Effect of Temperature and Current Density in Electrodeposited Co-W Magnetic Thin Film

Anas Islam*, Aman Sharma, Rishabh Chaturvedi, Kamal Sharma
IET Department of Mechanical Engineering GLA University Mathura-281406

* Corresponding author: anasmechengg@gmail.com

Abstract. Co-W thin films have been produced as organic compounds using "electro deposition" with tri-sodium citrate. Typically, Co-W alloys have a strong toughness. Its hardness has been observed in various current temperatures and pressures. Co-W film having a strong magnetic behavior at a relatively low temperature and subtly changed to a soft magnetic nature as the temperature is elevated to a higher point. It was tested using a vibrational Sample Magnetometer. Surface morphology was analyzed using "XRD and SEM" measurements.

Keywords: "Electro-deposition", Temperature, Current density, SEM etc

1. Introduction
Thanks to its realistic application of industrial manufacturing of specific goods, that cannot otherwise be developed, "electro deposition" of alloys has been increasing in popularity in recent years. There is a large range of film deposition processes, but "electro deposition" is the easiest and simple process. In the fastest country, magnetic alloys are being produced, which are highly important in the extremely advanced electronics industry in association with missiles, machines, space technologies etc. [1-4] For MEMS and NEMS, hard and soft components, micro actuators, electrodes and micro gears are used [5-7]. The micro-magnetic structures are often used, in the head recording the soft magnetic thin films, and in storage devices hard magnetic films (8-9).

The Fe, Ni & Co alloying elements are specifically electrified and used in different magnetic applications. The "electro deposition" approach is mainly used for application of micro-production technologies. Tungsten has not yet been extracted as pure metal from the watery solution specifically from a particular element. Thanks to their varying good crystalline temperatures and corrosion tolerances [10] the most frequent scientists focus on iron group alloys. Different microstructures may generate cobalt layers depending on electrolytes, solutions pH, temperature and "current deposition density (c.d.)"[11-14]. Tungsten is co-deposited to create rough steel film with a magnetic layer with good tensile and corrosion resistance [15-18].

This research aims to deposit cobalt tungsten alloy with sodium electrolyte tri sodium citrate and to change the present temp and volume.

2. Experimental Procedure
As an anode of galvanotatic "electrodeposition", a copper substrate of the size 1.5X 5 cm is used as cathode and platinum. A d.c current was transmitted from a controlled power supply to the electrical deposition network. Bath water was formulated using industrial quality chemicals [19, 20]. The area on which a film deposition was wished was a mask for all the substrate. The electrode of copper was buffed with a buffing cloth with aluminum oxide abrasive to remove scratches on a mechanical
polishing roller [21, 22]. Upon buffing, con H2SO4 or acetone washed the substrates. Such substrates had been electrically washing until "electro deposition" in an alkaline electro-cleaning bath after the substrates had been purified. Different current densities and temperatures were used for electro deposing.

Co-Tg thin magnetic layer was plated with electrostatic cotton from a bath comprising "0.1 M (CoSo4.7H2O), sodium tungstate (Na2Wo4.2H2O) 0.05 M (Na2So4) 0.3 M and three sodium citrate (Na3C6H35O7.2H2O) 0.3 M (Na2Wo4.2H2O)". The pH of the track was kept at 8.0 and the temp at 40&60°C. The film has been coated for various times such as 15 minutes, 30 minutes and 45 minutes. The effects of tungsten cobalt have been studied.

Digital micrometers (Mitutoyo, Japan) have been used to test the deposits' thickness. Using vibrational sample magnetometry, magnet properties of film deposits were examined. In this procedure a sample holder positioned between the poles of a laboratorial magnet held the substance under study. A slender vertical sample rod links the sample holder with the transducer assembly. The transducer converts the sample rod into a vertical sinusoidal wave of alternating current signal. Coils placed on the poles of the magnet produce the signals that originate from the rotation of the sample.

"X-ray diffraction (XRD)" the morphology and structure of such magnetic films were studied by Rich Seifert, Germany, model 3000 and "Scanning Electron microscopy (SEM)" Mosumy Electronics Japan made by JEOL. "The accumulated CoW and the film stress is determined for XRD sample crystallite sizes. EDAX was used as a proportion of elemental "CoW film" research. Deposit hardness was measured by using the diamond in tender process for the Vickers’s hardness tester. Fine bowing and scratch or chisel tests also measured adhesion to the film. These measurements are usually used in electro-deposition.

