Nanostructured Anode Material ($Ce_{0.4}$ $Zr_{0.6}$) for Low Temperature S0FC

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***Abstract*: - SOFC have much capability to become an economical alternative energy conversion technology .The nanoscale engineering have been incorporated to improve catalytic activity. We have made nanocomposite anode material for low temperature solid oxide fuel cell for operating at low temperature . The nanomaterial is made up by sol gel method. The material demonstrated the outstantding electrochemical out put 550 mv/cm^{-2} at 600 ◦C. anode shows good conductivity and crystalinity**

Keywords: Sol-gel, Nanocomposite SOFC, Impedance, XRD

I. INTRODUCTION

Solid oxide fuel cells had (SOFCs) have a high essential effectiveness for inter change between chemical and electrical energy, fuel flexibility, which is matchless by other fuel cell technologies .hence, SOFCs possibly will comprise a tactical technology to help the change from a "carbon ",based on the use of fossil fuels, to a "green economy" based on the use of renewable sources and distributed energy generation [1].

It is necessary to develop lower temperature fuel cell which could be operate at comparatively less temperature i.e. between 500 -600 ^{O}C .and even in different operating condition. In recent years novel research is in progress giving rise to in new material known as nano form materials , to achieve the goal of low temperature [2,3] . In development of SOFC material as anode NIYSZ is mostly used cermets as anode. But it has certain issues of carbon deposition , poor tolerance to sulphur as most of fossils fuel contains sulphur as impurity, issues created by metal degeneration ,so it is demand of technology to develop more durable and active anode [4,5] . after reviving consideration is given on optimisation of anode material which will work as good oxidation catalyst , so cerium and the transition metal alloy , such as ceria[7-8],and other transition metal alloys are in attention of researcher. The CeO_2 nanocomposite material gives the very high catalytic activity towards hydrocarbon oxidation also such material acquire considerable n type electron conductivity which contributes to the extension of three phase boundary to broad portion of anode surface .Due to redox properties of cerium ions . Oxygen transport properties and reducibility can be enhanced by acceptor type doping. The ceria based zirconia is found useful for overcoming the problems of Nickel based electrocatylist such as Ni-YSZ and NI-SDC [6,7] The problems that includes the deposition and degradation of electro catalyst .These disadvantages can be overcome by developing carbon resistant electrocatalyst that have elevated catalytic activity.some LTSOFC electrode catalyst material have increased electronic and ionic conductivity , some issues that concerting the electrode morphology and electrolytic compatibility at low temperature [8-9].Each component is enhancing the performance of fuel cell in term of morphology conductivity and compatibility with each other. To achieve high performance the anode must have nano particle size which gives high surface area, enough porosity and sufficient Ni content according to some researcher [10,11] . The purpose of this paper is to develop nickel free nancomposite as metal oxide for LTSOFC , that will work well in low temperature

II. MATERIALS AND METHODS

2.1 Sample Preparation:

Nanocrystalline $Ce_{0.4}Zr_{0.6}O_3$) were prepared using sol–gel [12] method. High purity nitrates were used for the preparation. A stoichiometric mixture cerium nitrate and zirconium nitrate were used as raw materials. A stoichiometric mixture of nitrates was mixed with equal amount of citric acid and 30 ml ethanol and stirred magnetically on hot plate at 80^{O}C for 3h to obtain a homogenous mixture; the solution was further heated in a pressure vessel at about 130^{O}C for 12 hrs and subsequently kept at 350^{O}C for 3 hrs in muffle furnace and then milled to a fine powder The dried powder was then calcined in the range of 350°c to 750^{O}C for 6 hrs in order to improve the crystallinity and surface morphology and porosity of the powder .The pellets of powder was made by applying 8 tones of pressure in pellets machine in stainless steel die.The pallets are made of 13.2 mm diameter and 1.45 mm thickness .The impedance measurement were done on the pellets by applying silver paste on it . By using an HIOKI 3532-50 LCR HI-TESTER . Impedance measurement was carried out in the frequency range 42 Hz-500 MHz and at temperature range 400°C to 600°C.

