



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

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## 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<sub>2</sub>O<sub>3</sub> layers coated through atomic layer deposition effectively suppress the degradation of nanoporous Pt thin-film electrodes. Although Al<sub>2</sub>O<sub>3</sub> 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<sub>2</sub>O<sub>3</sub> 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.

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## 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-

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