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Cofe$_2$O$_4$ Thin Films for Super Capacitor Applications

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Abstract:
This paper presents overview on CoFe2O4 thin films as electrode for electrochemical supercapacitor applications. Supercapacitor, have been known for Energy storage device. Storage capacity in the form energy density and power density depends upon the material which are to be used for fabrication of Electrode. So Commonly investigated materials as Electrode for supercapacitor are cobalt ferrite. This brief overview focuses on the supercapacitive performance of CoFe2o4 Thin films as electrode for Electrochemical Supercapacitor. The exhibited specific capacitance of CoFe2O4 between 18.17 F/g to> 900 F/g which are quite good as comparable with the pure metal oxides. Therefore it is likely that CoFe2O4 will continue to plays a vital role for supercapacitor Applications.

Index Terms – Supercapacitor, CoFe2O4ThinFilms, Specific capacitance.

I.INTRODUCTION

The growing popularity of various portable electronic devices and motor vehicle has increased the request of energy storage devices. In this respects energy storage and conversion from alternative energy sources has been attracting widespread interest in both fundamental research and technological development. In many application areas some of operative and practical technologies for electrochemical energy conversion are storage batteries, fuel cells and supercapacitor [1]. Among these devices, supercapacitors signify as an emerging class of energy storage devices that have attracted increasing courtesy because of numbers of important features including high power density, recycle stability, fast charge or discharge rate, environment friendly, safe and light weight.[2] Supercapacitors storage energy in either capacitive (double layer of electrostatic charges) or pseudo capacitive (a faradic battery like reaction) nature [3]Supercapacitor developing both the advantages of battery (high energy density) and conventional capacitors (high power density).[4]

II.TYPES OF SUPER CAPACITOR

Usually according to the fundamental charge storage mechanism Supercapacitor can be classified into three types.

EDLCS (Electrochemical double layer capacitor) These capacitor is based on carbon based structure exploiting non faradic electrostatic charging of the electrical double layer formed at the electrolyte- electrode interface, hence it is called electrical double layer capacitor .In this capacitor oxidation reduction reaction does not takes place.The capacitance of EDLCS comes from the charge separation arising at interface between the electrode and electrolyte. Materials used in EDLCS are Carbon Aerogels, carbon nanofiber, Activated carbon, carbon nanotubes etc. [5]

Hybrid supercapacitor: The most supercapacitors relay on carbon based structures exploiting electrochemical double layer capacitor effect. By contrast a pseudocapacitor depends on charge stored due to faradic charge transfer process with the surface atoms. A combination of faradaic and non-faradaic components would create supercapacitors that exhibit high capacitance for pulse power as well as persistent energy. These supercapacitor are termed as Hybrid supercapacitor.Materials used in Hybrid supercapacitor are carbon materials, conducting polymer, carbon materials, Metal oxides etc.[6]

Pseudocapacitor

In pseudocapacitor, capacitance arises from faradic reaction occurring at the electrode material. The interest using Pseudocapacitor based materials for electrochemical capacitor is that the energy density associated with faradaic reaction is much higher than traditional double layer capacitance. Materials used in pseudocapacitor are Metal oxides and conducting polymers. [7]

The transition material oxides such as Ruthenium oxide, manganese's oxide, iron oxide, tin oxide, nickel oxide, Indium oxide, Bismuth oxide, Vanadium oxide, Bismuth Iron oxide, Iridium oxide, perovskites, Ferrites etc. are widely used as electrode material for Psuedocapacitor because of their fast reversible faradic reaction. This reaction can provide high energy density for pseudo capacitor and provided high specific surface area with good electrical conductivity. Among these metal oxides metal ferrite such as

$NiFe_2O_4$ [8], $CoFe_2O_4$ [9], Cufe2o4 [10] and $ZnFe_2O_4$ [11] thin films have demonstrated as high potential electrode material for supercapacitor applications as compare to pure metal oxides [12]. Particularly $CoFe_2O_4$ is most abundant material due to its low cost, high specific area, easy availability. It is with the above advantages and applications present or future work to develop supercapacitor using novel nanostructured inexpensive Cofe2O4 thin film as potential electrode directing on high power supercapacitor in general and storage device applications [13-14]

