전기방사법을 통해 제작된 실 구조 고체산화물 연료전지 공기극의 계면 접촉 향상

Enhancement of the interfacial contact of fiber-shaped cathode of solid oxide fuel cells fabricated by electrospinning

Sanghun Lee†* (int167@kaist.ac.kr)**, Sejin Song*, Joongmyeon Bae***
(* Department of Mechanical Engineering, Korea Advanced Institute of Science and Technology (KAIST))

Abstract

Electrospinning has been widely used for fabricating fiber-shaped structures, which provide high surface area, and continuous ionic and electronic conduction. Therefore, electrospinning can improve electrochemical performance of electrodes. There has been studies to apply electrospinning to cathode of solid oxide fuel cells. However, fiber-shaped cathode has low adhesion to electrolyte due to low contact area, which increase contact resistance. In this study, several approaches to improve interfacial contact of fiber-shaped cathode were proposed. To evaluate contact resistance, impedance spectra of symmetrical cells were measured. As a result, it was observed that ohmic and polarization loss were significantly decreased by improved interfacial contact of fiber-shaped cathode through the several approaches.

Introduction

▪ Solid Oxide Fuel Cell (SOFC)

- High energy conversion efficiency ➔ Solution for energy issue
- Issues for commercialization

➔ High manufacturing cost: Improving energy efficiency
→ Less materials cost

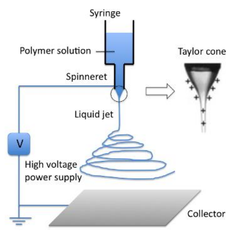
➔ Low volumetric energy efficiency: Improving power density
→ Less package volume

▪ Electrochemical performance

- Limitation: Cathode performance
- Key issues: Triple phase boundary + Connectivity between particles

➔ Fiber-shaped cathode can improve connectivity between particles

▪ Fabrication of fiber-shaped cathode



- Easy fabrication of fiber-shaped cathode by electrospinning
- High interfacial resistance between fiber-shaped cathode and electrolyte due to bed interfacial contact
  → Low electrochemical performance
  ➔ A method to improve interfacial contact is required

Experimental

▪ Preparation of slurry for electrospinning

− BSCF (Kceracell, Republic of Korea), GDC (UHSA, Rhodia, USA), poly vinyl pyrrolidone (PVP, Mw ~ 1,300,000), and ethanol mixture, ball milling for 24 h

▪ Fabrication of fiber-shaped cathode by electrospinning

− Loading the slurry in a syringe, Applying voltage between stainless steel plate and needle, Feeding slurry with fixed rate
− Distance between need and plate: 10cm, Voltage: 11 kV, Needle: 24 gauge, Feeding rate: 1.8 ml/h
− Calcinated at 500 ℃ for 4 h

▪ Impedance spectra analysis

− $Gd_{0.1}Ce_{0.9}O_{1.95}$ (GDC) was dry-pressed and sintered at 1450 °C for 6 h to fabricate electrolyte support
− Cathode paste was coated on the both side of the electrolyte support by screen printing, and sintered at 950 °C for 2 h
− The AC impedance spectra of fabricated half cells were tested by 4-probe method
(SI 1260, SI1287, Solartron, UK)

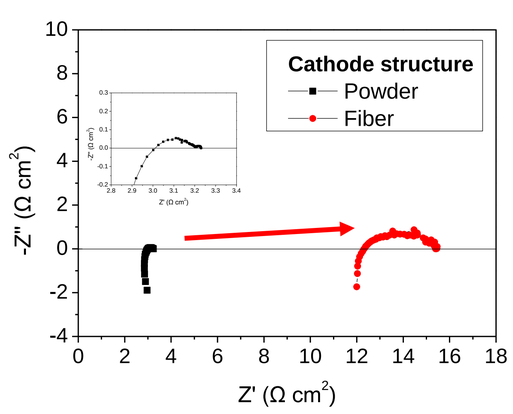
Conclusion

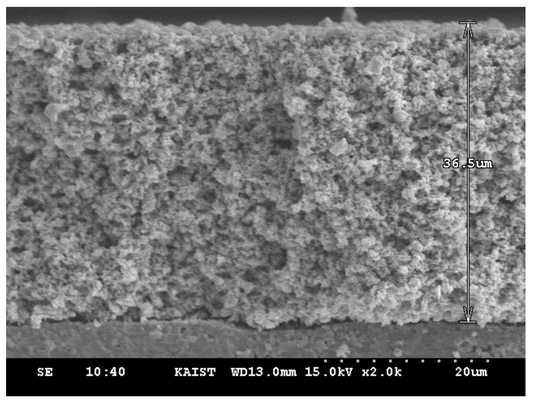
- Fabrication of BSCF-GDC fiber-shaped cathode by electrospinning
- Effects of interfacial contact of fiber-shaped BSCF-GDC on impedance spectra
- Improvement of interfacial contact by mixing GDC powder and BSCF fiber
- Higher interfacial contact with addition of nano-size GDC

