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Ni-Co-S Electro Plated Alloy Thin Films: Investigation on Current Density of Electrolytic Solution

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ABSTRACT

Electrodeposition was used to deposit nanocrystalline Ni-Co-S alloy thin films on a copper substrate at various current densities. The structural, mechanical, and magnetic properties of electrodeposited Ni-Co-S thin films were investigated. The SEM images of NiCoS thin films reveal that the deposits are crack-free, homogeneous, and brilliant, with tiny grain sizes. All of the electrodeposited Ni-Co-S films had an FCC crystalline structure with nanoscale crystalline size. The saturation magnetisation value of NiCoS thin films coated at 3 mA/cm2 has the highest saturation magnetisation value with the lowest coercivity, according to the VSM results. NiCoS thin films are used to make super capacitors because of their high magnetisation value and low coercivity.

Keywords: Surface morphology, Thin films, electrodeposition , Xray Diffraction, crystal size , Micro hardness.Temperature.

1. INTRODUCTION

Soft magnetic materials, such as nickel cobalt based alloys, are the most often utilised magnetic materials in MEMS and NEMS (1-3). Magnetic recording heads are the most common application of soft magnetic materials. High magnetic saturation, low coercivity, high permeability, near zero

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magnetostriction, high electrical resistance, and good corrosion resistance are all important requirements for high quality thin film recording heads (4-6). Electroplated NiCo films have been used in tiny sensors, actuators, and systems due to their low coercivity, relatively high magnetic saturation, and superior corrosion resistance. Because of their potential uses in MEMS, the iron group metals (Ni,Co,Fe) have been electroplated as magnetic thin films(7-9). Electrodeposition of ferromagnetic alloys has received a lot of interest in recent years as a viable method for fabricating micro devices and sensors due to its ability to fill patterns with high aspect ratio qualities when compared to traditional vacuum deposition processes like CVD and PVD (10-12). As a result, the electrodeposition approach was adopted for coating the CoNiS thin films in this study. In power electronics industry, CoNiS thin films are good materials for making super capacitors. The ternary nickel cobalt sulphides have been studied as potential super capacitor electrode materials with enhanced magnetic and electrochemical properties. Sulfur is also a stress reliever (7-9). The effect of varying current densities on CoNiS thin films is investigated in this paper. The fabrication and characterisation of electroplated nano crystalline NiCoS thin films with various current densities are summarised in this work.

2. EXPERIMENTAL PART

Nickel sulphate (30 g/l) ,Thiourea (10 g/l), ammonium sulphate (40 g/l), cobalt sulphate (15 g/l), saccharin (10 g/l) and boric acid (10 g/l) electrolyte baths were used to develop NiCoS alloy films at current densities of 2,3,4 and 5 mA/cm2. The deposition took 15 minutes to complete. stainless steel and Copper substrates with dimensions of 7.5 cm x 1.5 cm were used as the anode and cathode in this study(8-10). The electrolytic bath pH was adjusted to 6.0 by adding ammonia solution, and the electroplating procedure was performed at 30°C. After 15 minutes, the copper or cathode was gently removed from the bath and dried for a few minutes (11-12).The micro hardness,atomic composition of film deposits, crystal structure and magnetic properties were found.

RESULTS AND DISCUSSION

3.1 ELEMENTAL COMPOSITION OF NiCoS THIN FILMS

The elemental composition of NiCoS films was determined by EDAX analyser. The obtained data by this analyser are given in Table 1. From result, at current density 3 mA/cm^2 , nickel 38.05 % .

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Table 1: EDAX analysis of thin films

S. No	Current density mA/cm^2	**Co Wt%**	**Ni Wt%**	**S Wt%**
1.	2	50.93	35.64	13.43
2	3	46.30	38.05	15.65
3	4	51.13	32.91	15.96
4	5	57.75	29.17	13.08

