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CuO THIN FILM ELECTRODE FOR SUPERCAPCITOR APPLICATION

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Abstract

Cost effective thin film was prepared for technological application. Stainless steel used as substrate for thin film preparation as a low cost material. A typical process consists of electrochemical deposition of thin film of copper oxide by 0.3 M $CuSO_4$ aqueous solution. Deposited sample were characterized by XRD,. This prepared thin film was used for Supercapcitor application. As precursor is cost effective, environmentally compatible, it's possible to make device based on cost effective CuO based capacitor for technological application which show 313 Fg^{-1} Specific capacitance in 1M KOH.

Keywords: - Thin film, CuO, Supercapcitor

INTRODUCTION

The increasing need for cost-effective and environmentally friendly energy for the world's increasing population has led to rigorous research for efficient energy storage systems [1]. In particular, due to their intermittency, the grand challenge for most renewable energy systems, such as e.g. wind power and solar power, is storage. High energy, high power density and fast availability are the major requirements of a storage device. Such needs are particularly urgent in rural areas, in which there is no decentralized energy distribution. The combination of renewable energy technologies and better energy storage devices is therefore expected to have a major force in the developing world [2, 3].As an important p-type transition-metal oxide with a narrow band gap (Eg=1.2 eV), CuO has been explored as an electrode material for high-power electrochemical pseudocapacitors due to its plentiful resources, environmental compatibility, cost effectiveness and encouraging pseudocapacitive characteristics. It was found that the morphology and particle size of CuO remarkably affected its specific capacity. For instance synthesized the porous amorphous copper oxide thin films which exhibited a specific capacitance around 40 F g^{-1} in 1 M Na_2SO_4 electrolyte. [4,5]. In this study, we have prepared room temperature CuO thin film by cathodic electrodeposotion in single step. The structure and electrochemical properties of the CuO nanostructures were investigated and electrochemical performance was examined.

2. Experimental details

Room temperature synthesis of copper oxide thin films was made by single stepcathodic electrodeposition onto the stainless steel substrates in an aqueous 0.3 M $CuSO_4$ solution. The stainless steel substrates were first polished with zero grade polish paper and finally washed with distilled water. Deposition of copper hydroxide thin films were carried out at constant cathodic current density of 80mA/cm^2. After deposition, thin brown colour copper hydroxide coating gets deposited onto the stainless steel substrates. The obtained sample film annealed at 673 K for 1 hr. Weight of the copper oxide deposited on the stainless steel-substrates was measured by gravimetric weight difference method.

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3. Result and Discussion

Fig 1. CuO thin film Assembly

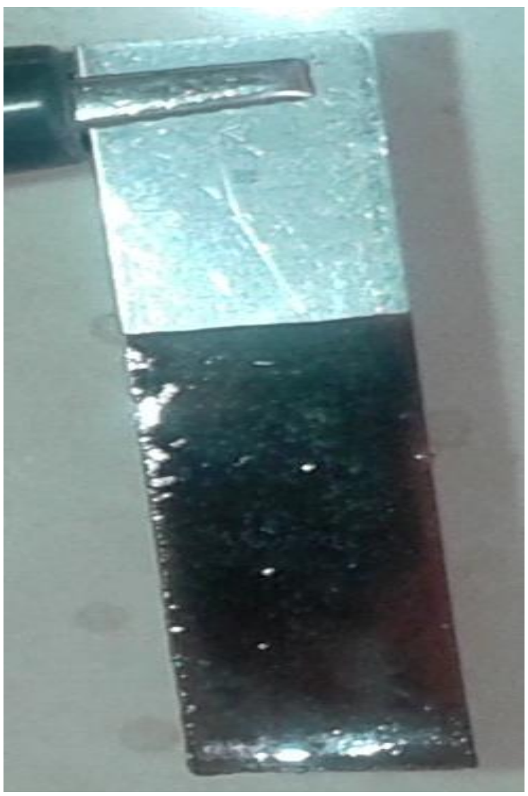

Fig 2. CuO thin film Assembly

3.1 Structural study

The XRD pattern of deposited copper oxide thin film is shown in Fig. 1. Deposited material

The structural properties of the deposited films were further investigated using XRD.

Fig. 1 shows the XRD pattern of CuO deposited on blank stainless steel and CuO coated on stainless steel. Strong peaks corresponding to the (111) and (200) direction planes of CuO are observed. Other identifiable peaks of CuO are corresponding to the diffraction planes (202), (-311) and (220) respectively (JCPDS #. 80–0076). The films exhibit very sharp peaks, which is most likely the result of the enhanced crystallinity of the films.

