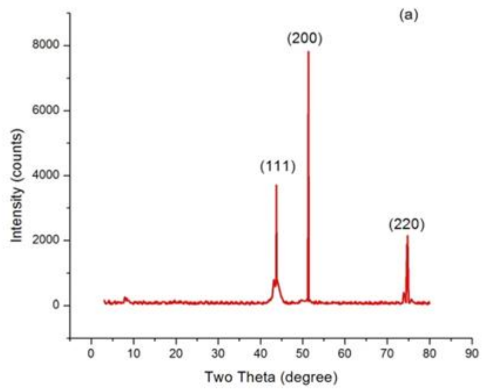
(b)

Fig -1: SEM images for Electro deposited Ni-Co-B thin film for different bath temperatures (a) 30˚C (b) 90˚C

3.3 Structural Characters

Structural characteristic (from XRD Data) results of deposited materials prepared with different temperature are shown in figure 2. From XRD pattern of NiCoB, crystal formation of deposits can be concluded.

The XRD results of NiCoB films have shown face centred cubic phase with three diffraction peaks. The nano crystallite deposits was obtained.



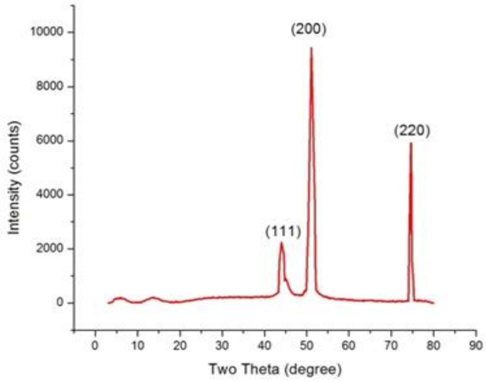


Fig -2: XRD pattern of electro deposited thin film for different bath temperatures (a) 30˚C (b) 90˚C

The crystallite sizes of NiCoB deposits are tabulated in table 2. When temperature increases the crystal size decreases.

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Table -2: NiCoB alloy films -Structural properties

S. No	Temperature	2θ (deg)	d (A^0)	Particle Size(D) (nm)
1	30˚C	49.34	1.4457	112.12
2	50˚C	49.03	1.3147	104.34
3	70˚C	50.65	1.5370	94.96
4	90˚C	48.17	1.5279	88.56

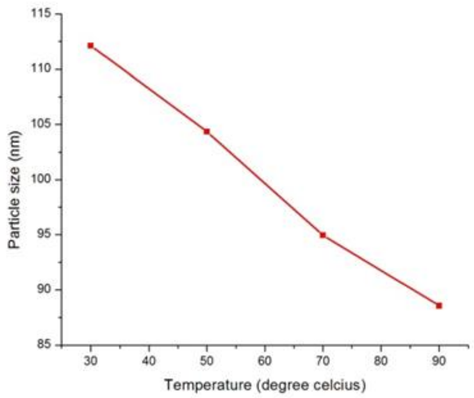

Fig -3: Particle size changes with condition

3.4 Mechanical Properties

Micro hardness measurement of deposits was done by Vickers hardness tester. The hardness values of thin films at different temperature are shown in table 3. When temperature increases, the hardness increases.

Table.3: NiCoB alloy films -Hardness

S. No	Temperature	Hardness (VHN)
1	30˚C	87
2	50˚C	110
3	70˚C	118
4	90˚C	143

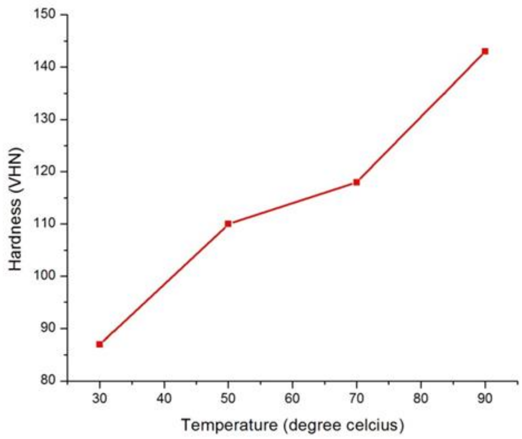

Fig -4: Hardness changes with Temperature

3.5. Magnetic Properties of the Deposits

Magnetic properties of Ni-Co-B films were observed by Vibrating Sample Magnetometer (VSM)5. The magnetic hysteresis curves of Ni-Co-B thin films for temperature 30˚C is shown in figure 5.

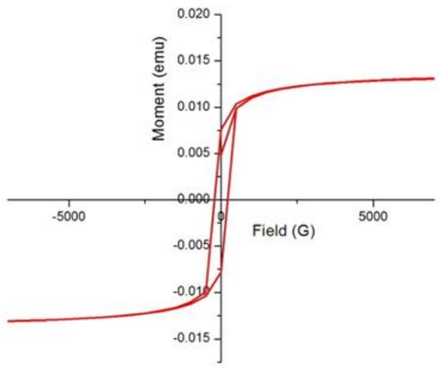

Fig -5: Magnetic Hysteresis loops of Ni-Fe-W thin film at temperature 30˚C

Thin film coated with different temperature reveals higher magnetization. It is observed that the magnetization and coercivity are 0.0126 emu and 170 G.

4. CONCLUSIONS

A thin alloy film NiCoB was made using an electro deposition technique at various temperatures. The properties of NiCoB films were studied. According to the EDAX results, boron reduced as temperature climbed whereas nickel increased. Face-centered cubic phase with three diffraction peaks was observed in NiCoB films using XRD. The thin films are brilliant and uniformly coated on the surface when made at different temperatures. From the outside, they look to be free of cracks. When the temperature rises, the hardness values of thin films rise as well.

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