



Contents lists available at ScienceDirect

Journal of Power Sources

journal homepage: [www.elsevier.com/locate/jpowsour](http://www.elsevier.com/locate/jpowsour)

# Cathode durability enhancement under start-up/shut-down process using IrRuO<sub>x</sub>/C catalyst in polymer electrolyte membrane fuel cell

Myoungki Min<sup>a</sup>, Eunyoung You<sup>b</sup>, Seung Woo Lee<sup>c</sup>, Chanho Pak<sup>c,\*</sup>

<sup>a</sup> Fuel Cell Group, Battery R&D Center, Samsung SDI, Yongin-si, Gyeonggi-do, 17084, Republic of Korea

<sup>b</sup> Fuel Cell Engineering Team, Division of Electric Powertrain, Hyundai Mobis Co., Ltd., Uiwang-si, Gyeonggi-do, 16082, Republic of Korea

<sup>c</sup> Graduate School of Energy Convergence, Institute of Integrated Technology, Gwangju Institute of Science and Technology, Gwangju, 61005, Republic of Korea

## HIGHLIGHTS

- Carbon-supported 80 wt% IrRuO<sub>x</sub>/C catalysts is prepared by a sub-substrate method.
- Ir<sub>1</sub>Ru<sub>1</sub>O<sub>x</sub>/C is observed to be the best catalyst in terms of activity and stability.
- The application of a 2.5 wt% catalyst in cathode improves SU/SD MEA durability.
- The AST resulted in the 15% reduction of ECSA of the Pt in the OER-added cathode.

## ARTICLE INFO

### Keywords:

Cathode durability  
Membrane electrode assembly  
Start-up and shut-down  
Oxygen evolution reaction  
Carbon-supported IrRuO<sub>x</sub> catalyst

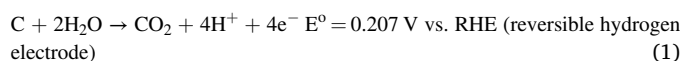
## ABSTRACT

The disruptive degradation of the electrode in the membrane electrode assembly (MEA) under the transient situation during the fuel cell electric vehicle operations such as fuel starvation, start-up and shut-down (SU/SD), etc. is to be addressed. To mitigate the carbon corrosion in the electrode, the catalyst for oxygen evolution reaction (OER) has been investigated recently. It evolves oxygen from water, thereby mitigating carbon corrosion at voltages over 1.5 V, which is typically induced during SU/SD cycles. In this study, carbon-supported IrRuO<sub>x</sub> catalysts towards OER are synthesized using a sub-substrate method, and their electrochemical and physico-chemical properties are analyzed using several methods. Ir<sub>1</sub>Ru<sub>1</sub>O<sub>x</sub> (Ir:Ru = 1:1 at. ratio in the oxide form) is observed to be the best catalyst in terms of activity and durability. The application of a 2.5 wt% OER catalyst to the cathode improves the carbon corrosion durability of the MEA by approximately 88 %. After 4000 SU/SD cycles, the electrochemical surface areas of the Pt in the OER-added MEA and reference MEA are reduced by 15 % and 57 %, respectively. When the OER catalyst is applied to the reference cathode electrode, it enhances the durability of the MEA without compromising the performance significantly.

## 1. Introduction

The polymer electrolyte membrane fuel cell (PEMFC) is a viable alternative powertrain for next-generation vehicles because of its higher energy density, higher conversion efficiency, and lower emissions of environmental pollutants compared with conventional energy sources [1,2]. After the commercialization of the fuel cell electric vehicle (FCEV) by the Hyundai Motor Company in 2013, Toyota, Honda, and Mercedes Benz have sequentially launched the Mirai in 2014, Clarity FCEV in 2016, and GLC F-Cell in 2018, respectively [3,4]. Despite the continuous developments of PEMFC systems, several challenges still persist for expanding the FCEV market including cost, performance, and durability

[3,5]. The ultimate durability target set by the United States Department of Energy (DOE), which has been updated recently, is more than 8000 operation hours [6]. Although it is difficult to clearly define the lifetime of a PEMFC, it is generally accepted that existing technologies cannot achieve the target lifespan. Particularly, repeated start-up/shut-down (SU/SD) conditions induce a carbon oxidation reaction (COR) and lead to overall performance degradation. The mechanism of COR is shown in Eq. (1)



\* Corresponding author.

E-mail address: [chanho.pak@gist.ac.kr](mailto:chanho.pak@gist.ac.kr) (C. Pak).

<https://doi.org/10.1016/j.jpowsour.2020.229423>

Received 19 July 2020; Received in revised form 28 October 2020; Accepted 26 December 2020

Available online 16 January 2021

0378-7753/© 2021 Elsevier B.V. All rights reserved.