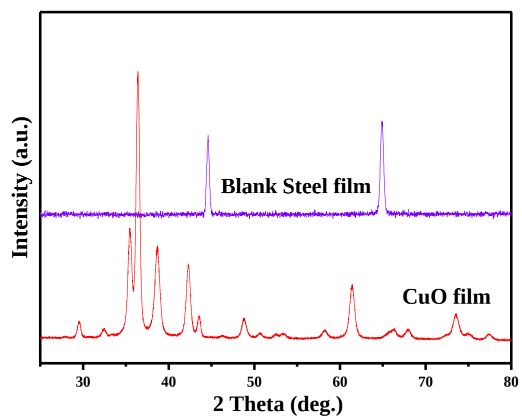

Fig 3 . XRD Studies

3.2 CV Studies

The CV curves of the films on stainless steel substrates recorded in 1 M KOH aqueous solution at various scan rates is shown in Fig. CV curves of the CuO nanostructured films exhibit very sharp redox peaks indicating that the electrochemical capacitance is due mainly to redox reactions. The redox peaks corresponds to the reduction of Cu^{2+} to Cu^{+} and the oxidation of Cu^{+} to Cu^{2+} during the intercalation of smaller H^{+} or the bigger K^{+} into the matrix of the material.

Table 1. Electrochemical parameters of CuO thin film

Electrode	Electrolyte	Capacitance F	Specific capacitance Fg^{-1}	Stability %	Specific Energy(SE) Wh/kg	Specific Power(SP) W/kg	Coulomb efficiency(η)%
CuO	1M KOH	0.0125	313	73.50	67.08	34.5×10^3	96.31

$$Cs = \frac{I_{max}}{(\frac{dv}{dt}).W} \quad \ldots (1)$$

where, I_{max} is the average current in ampere(A), dv/dt is the voltage scanning rate in volt (V) and W is the weight of CuO material dipped in electrolyte.

$$\text{Specific energy (SE)} = \frac{I_D \times t_D \times V}{W} \quad \ldots.2$$

$$\text{Specific Power (SP)} = \frac{I_D \times V}{W} \quad \ldots.3$$

$$\text{Columbic efficiency } (\eta) = \left(\frac{t_D}{t_C}\right) \times 100 \quad \ldots.4$$

