Indian Institute of Technology Delhi
Department of Chemical Engineering

Date: 23/07/2020

Ph.D. Viva-Voce Examination

Mr Baijnath (2014CHZ8164) will defend Ph.D. thesis titled '**Development of Cobaltite and Ferrite based Perovskite Cathodes for Solid Oxide Fuel Cells**' on July 29 (Wed), 2020 through MS-Teams webinar in the Department of Chemical Engineering at 10 AM. The link will be sent separately.

All are cordially invited to attend the seminar.

Date & Time: July 29, 2020 (Wed) at 10 AM

Through MS-Teams (link will be sent separately).

SBasu

Prof Suddhasatwa Basu
(Supervisor)

Copy to:

1. HOD; DRC Chair
2. External Examiner: Dr S. T. Aruna, CSIR-NAL Bangalore
3. SRC Members: Prof. Anil Verma, Prof Ali Haider, Prof. Pravin P Ingole (Chem)
4. All Faculty Members
5. DRC, Sec & Ph.D. coordinator
6. Department Notice Board – PG students
7. All HODs – for circulation

Abstract overleaf

Abstract

Development of Cobaltite and Ferrite based Perovskite Cathodes for Solid Oxide Fuel Cells

Perovskite cathode materials have been synthesized by different methods and tested in solid oxide fuel cell (SOFC) to enhance the oxygen reduction reaction. Single perovskite, $La_{0.5}Sr_{0.5}CoO_3$ (LSCO) cathode has been synthesized by different synthesis routes i.e., sol-gel method, glycine-nitrate method, solid state route and impregnation method. Comparative study has been done for ionic conductivity and to assess the performance of SOFC. LSCO synthesized by sol-gel method provided highest ionic conductivity of 0.42 S/cm at 700 °C and lowest activation energy of 0.32 eV between 500 to 700 °C among all other synthesis methods. LSCO synthesized by sol-gel method shows lowest area specific resistance (ASR) of 3.52 Ω cm^2 at 800 °C for half-cell (LSCO- yttria doped ceria (YDC)/YDC). 5, 7 and 10 wt% LSCO impregnated porous yttria-stabilized zirconia (YSZ) cathodes have been electrochemically characterized using 2-probe AC conductivity method. Maximum ionic conductivity of 0.27 S/cm at 800 °C and activation energy of 0.15 eV between 600-800 °C have been observed for 10 wt% LSCO-YSZ cathode. ASR of 1.01 Ω cm^2 at 800 °C is estimated for the electrolyte supported half cell (10 wt% LSCO-YSZ/YSZ). The electrolyte supported full cell (10 wt% LSCO-YSZ/YSZ/NiO-YSZ) has been tested and maximum power density 51.12 mW/cm^2 (109.38 mA/cm^2) at 800 °C is observed. The electrolyte supported full cell exhibited 6 Ω cm^2 electrode polarization at 800 °C in H_2, which is in higher side leading to low performance. LSCO impregnated porous YSZ performed better than other synthesis routes.

To assess the electrochemical performance of double perovskite cathodes $Ca_2Fe_2O_5$ (CFO), $Ca_2Fe_{1.8}Mo_{0.2}O_5$ (CFMO), $Ca_2Fe_{1.8}Co_{0.2}O_5$ (CFCO), and $Ca_2Fe_{1.8}Mo_{0.1}Co_{0.1}O_5$ (CFMCO) have been synthesized and tested in SOFC. Fe site of parent $Ca_2Fe_2O_5$ (CFO) structure is partially substituted by Co and/or Mo as well as Co-Mo co-doping and tested as cathodes in SOFC. Physical characterizations such as X-ray diffraction (XRD), scanning electron microscope (SEM), energy-dispersive X-ray spectroscopy (EDX), transmission electron microscope (TEM), and Brunauer–Emmett–Teller (BET) have been carried out to assess the phase formation, microstructure, presence of constituent elements, particle size, and surface area of the cathode, respectively. The Co doped CFO cathodes have better percolation, large surface area, and extended triple phase boundary. Further, the doped CFO cathodes exhibited chemical compatibility with other cell components during fabrication and cell testing as evident from SEM micrographs. The best electrical conductivity, 0.47 S/cm at 800 ºC and the corresponding activation energy of 0.17 eV is exhibited by $Ca_2Fe_{1.8}Co_{0.2}O_5$ (CFCO), whereas $Ca_2Fe_{1.8}Mo_{0.2}O_5$ (CFMO) and $Ca_2Fe_{1.8}Mo_{0.1}Co_{0.1}O_5$ (CFMCO) cathode shows electrical conductivity 0.11 S/cm and 0.15 S/cm at 800 ºC, respectively. CFMO performed better with SDC than YSZ electrolyte between 600-700 °C although the lowest area specific resistance (ASR) of 1.28 Ω cm^2 at 800 °C is observed for CFMO with YSZ electrolyte. Similarly, CFMCO provided low ASR at lower temperature with SDC than that with YSZ electrolyte but exhibited lowest ASR of 0.41 Ω cm^2 at 800 °C with YSZ. The CFCO cathode shows lower ASR with YSZ than that with SDC for all the temperature and provided lowest value of ASR 0.21 Ω cm^2 at 800 °C. CFCO cathode has been tested in 900 μm thick electrolyte (SDC/YSZ) supported solid oxide fuel cell (SOFC) CFCO-SDC/SDC/NiO-SDC and CFCO-YSZ/YSZ/NiO-YSZ provided maximum power densities of 171 and 506 mW/cm^2 (i-R corrected) at 800 °C, respectively. It is inferred that the CFO based double perovskite cathodes performed better than that of LSCO in SOFC test condition.

Keywords: SOFC, perovskite cathode, mixed ionic electronic conductor,