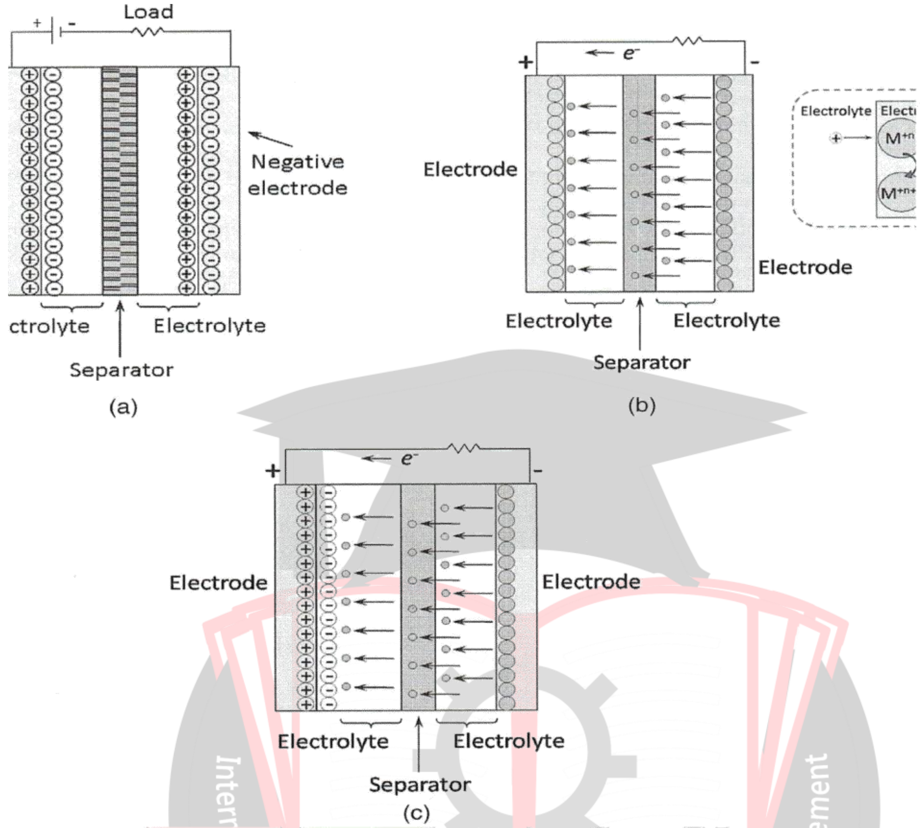

Fig.1 Schematic Diagram of 1) EDLC 2) Pseudocapacitor 3) Hybrid supercapacitor [15]

III.DEPOSITION METHOD OF $CoFe_2O_4$ THIN FILMS

Thin Film Deposition can be possible through Physical and Chemical Methods.

Physical Method

Physical method is not easy and economically fit for metal oxides and its ferrite thin films Physical Methods consists Physical Vapour deposition, Laser Ablation, Molecular beam epitaxy and sputtering.[16]

Chemical Method

Chemical method are relatively economical and easier ones as compared to physical method. Chemical methods are categories as Gas Phase and Liquid phase method. The Gas phase Methods are Spray , sol-gel [17], spin [18] and dip coating[19], atomic layer Epitaxy [20], chemical vapour deposition[21] and atomic layer Epitaxy[21]

THIN FILMS

Thin films are the thin layer of different materials like metal oxides, conducting polymer whose thickness is in nanometer size deposited on glass or steel substrate by using different deposition method for different applications. Application of thin films are widespread. Generally thin films are used in solar cell, Antireflection coating, gas sensor and supercapacitor.[22] particularly ferrite films are superior as compared to pure metal oxide thin films which are used in optoelectronic devices and energy storage devices.[23]

CoFe2O4 Thin Films as Electrode

Cofe2o4 Thin film based supercapacitors Exhibited superior values compared to their bulk and composite electrodes [24]. Level of supercapacitor performance of CoFe2O4 is sufficient for certain applications than pure iron oxide [25]. CoFe2O4 ferrite has high coerecivity, Mechanical strength, Chemical stability, moderate saturation magnetization, easy preparation methods, low cost has been used as electrode in supercapacitor applications [26].When CoFe2O4 thin film behave as a electrode for supercapacitor. Following parameter are required to check.

