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BINARY (NI: CU) METAL OXIDE THIN FILM: SEM, EDAX AND EIS ANALYSIS

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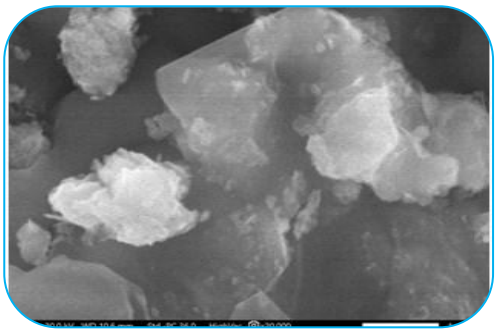
ABSTRACT



In the present work, the Binary (Ni: Cu) Metal oxide thin film was synthesized by using Sol-gel spin coating technique from $NiCl_2.6H_2O$ and $CuCl_2.6H_2O$ precursors. The obtained thin films were characterized using Scanning Electron Microscopy (SEM), Energy-Dispersive X-ray Spectroscopy (EDAX) and Electrochemical Impedance Spectroscopy (EIS). Deep porous and rough surface morphology has been observed from SEM micrographs. The EDAX spectrum of binary (Ni: Cu) metal oxide thin film shows nickel, copper and oxygen elements existed in the sample. EIS measurements were conducted to understand the electrochemical behavior and the chemical compatibility.

KEYWORDS ; *(Ni: Cu) oxide; Sol-gel spin coating; SEM; EDAX; EIS;.*

1. INTRODUCTION

Electrochemical capacitors or supercapacitors have the considerable attraction in recent years due to the growing demand of power sources. Supercapacitors have wide range of applications in various areas such as hybrid electric vehicles, telecommunications, digital communication devices particularly associated with cellular phones for a reduction of the size of the batteries, electrical tools, pulse laser technique, uninterruptible power supplies etc[1-4].

Electrode materials, which have a dominant effect on the supercapacitor performance, have become the research focus for several years [4, 5]. Among them, pseudocapacitive-based materials such as transition metal oxides (TMOs) have become judicious choices due to their robust crystal structure, ultrahigh capacitances and energy densities [6, 7]. To enhance the performance of transition metal oxides with unitary component, nickel oxide for example, binary transition metal oxides (BTMOs) have attracted worldwide interest as supercapacitor materials because cationic substitutions in binary oxides have shown dramatic improvements over their binary analogues. It has also discovered that nickel copper oxide is another promising binary oxide candidate to enhance the performance of bare nickel oxide, and 30% increment in specific capacitance is achieved [8]. In the present work we report on the synthesis of binary (Ni: Cu) metal oxide thin film and its morphological, compositional and electrochemical properties.

2. MATERIALS AND METHODS

2.1 Preparation of binary (Ni: Cu) metal oxide thin film

The binary (Ni: Cu) metal oxide thin film is deposited on stainless substrates by Sol-gel Spin Coat method. The cationic solutions of 0.0125 and 0.2 M were prepared by using Nickel chloride ($NiCl_2 \cdot 6H_2O$) and Cupric chloride ($CuCl_2 \cdot 6H_2O$) with a complexing agent ethanol. Equal proportions of both solutions were mixed continuously on magnetic stirrer for 6 hours by keeping the magnetic stirrer temperature at 600C. The above solution was deposited on to the stainless steel substrate (SS) by spin coating technique.

2.2 Characterizations

The surface morphological study has been carried out by Scanning Electron Microscopy (SEM) using JEOL JSM-IT200 instrument. The compositional analysis of the as deposited binary (Ni: Cu) metal oxide thin film electrode was carried out using EDAX technique by JEOL JSM-IT 200 instrument. The electrochemical analysis of the as deposited binary (Ni: Cu) metal oxide thin film electrode was carried out using EIS technique by Zive MP1 Multichannel instrument.

3. RESULTS AND DISCUSSION

3.1 Morphological Analysis by SEM

The SEM image shows the formation of thin film which is well adherent to the substrate. The SEM image of binary metal (Ni: Cu) oxide at x2,000 magnification is as shown in the Fig.1 From the SEM image the irregularly arranged agglomerates forming a rough surface with porous morphology is observed. The porosity prompts possibility of better electrochemical supercapacitor behavior of binary metal (Ni: Cu) oxide thin film electrode[9].

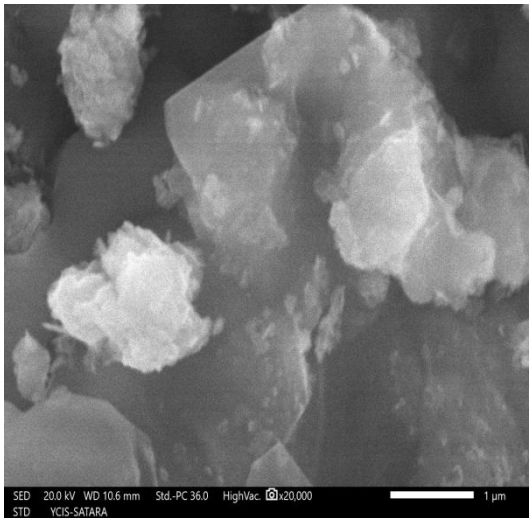


Fig.1: SEM Morphology of as deposited binary metal (Ni: Cu) oxide thin film at x2,000 magnification

3.2 Compositional Analysis by EDAX

Energy dispersive X-ray spectrum was shown in the Fig.2 to investigate elemental composition of the as prepared material surface. It indicates the formation of binary (Ni: Cu) metal oxide on the substrate. In the EDAX measured result, Nickel, Copper and Oxygen were detected. From the obtained data it was found that the Ni and Cu were present in the sample.