W= 0.00004 gm

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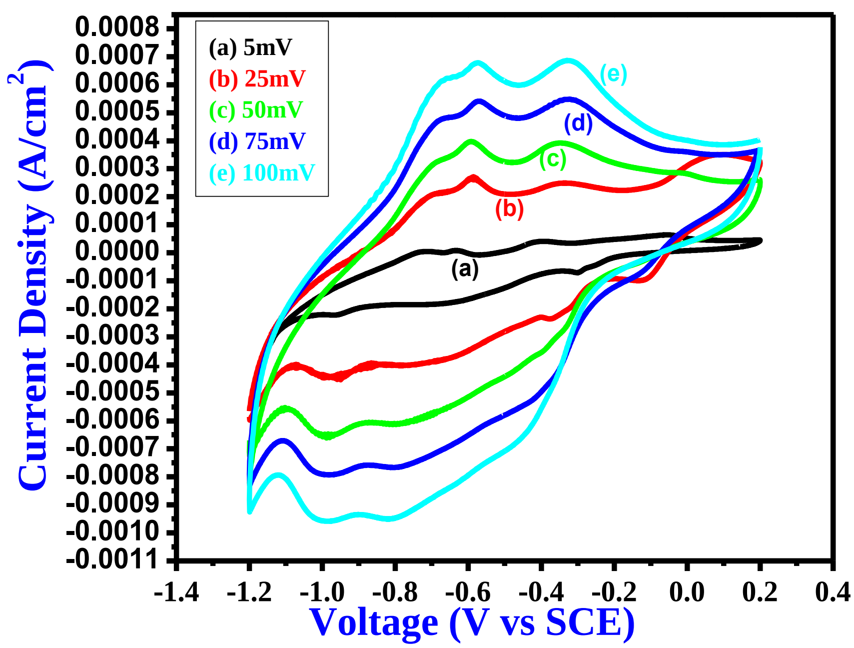
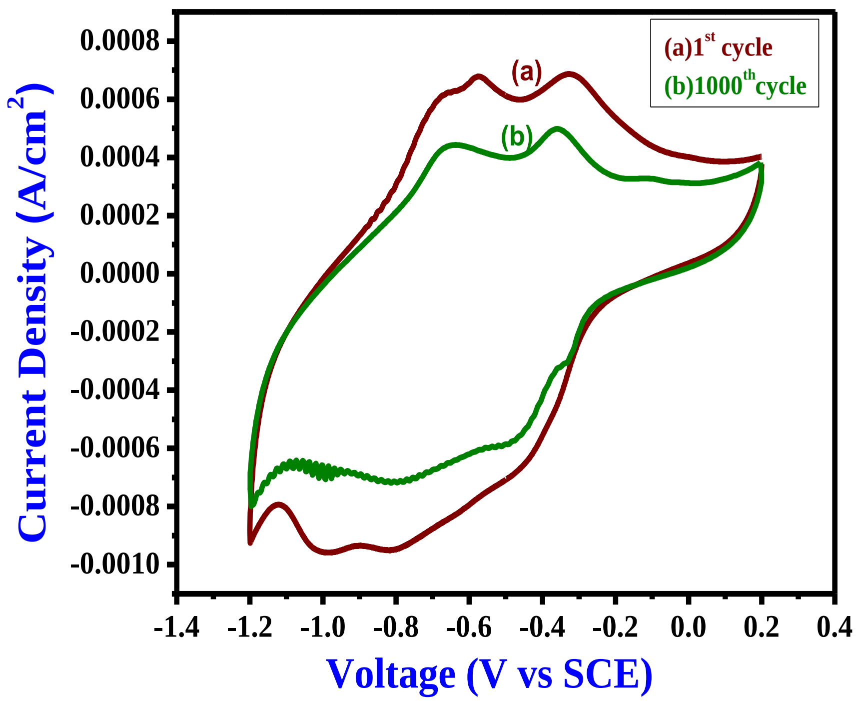
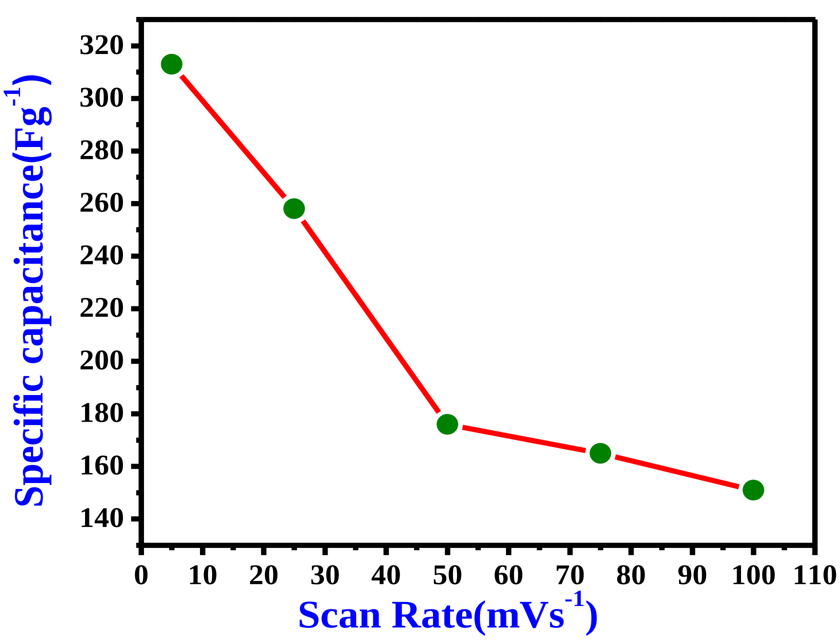



(a)1st cycle
(b)1000th cycle
(a)
(b)
Current Density (A/cm2)
Voltage (V vs SCE)
0.0008
0.0006
0.0004
0.0002
0.0000
-0.0002
-0.0004
-0.0006
-0.0008
-0.0010
-1.4
-1.2
-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4


Specific capacitance(Fg-1)
Scan Rate(mVs-1)
320
300
280
260
240
220
200
180
160
140
0
10
20
30
40
50
60
70
80
90
100
110

4. Conclusion

A simple, cost effective, electrodeposotion method was used to deposit nanostructures of CuO films on Steel. The film showed good application as supercapacitive electrodes. A high specific capacitance of up to 313 Fg_1 is obtained in 1 M KOH. This value is higher than most of the previously obtained results. In addition, a typical electrode showed 73 % stability and 96.31 coulombic efficiency indicating that our electrodeposited CuO film electrodes have excellent properties for use as supercapacitor electrode. Based on these encouraging results, future research efforts will be geared towards investigating theelectrochemical properties of the tandem structure of active materials (e.g. CuO films) working under extreme conditions such as high temperature and high pressure.

5. Refrenceses

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