Characterization of CoFe2O4 Thin Films

X ray diffraction (XRD) The crystallographic structure are characterized by X ray Diffractions as well as to check the phase of material and particle size [27]

Scanning Electron microscopy

The micro morphological and structural characterization are investigated by Scanning Electron microscopy. Generally porous morphology indicates the specific capacitance High. [28]

Supercapacitor parameters

The specific energy stored and the specific power that can be delivered to the load are the vital characteristics of a supercapacitor device along with others, such as its cycling life, selfdischarge current and efficiency.

Cyclic voltammetry

Tool for initial screening of materials for electrochemical capacitor applications.it is used to characterize the performance of energy storage device in the form of specific capacitance.Specific capacitance calculated from following formula Where Cs is the specific capacitance, vis the potential scan rate,(vc-va) oprtional potential window, m is the mass of electrode material and I is the current response of electrode[29]

Charge discharge

Tool for measuring the charge and discharge time of supercapacitor.From discharge time it is possible to find out the specific capacitance of the materials.Specific capacitance calculated from charge discharge is,

IV.LITERATURE SURVEY

Following survey represents Deposition methods with conditions, Specific capacitance, Potential window, scan rate, Electrolyte, cyclic stability and retention of CoFe2O4 materials.

TABLE I. Progress of CoFe2O4 thin films for Super capacitor

Sr.no	Deposition method and conditions	Specific capacitance	potential window, scan rate, Electrolyte	Cyclic stability and retention	references
1	Co-percipitation method	18.17 at 1ma/cm^2	1M Na2so4	-	30
2	Hydrothermal Method	52.7 F/g	1 mv/s 1M KOH	-	31
3	Chemical co-percipitation method	142 f/g at 2mv/s	-0.1 to-0.5 v 2 to 50mv/s Alkaline electrolyte	71.8% retention after 1000cycles	32
4	Facile hydrothermal method	166.5c/g at 0.5A/g and 127.0at 10 A/g	-	79.3% retention after 5000cycles	33
5	Combustion method	356f/g	1ma/cm^2 1MKOH	-	34
6	Electrodeposition	366 f/g	1MNaoH 5mv/s	-	35
7	Simple chemical route method, cobalt chloride and ferrous chloride dissolved in distilled water	366f/g at 5mv/s	-0.2 to -1.0v 1M NaOH	91.6 retention at 10,000 cycles	36
8	Hydrothermal and co-precipitation method 1MFe (NO3)3.9H2O to 0.5M Fe (No3)3.9H2OFe/Co = 2:1).	specific capacitance 429 at 0.5A/g	0 to 0.4 v 5to 100mv/s 6MKOH	98.8 retention after 6000cycles at 10 A/g	37
9	Aerosol assisted chemical vapour deposition	540 uf/cm^2	0 to 1v 0.1 to 15v/s 1 M NaOH	80% retention after 7000cycles	38
10	Co-precipitation method 0.1 M Co (NO3)2_6H2O,	Specific capacitance 609 f/g at 2mv/s	-	-	39

	0.2 M Fe (NO3)3_9H2O and 0.29 M of citric acid (C6H8O7) were dissolved in 20 ml of Deionized water individually.				
11	Facile combustion method	758.86f/g at 2mv/s	2 to 50mv/s 1m KOH	-	40
12	Hydrothermal method	>900f/g	-0.01 to 40 v 6 MKOH	82.6 % retention after 6000cycles	41

Technology Challenges and Future outlook

The preceding section of this review describes some of the research and development efforts of Specific capacitance of CoFe2O4 thin films as Electrode Material for super capacitor applications. This is necessary to improve the super capacitance of CoFe2O4 and continue work on it in future. For the improvement appropriate methods, Materials, procedure, and Electrolyte Knowledge are required.