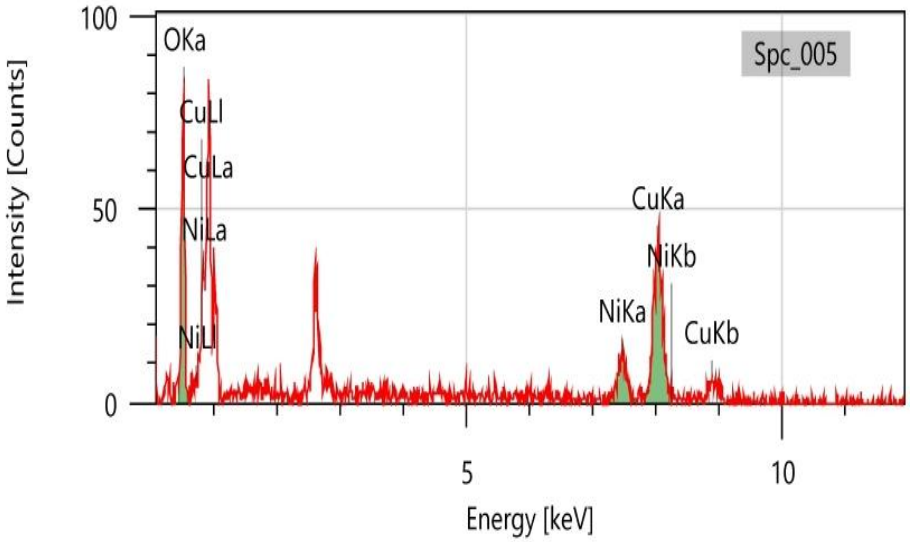


Fig.2 : EDAX result of as deposited binary metal (Ni: Cu) oxide thin film.

3.3 Electrochemical Analysis by EIS

The EIS measurement of binary (Ni: Cu) metal oxide thin film electrode was carried out in the frequency range 0.01 Hz to 100 kHz. The equivalent circuit we chosen to fit the measured EIS data is as shown in the Fig. 3(a) the fitted result (red dots) shows a quite good match with the measured result (black dots). In the equivalent circuit, the R_s represents equivalent series resistance, R_1 represents electrolyte resistance, R_2 represents charge transfer resistance and W is the Warburg diffusion resistance [10].

The Nyquist plot shown in Fig. 3(b) obviously displays three variation ranges including a partial semi-circle part, a slope with 45^0 and a slope with angle more than 70^0. It is well known that a larger semicircle means a larger charge transfer resistance, the slope with 45^0 indicates the Warburg resistance caused by electrolytic ions diffusion and steeper slope signifies a lower ion-diffusion rate [11,12]

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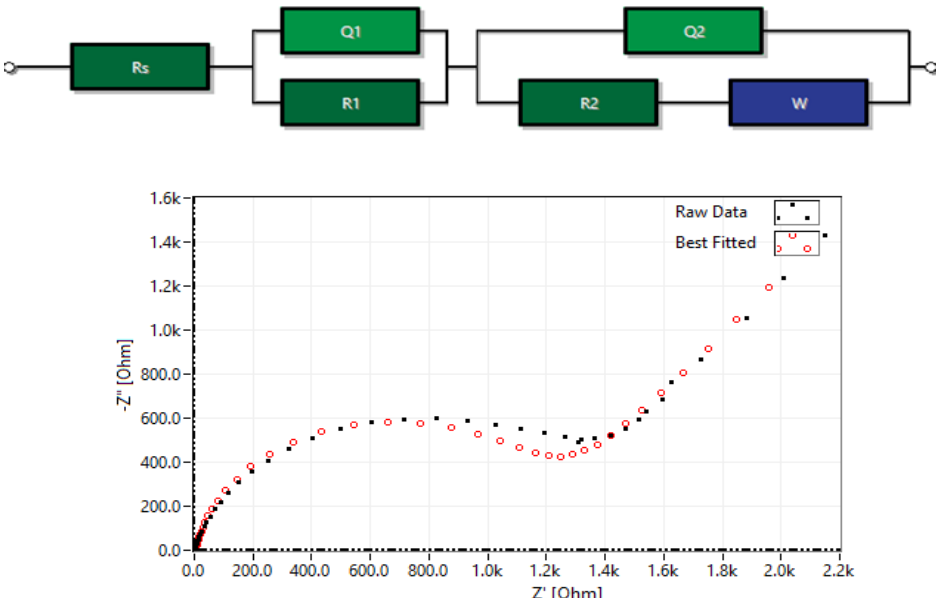

Fig.3 (a) Equivalent circuit (b) Nyquist plots at frequencies between 100 kHz and 0.01 Hz.

CONCLUSION

The present study shown successful synthesis of binary (Ni: Cu) metal oxide thin film electrode as confirmed by different characterizations such as SEM, EDAX and EIS. SEM images revealed irregularly arranged agglomerates forming a rough surface with porous morphology. EDAX spectrum shows the presence of Copper, Nickel and Oxygen elements in the sample which indicates the formation of binary Nickel Copper metal oxide on the substrate. The EIS measurement is carried out between the frequency range from 0.01 Hz to 100 kHz and the fitted data shows a quite good match with the measured result.

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