Result

▪ Impedance spectra of fiber-shaped cathode

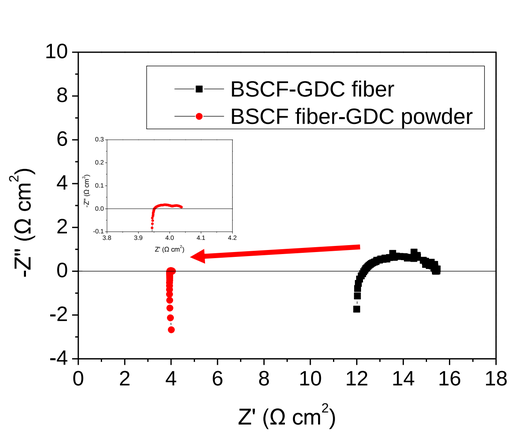
− Comparison of fiber-shaped BSCF-GDC (50:50) and BSCF-GDC powder (50:50)
− Increase in ohmic and polarization resistance in the case of BSCF-GDC fiber
− Delamination between cathode and electrolyte

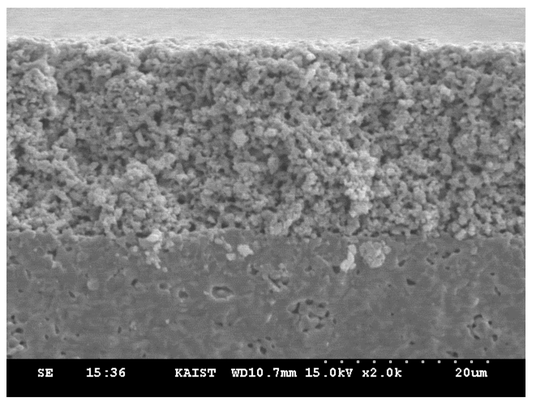




▪ Impedance spectra of BSCF fiber-GDC powder cathode

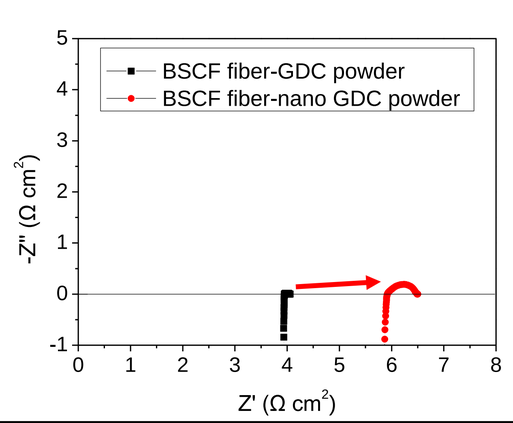
− GDC powder mixed with as-prepared BSCF fiber
− Decrease in ohmic and polarization resistance
− Improved interfacial contact between cathode and electrolyte

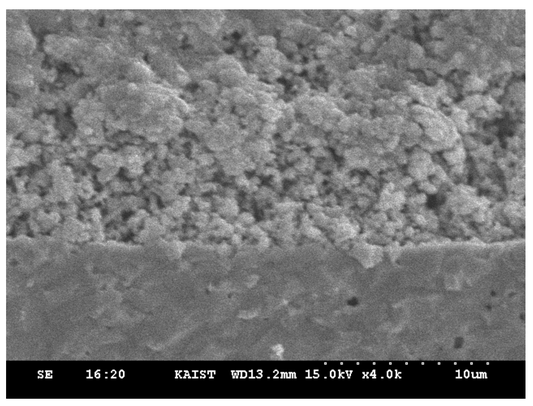




▪ Impedance spectra of BSCF fiber-GDC nano powder

− Nano-size GDC mixed with as-prepared BSCF fiber to improve interfacial contact and TPB length
− Increase in ohmic and polarization resistance
− Formation of small GDC particles on the surface of BSCF fiber
− However, worse interfacial contact, leading to higher impedance





Acknowledgement

This research was supported by a grant from the Fundamental R&D Program for Core Technology of Materials funded by the Ministry of Knowledge Economy, Republic of Korea and the Global Frontier R&D Program on Center for Multiscale Energy System funded by the National Research Foundation under the Ministry of Education, Science and Technology, Korea. Also, this work was supported by the Korea CCS R&D Center(KCRC) grant(No 2014M1A8A1049299) funded by the Korea government(Ministry of Science, ICT & Future Planning) and KEPCO & Korea Western Power Co..

KECS 2016 Annual spring meeting
(April 07-09, 2016, Kimdaejung Convention Center)