V.CONCLUSION

Super capacitor accepts the challenge of Energy storage problems. It behaves as a good energy storage device. For good energy storage behavior specific capacitance of Supercapacitor should be high and specific capacitance depends on Electrode materials.CoFe2O4 electrode shows the good specific capacitance as compare to pure metal oxides. This literature presents cofe2o4 thin film behaves as a good electrode which is fabricated by different methods and procedures. Development in the specific capacitance occurs from 15.17 to > 900 f/g. But some efforts are needed to balance the theoretical and practical value of the specific capacitance of CoFe2O4 by following different methods and Techniques.

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REFERENCES

[1] Nageshkumar et al. / Jouranal of clean Energy Technologies, Vol 6, No. 1 January 2018
[2] Oberja, VVN (2014) supercapacitors specialties -material Review AIP conf Proc1597:98-120
[3] Quan H et al. / Chem. Engg 2016, 283, 167-178
[4] C .D. Lokhande et al. / Current Applied Physics 11 (2011) 255-270
[5] A. A .Yadav/ Journal of Alloys and compounds 552 (2013)318-323
[6] V .S .Kumbhar et al. /Applied Surface Science 259 (2012).
[7] S. G .kandalkar et al. / Applied Surface Science 253 (2007) 3952-3956 395
[8] D .Chen et al. / J. Power Technology 133 (2003) 247-250
[9] X Shi et al. / Adv. Mater. 20 (2008) 1671-1678
[10] A. A. Yadav/ Journal of Alloys and compounds 543 (2012)129-134
[11] S.-L. Kuo et al. / Wu, Electrochem. Solid-State Lett. 8 (2005) A495.Nanostructured Thin Film Electrodes
[12] P. Sivagurunathan J Mater Sci; Mater Electron (2016) 27: 8891-8898
[13] Zarahadeen S. et al. / int, j. Electrochem. Sci., Vol. 11, 2016
[14] A.K. Shukla et al. /Electrochemica Acta 84 (2012) 165-173
15] Dinius perednis et al./ Journal of Electroceramics, 14, 103-111, 2005.
[16] R.R. Chamberlin et al. / J.Electrochem.Soc, 113 (1)86 (1996)
[17] C.J.Brinker et al. / J. Non Crys. Solids, 121(1-3), 294 (1990)
[18] C.C.Chen et al. / J. Electrochem Soc., 140 (12)3555 (1993)
[19] C.J. Brinker et al Thin Solid Films, 201(1), 97(1993)
[20] T. Suntola, Thin solid Films216 (1), 84 (1992)
[21] R. N. Ghosbtagore, J. Electrochem Soc, 125(1), 110 (1978)
[22] S.S Bellad et al. /Thin Solid Films 322 (1998) 93-97
[23] S. F.Alvarado, Z. Phys. B33-1979.51
[24]G.A. Shobaky, Journal of Alloys and compounds 493 (2010) 415
[25] I. Sandu et al. / Thin solid Films 495 (2006)
[26] D. K. Pawar et al. / Journal of Alloys and compound 509 (2011)3587

[27] Abhijit A. Yadav et al. / Journal of Electroanalytical chemistry (2016)
[28]Abhijit A Yadav et al. / Thin Solid Films (2016)
[29] Abhijit A. Yadav et al. / Electrochemica Acta (2017)
[30] He.P Hang et al. / J .Electrochem 49(4), 359-364(2013)
[31] Xiong P et al. / J. power Sources 245:937-946 (2014)
[32] L.lv et al. / Material Letters(2013)
[33] Ping Liu et al. / Electrochemica acta (2017)
[34] Umesh Babu e et al. / Int. J Hydrogen Energy 39:15627-15638
[35] Kumbhar V.S. et al. / Appl Surf Sci 259:39-43
[36] V. S.Kumbhar et al. / Applied surface science 259 (2012) 39-43
[37] H Kennaz et al. / J Solid State Electrochem (2017)
[38] Jagdeep S Sagu et al. / Elctrochemica Acta 246 (2017) 870-878
[39] P Sivagurunathan et al./ J Mater Sci: Mater Electron (2016) 27: 8891-8898
[40] A.Shanmugavani et al. / Materials Research Bulletin (2015)
[41] Xueyi Guo et al. / Journals of Alloys and compounds (2017)