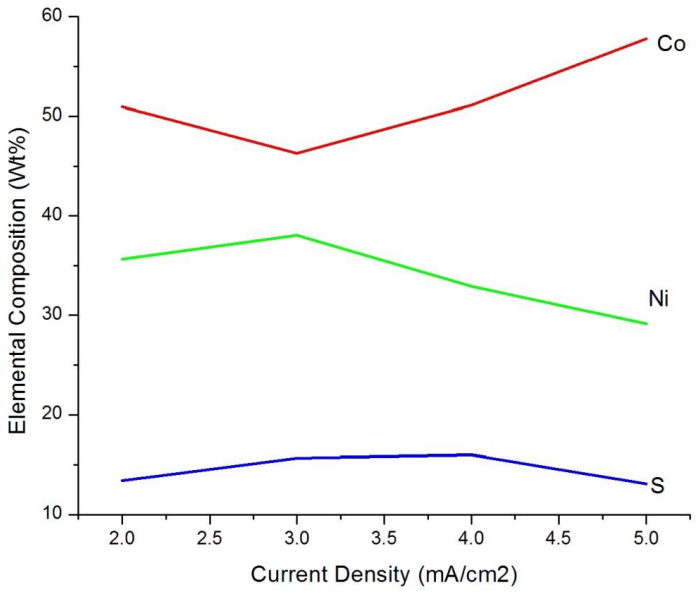

Figure 1. Elemental composition film for different current densities

(a) 2 mA/cm^2 (b) 3 mA/cm^2(a) 4 mA/cm^2 (b) 5 mA/cm^2

3.2 MORPHOLOGICAL OBSERVATION

The surface appearance of NiCoS thin films for diffrent current densities was studied using scanning electron microscope (SEM) pictures, as shown in Figure 2. The thin films are brightly coloured and evenly deposited over the surface. They don't appear to have any cracks.

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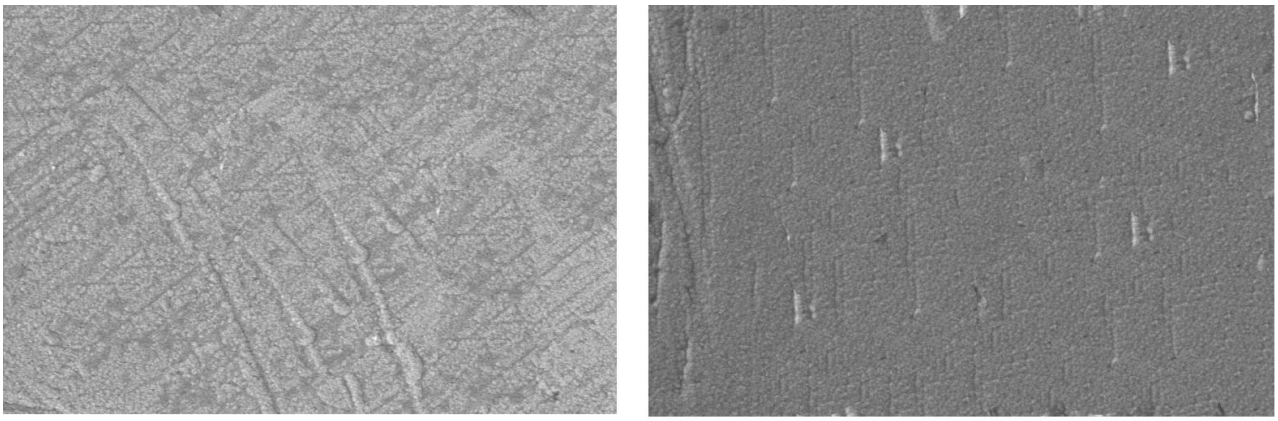

(a) **(b)**

Figure 2. SEM images for Electro deposited Ni-Co-B thin film for different current densities

(a) 3mA/cm^2 (b) 5mA/cm^2

3.3 STRUCTURAL CHARACTERS

Figure 3 shows the structural characteristics (from XRD data) of deposited materials created with various current densities. Crystal structure of deposition can be found from the XRD pattern of NiCoS.The NiCoS films' XRD measurements revealed a face-centered cubic phase with three diffraction peaks. Nano crystallite deposits were discovered.

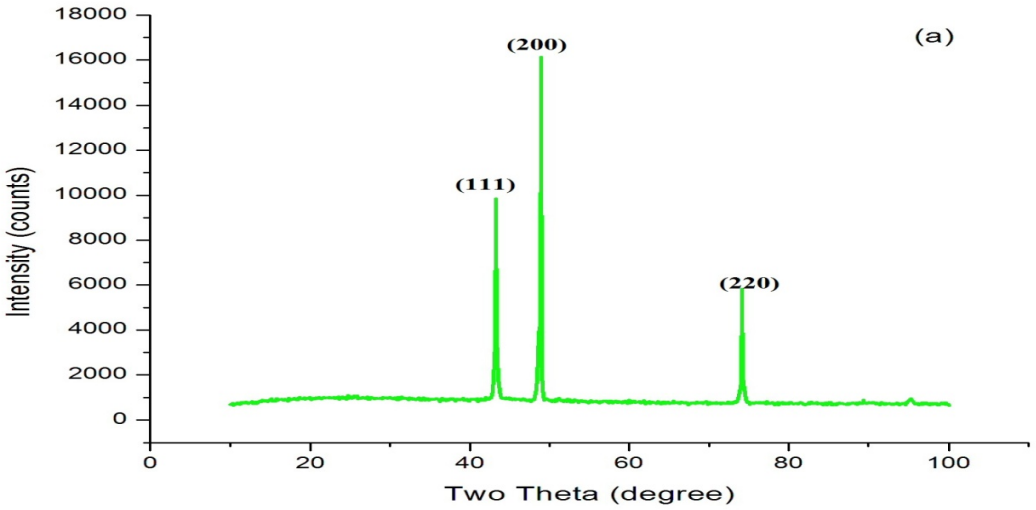

Figure.3. XRD pattern of electro deposited thin film for different current densities