3. Result and Discussion

3.1. Thickness Study
With the rise in density as well as the change in time for deposition at temperatures 40 and 600°C, film thickness was improved. The table 1 presents it.

| Temperature (°C) | Current density (mA/cm²) | "Deposition time (min)" | "Thickness of the deposit (µm)" | "Magnetic saturation (emu)" | "Remanent (emu)" | "Coercivity (Oe)" | "Squareness" |
|-----------------|--------------------------|------------------------|-------------------------------|---------------------------|----------------|----------------|-------------|
| 20              | 5                        | 1                      | 0.3                           | 0.969                     | 0.32           | 831            | 0.3         |
|                 | 0                        | 3                      | 0.6                           | 0.954                     | 0.31           | 792            | 0.3         |
|                 | 5                        | 4                      | 0.8                           | 0.946                     | 0.26           | 760            | 1           |
|                 | 1                        | 0.5                    | 0.932                         | 0.26                      | 722            | 2             |
| 40              | 5                        | 3                      | 0.9                           | 0.920                     | 0.24           | 690            | 2           |
|                 | 0                        | 4                      | 1.3                           | 0.910                     | 0.21           | 650            | 0.2         |
|                 | 5                        | 1                      | 0.8                           | 0.901                     | 0.26           | 629            | 3           |
|                 | 5                        | 3                      | 1.2                           | 0.887                     | 0.25           | 605            | 2           |
| 30              | 5                        | 4                      | 1.7                           | 0.873                     | 0.22           | 580            | 8           |
Table 2. "Crystalline size, hardness and composition of Co-W films for different temperature and current density"

| "Temp (°C)" | "Current density (mA/cm²)" | "Crystalline size (nm)" | "Vickers Hardness (VHN)" | "Film Composition) (at %)" |
|-------------|-----------------------------|-------------------------|--------------------------|---------------------------|
| 40          | 20                          | 80                      | 580                      | 7.74                      | 24.26                     |
| 60          | 20                          | 64                      | 595                      | 73.53                     | 26.47                     |

3.2. Surface characterization:
Specific temperature baths such as 40 and 600°C have been developed for Co – Tg electrodeposits of 20 and 30 mA and 30 min have been set for the current density and periods of deposition of "Electrodeposition" respectively. The XRD data were compared to standard data and seen to have a closed hexagonal structure and mostly a plane of (200). The formulation was determined from the XRD model edge, emphasized in the film:

"Young’s modulus = stress / pressure".

Crystalline deposit sizes have been estimated from the formula XRD pattern: crystalline = 0.9 / B cos section.

Such values prove simple that "Electro deposition" processes provide nano-scales in the crystallite sizes of the Co-W layer. Table 2 displays the crystallite proportions of deposits.

XRD evidence reveals a hcpp from a bath with a higher temperature of Co3W crystalline structure, and a decrease in crystalline size is found by increasing the lecture temperature. The films are really strong and well adhered.

SEM tests were performed for electrodeposited cobalt tungsten films from various baths, as described in XRD. The micrograms are shown in the chart. 1. The microstructure of the Co-W film is typically significantly influenced by the bath temperature. Energy dispersive X-ray spectroscopy evaluated the elements present in the "films", and the findings are shown in table 2

3.3. Mechanical properties
Bending and scraping checks will monitor the fidelity of the film to the substratum. It showed that the film adheres well to the substratum. As the film deposited from the temperature and current density decreases, the strength of the film rises. Table 2 shows the results.

![Figure 1. SEM Images of Co-W films at 400°C (a) 20mA, (b) 30mA and at temperature 600°C (c) 20mA, (d) 30mA](image)

3.4. Magnetic properties

Research of "electrodeposition" of various bath temperatures is carried out. Table 2 offers data from Co-W "electrodeposition" for varying bathing temperatures as 40 and 60°C and its magnetic properties. The sediment size decreases with an increase in present density and deposition time as the low-temperature bath was used for depositing. The principles in films are strongly manipulative and enduring. The film is a strong magnetic material at low temperatures.

Films generated (600°C) were clear and bright in "heat deposition" experiments. That is since the crystallisation path is adsorbed on initially deposited crystals uniformly through "electrodeposition." Both films are low intrusive and remnant relative to the deposit from medium-temperature bath film, as shown by the magnetic properties of the high-temperature bath films.