III. RESULT AND DISCUSSION

3.1 Strictural and Morphological analysis:

A. XRD Analysis

The sample were studied for their crystal structure using an X ray diffractometer Rigakujapnese smart lab defreactormeter with 3 kw x ray generator Cu tube in Nitrogen atmosphere The analysis of morphology and nanostructure is analysed by SEM and TEM images.

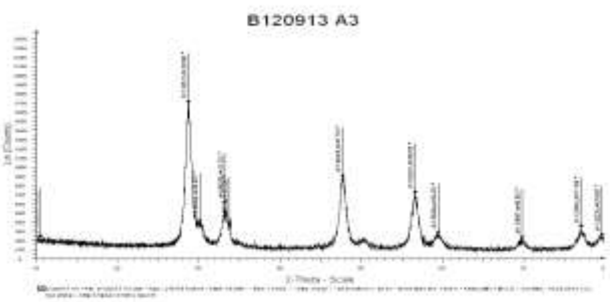

Figure 1 The XRD analysis of Ceria doped Zirconia

The sample preparation sol-gel process large quantity nanoparticels Ce .The small Ce paritcal is responsible for large catalytic activity .The ZrO is responsible for increasing electronic activity [13,14] . The XRD pattern shown in Figure 1 shows reaction taking place between CeO and ZrO . The XRD peaks observed for oxides so it is clear that solid state reaction is occurred in oxides . The average particle structure obtained from Debyeshearer formula is found to be 10-25nm . The SEM image reveals the porous but homogeneous structure which is formed due to the optimal sintering temperature of 750^{O}C for 6hours . By which anode performed well.The sol gel process produces nanoparticals which are responsible for catalytic activity large quantities of Ce Zr. Preparation method produces large quantities inexpensively. In the CeZr anode, the small Ce particle size might be important to catalytic activity [15].

The XRD pattern is presented in Fig. 1, which shows the significant reaction occurring between CeO and ZrO. The CZ prepared oxides possessed a perovskite phase tetragonal cubic structure with CeO incorporated into a phase. The XRD peaks showing oxides. These showed that a solid-state for mateiral

B. The SEM and TEM analysis:

The SEM Fig 2 (a , b) results homogeneous surface morphology along with nanocomposite particles.The connectivity of particles within material is very excellent and found also porous.As product is subsequently pressurised for 12 hours and sintered for nearly 6 hours temperature 700 ◦C resulted in this type of surface structure that could be beneficial for conductivity . The optimised nanostructure and surface morphology will be the best improvement in the anode properties.The fine particle size allocation (about 10–30 nm), the adequate porosity, and the amount of well-connected Ce and Zr all contributed to the fuel cell's high performance. These well-connected Ce Zr nanoparticles and relatively high content Zr phase in the composite electrode and anode enhanced the electronic conduction which are the key features found in TEM Fig. 2(c) and (d).

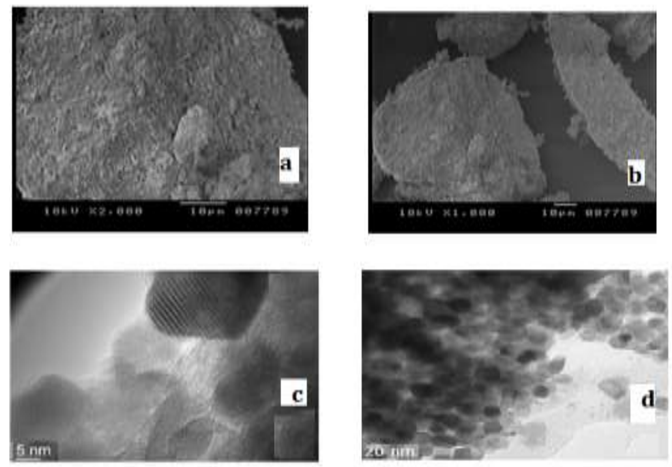

Figure 2 SEM images of $Ce_{0.4}$ $Zr_{0.6}$ (b and c)TEM images c and d

3.2. Electrochemical Impedance analysis : Conductivity Measurement:

The impedance measurement were done on the pellets by applying silver paste on it . By using an HIOKI 3532-50 LCR HI-TESTER . Impedance measurement were carried out in the frequency range 42 Hz-500 MHz and at temperature range 400°C to 600°C in air. The maximum value of DC conductivity reveals that the material is suitable for anode material. The OC Voltage and power densities shown in Fig. 3 were 500mWcm^{-2} at 550 ◦C.The performace of anode resembles with the Nickel yittriab stabilised anode and Ni-SDC at comparatively lower temperature.[14-16]