(a) 3 mA/cm^2 (b) 5 mA/cm^2

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The crystallite sizes of NiCoS deposits are tabulated in table 2. During **current density value at 3** mA/cm^2, the crystal size was 86 nm.

Table.2: NiCoS **alloy films -Structural properties**

S. No	Current density mA/cm^2	**2θ (deg)**	**d (A^0)**	**Particle Size(D) (nm)**
1.	2	45.06	1.2045	154
2	3	46.62	1.2376	86
3	4	45.87	1.3723	122
4	5	46.10	1.3061	221

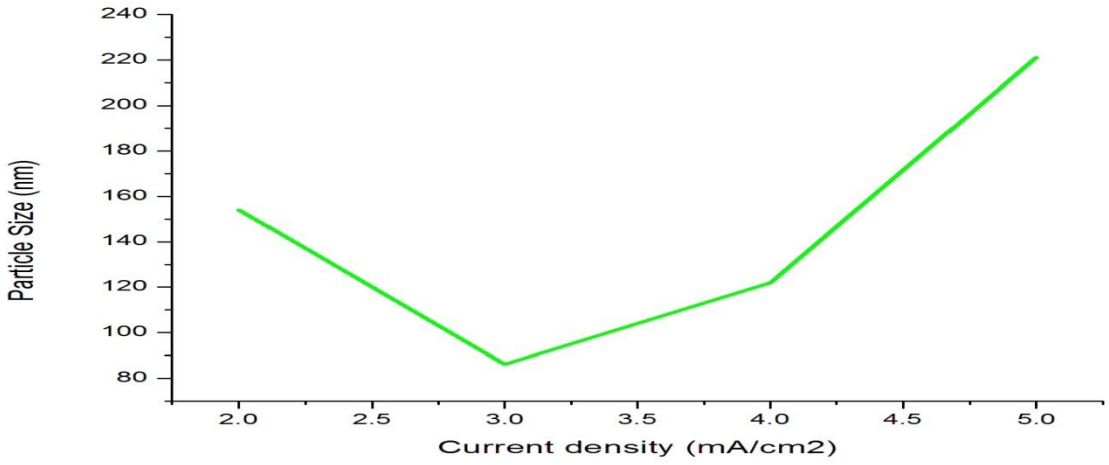

Figure.4.Particle size changes with different current densities condition

3.4 MECHANICAL PROPERTIES

Vickers hardness tester was used to measure the hardness of the deposits. Table 3 shows the hardness values of thin films at diffrent current densities. The hardness was 170 VHN when the current density was 3 mA/cm2.

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Table.3: NiCoS **alloy films -Hardness**