The normal size of the films in crystallite is in nano scale and thus the magnet nature will vary dramatically. If the crystalline dimensions exceed small nano levels, the width of the domain wall is equal to the crystalline dimensions of the oppressive kind. An examination of the crystallite dimension, micro-structure and magnetic properties shows that a clear association between the single domain crystals is the root of magnetic properties. It is mostly because of the films from hot water.

4. Conclusion

A "cobalt tungsten" film with strong hard magnetic field may be significantly improved from a lower-temperature tungsten pan. The character of the film reveals a strong magnetic structure in the high temperatures water. The film stress, which is a cause of cracked film increases as well the low stresses
used by MEMS devices are the high-temperature bath films. In higher temperature bath films with fewer oppressive and lower residual values, the stiffness of the film often decreases. Such films also have strong substrate adhesion and nano-scale crystallographic scales.

5. References

[1] S.C. Srivastava, Surface Technology, 10 (1980) 237-257.
[2] A Kumar, K Sharma, AR Dixit, A review of the mechanical and thermal properties of graphene and its hybrid polymer nanocomposites for structural applications, Journal of Materials Science 54 (8), 5992-6026.
[3] F. Lallemand, L. Ricq, M. Ricq, et al. Surf. Coat. Technol. 179 (2004) 314.
[4] K Sharma, M Shukla, Three-phase carbon fiber amine functionalized carbon nanotubes epoxy composite: processing, characterisation, and multiscale modeling, Journal of Nanomaterials 2014
[5] E. Chassaing, J. Electrochem. Soc. 148 (2001) C690.
[6] Goyal, M. and B. Gupta, Study of shape, size and temperature-dependent elastic properties of nanomaterials. Modern Physics Letters B, 2019. 33(26): p. 1950310.
[7] Gomes, M.I. da Silva Pereira, Electrochim. Acta 51 (2006) 1342.
[8] K Sharma, KS Kaushalyayan, M Shukla, Pull-out simulations of interfacial properties of amine functionalized multi-walled carbon nanotube epoxy composites, Computational Materials Science 99, 232-241
[9] C.H. Ahn, M.G. Allen, IEEE Trans. Ind. Electron. 45 (1998) 866.
[10] T.S. Chin, J. Magn. Magn. Mater. 209 (2000) 75.
[11] A Yadav, A Kumar, PK Singh, K Sharma, Glass transition temperature of functionalized graphene epoxy composites using molecular dynamics simulation, Integrated Ferroelectrics 186 (1), 106-114
[12] Nosang V. Myung, D.-Y. Park, B.-Y. Yoo, Paulo T.A. Sumodjo, Journal of Magnetism and Magnetic Materials 265 (2003) 189-198.
[13] PK Singh, K Sharma, A Kumar, M Shukla, Effects of functionalization on the mechanical properties of multiwalled carbon nanotubes: A molecular dynamics approach, Journal of Composite Materials 51 (5), 671-680
[14] P.C. Andricacos and N. Robertson, IBM J.Res.Develop, 42(5), (1998) 671-680.
[15] Fred E. Luborsky, IEEE Transacations on Magnetics MAG6 (3) (1970)502-506.
[16] M. Svensson, U. Wahlstrom, G. Holmbom, Surface and Coatings Technology 105 (1998) 218–223.
[17] PK Singh, K Sharma, Mechanical and Viscoelastic Properties of In-situ Amine Functionalized Multiple Layer Graphene/epoxy Nanocomposites, Current Nanoscience 14 (3), 252-262
[18] T. Chen, P.L. Cavallotti, Appl. Phys. Lett. 41 (1982) 205.
[19] Goyal, M. and B. Gupta, Analysis of shape, size and structure dependent thermodynamic properties of nanowires. High Temperatures--High Pressures, 2019.48.
[20] A Kumar, K Sharma, AR Dixit, Carbon nanotube-and graphene-reinforced multiphase polymeric composites: review on their properties and applications, Journal of Materials Science, 1-43
[21] P.L. Cavallotti, M. Bestetti, S. Franz, Electrochimica Acta 48 (2003) 3013–3020.
[22] Singh PK, & Sharma K, Molecular Dynamics Simulation of Glass Transition Behaviour of Polymer based Nanocomposites, Journal of Scientific & Industrial Research, 77 (10) (2018) 592-595.