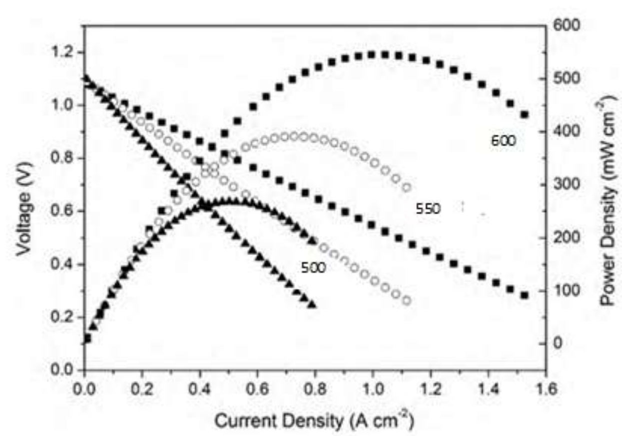

Figure 3 Cell voltage and power density as a function of current density in air in rage of 500-600^{O}C

The current voltage (I-V) and the corresponding power density (I-P) curves for CZ operating at pure 400^{O}C to 600^{O}C as shown in figure .The power density increases with temperature .The increased ionic conductivity electronic conductivity and lower resistance for electrode reaction contribute to improved performance of anode. The highest power density obtained for sample $Ce_{0.4}Zr_{0.6}$at 600^{O}C.which is 550 Mv/cm^{-2} . Which could be increased further on basis of observation .This observation indicates that we can use nanostructure CZ material as anode in fuel cell.

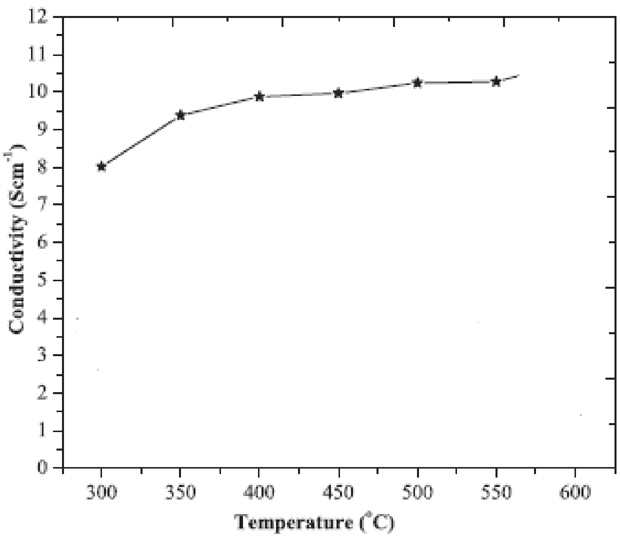

Figure 4: Arrhenius plot of DC conductivities of $Ce_{0.4}Zr_{0.6}$ in air D.C.

The DC conductivity of sample were measured in dry air in temperature range of 300-600^{O}C .Their results of measurement is shown in Figure 4 ,The maximum value of DC conductivity was found to be 10.83 S/cm at temperature 550^{O}C.This electrical conductivity follow the metallic behaviour.

IV. CONCLUSION

The anode nanostructure material CeZe have been successfully synthesized by sol gel method .The XRD pattern shows that all composition ranges from 10nm to 30 nm . SEM Images show good prorous structure and TEM image reveals Nano size of material. It has been observed that component has maximum power density of at 550mv/cm^2 at 600^{O}C.The purpose of study to find Ni free composite anode on the basis of Nano material aspects . It concludes that said sample is highly suitable as anode material or can have infiltration with other metal which could be interesting aspect to see

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