Journal of Alloys and Compounds 835 (2020) 155347

Contents lists available at ScienceDirect

Journal of Alloys and Compounds

journal homepage: http://www.elsevier.com/locate/jalcom

Sintering-resistant platinum electrode achieved through atomic layer deposition for thin-film solid oxide fuel cells

Han Gil Seo [a, 1, 2], Sanghoon Ji [b, 1], Jongsu Seo [a], Sanwi Kim [c], Bonjae Koo [a, 3], Yoonseok Choi [a, 4], Hyunseung Kim [a], Jeong Hwan Kim [d], Taek-Soo Kim [c], WooChul Jung [a, *]

[a] Department of Materials Science and Engineering, Korea Advanced Institute of Science and Technology, 291 Daehak-ro, Yuseong-gu, Daejeon 34141, Republic of Korea
[b] Environmental Resource Research Center, Department of Land, Water and Environment Research, Korea Institute of Civil Engineering and Building Technology, 283 Goyang-daero, Ilsanseo-gu, Goyang 10223, Republic of Korea
[c] Department of Mechanical Engineering, Korea Advanced Institute of Science and Technology, 291 Daehak-ro, Yuseong-gu, Daejeon 34141, Republic of Korea
[d] Department of Advanced Materials Engineering, Hanbat National University, 125 Dongseo-daero, Yuseong-gu, Daejeon 34158, Republic of Korea

ARTICLE INFO

Article history:
Received 11 February 2020
Received in revised form
22 April 2020
Accepted 22 April 2020
Available online 28 April 2020

Keywords:
Thin-film solid oxide fuel cell
Atomic layer deposition
Al_2O_3
Pt electrode
Oxygen reduction reaction

ABSTRACT

Thin-film solid oxide fuel cells (TF-SOFCs) using a dense and thin electrolyte have attracted much attention as a promising portable power generator because they can lower the operating temperature of devices, which is a key issue related to conventional SOFCs, to below 500 °C and are compatible with several microfabrication processes. Highly porous interconnected Pt thin films are now widely used as oxygen electrodes, but their poor thermal stability seriously hampers the sustainable operation of TF-SOFCs. Here, we demonstrate how Al_2O_3 layers coated through atomic layer deposition effectively suppress the degradation of nanoporous Pt thin-film electrodes. Although Al_2O_3 is an electrical insulator, the selection of an appropriate overcoat thickness ensures stable electrochemical reaction sites of the Pt electrode at high temperatures even without serious current collection or gas flow issues. As a result, a 3.6-nm-thick Al_2O_3 layer maintains the high specific surface area morphology of Pt thin films at 450 °C and improves the electrode activity by more than twofold compared to an uncoated sample. These results suggest that a simple and scalable coating strategy enables the implementation of TF-SOFCs with ideal performance and durability outcomes.

1. Introduction

Solid oxide fuel cells (SOFCs) have attracted a considerable amount of attention as a promising electrochemical energy conversion device owing to their high conversion efficiency, fuel flexibility and low overall emissions [1]. However, the high temperature (>700 °C) required for their operation increases the material and system costs and shortens device lifetimes, which are grand challenges to those working toward SOFC commercialization [2–4]. Among the many attempts thus far to lower the operating temperature (<500 °C), thin-film-based SOFCs (TF-SOFCs) composed of a dense thin film of solid electrolyte between porous film electrodes have been actively studied in recent years [5–13]. The use of a thin electrolyte membrane can significantly reduce the ohmic resistance, even at reduced temperatures. Furthermore, TF-SOFCs can be miniaturized on Si or other commercially available wafers with microelectromechanical system (MEMS) components, making them easy to use in portable electronic devices. Nonetheless, the high electrochemical resistance of the essential cell components, the cathode in particular, at low temperatures remains the greatest obstacle preventing the implementation of high-

* Corresponding author.
E-mail address: wcjung@kaist.ac.kr (W. Jung).
[1] These authors contributed equally to this work.
[2] Current address: Department of Materials Science and Engineering, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139, USA.
[3] Current address: Department of Mechanical Engineering, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139, USA.
[4] Current address: Energy Materials Laboratory, Korea Institute of Energy Research, 152 Gajeong-ro, Yuseong-gu, Daejeon 34129, Republic of Korea.

https://doi.org/10.1016/j.jallcom.2020.155347