S. No	Current density mA/cm^2	**Hardness (VHN)**
1.	2	139
2	3	170
3	4	149
4	5	111

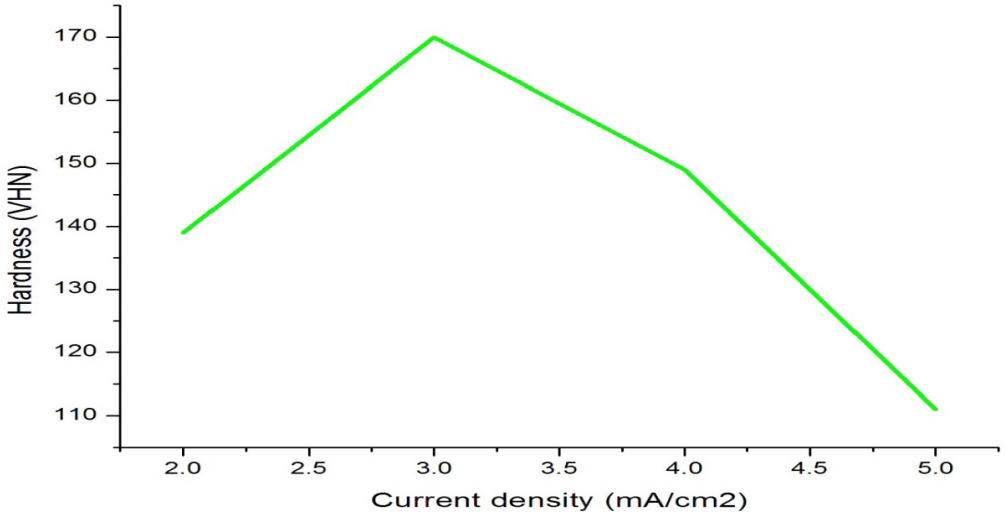

Figure.5.Hardness changes with current densities

3.5. MAGNETIC CHARACTERS OF THE DEPOSITS

Magnetic properties of Ni-Co-S films were observed by VSM (Vibrating Sample Magnetometer).The magnetic hysteresis curves of Ni-Co-S thin films for **current density**3 mA/cm^{2}is shown in figure 6.

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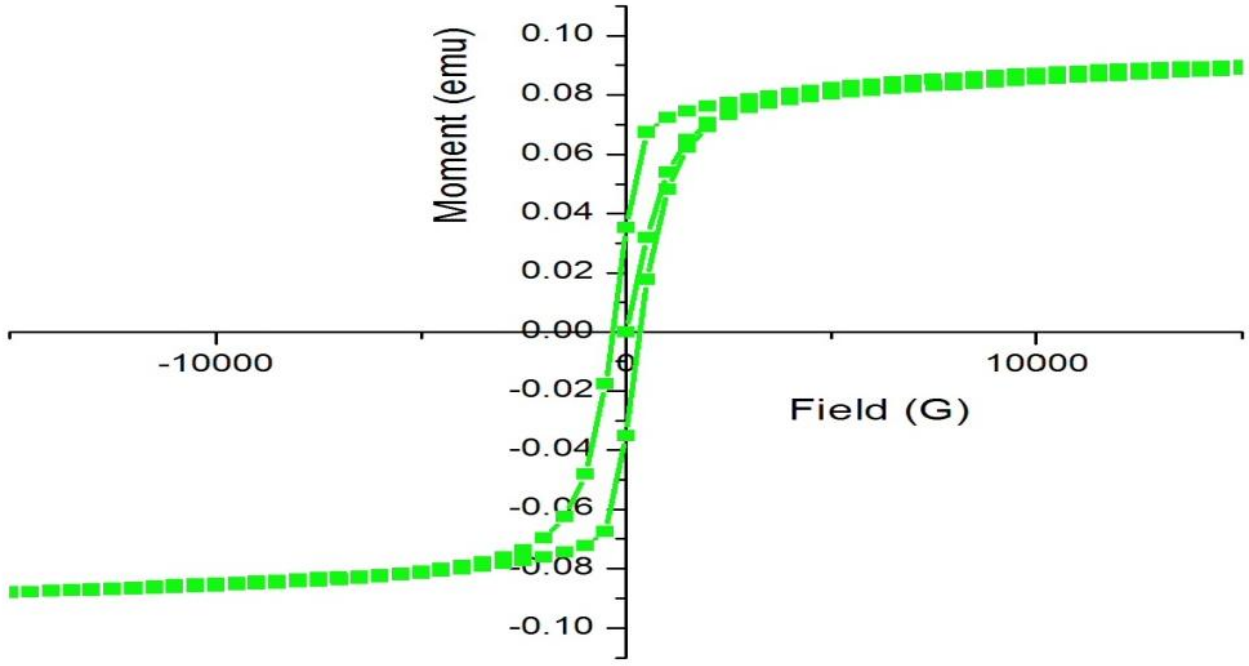

Figure 6. Magnetic Hysteresis loops of Ni-Fe-W thin film for current density 3 mA/cm^2

Thin film coated with different current densities reveals higher magnetization. It is observed that the magnetizationand coercivity are 0.1904 emu and 220 G.

4. CONCLUSION

Electro deposition of Ni-Co-S composite thin films with current densities 2,3,4 and 5 mA/cm^2 was achieved. Crack-free, brilliant, and homogeneous nanocrystalline films were created at various current densities. Electrodeposited Ni-Co-S thin films had a dominating structure of FCC. The deposits created by the electro deposition method have nanoscale crystalline diameters. The hardness was 170 VHN when current density value at 3 mA/cm2, and the magnetization and coercivity were 0.1904 emu and 220 G when current density valueat 3 mA/cm2. This is because Ni-Co-S has a nanocrystalline morphology and low film stress. This article summarises the optimal electroplated bath operation conditions. The creation of nickel cobalt sulphides with adjustable composition and their use as positive electrodes improves super capacitors with good energy storage capabilities.

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