Abstract

Reducing the operating temperature of solid oxide fuel cells (SOFCs) to the intermediate range of 500–800°C has become a priority to enhance system durability, lower costs, and minimize undesired chemical reactions between cell components. Strontium-doped lanthanum cobaltite (LSC) is a well-known cathode material for its high oxygen reduction activity, but its performance is limited by surface Sr segregation, which reduces oxygen exchange efficiency. Introducing Nb as a dopant into the B-site of LSC significantly improves its thermal stability and oxygen ion transport. The modified material demonstrates superior diffusion characteristics and enhanced stability, making it a promising candidate for intermediate-temperature SOFC (IT-SOFC) applications.

Further advancements in cathode materials focus on double perovskites such as $Sr_2CoNbO_{6-\delta}$ (SCNO), which exhibit improved electrochemical performance when integrated with Sm-doped ceria (SDC) as a composite material. SCNO-SDC composites enhance thermal expansion compatibility, increase oxygen vacancy concentration, and boost conductivity compared to pure SCNO. These modifications lead to higher power outputs and greater resilience under challenging conditions, such as air environments containing CO_2.

Structural modifications of SCNO-SDC composites significantly influence their electrochemical performance. Cathodes prepared through electrospinning achieve a nanofiber morphology, resulting in superior oxygen reduction reaction (ORR) activity and lower resistance compared to conventional synthesis methods like mixing or one-pot synthesis. Electrospun SCNO-SDC composites demonstrate enhanced oxygen adsorption and dissociation, leading to a substantial increase in performance under operating conditions. Additionally, co-sputtering techniques have been explored to fabricate SCNO-SDC electrodes for IT-SOFCs. These methods produce dense and stable electrodes, further improving ORR kinetics and reducing polarization resistance. Comparative studies reveal that cathodes fabricated with SCNO-SDC composites outperform those made with pure SCNO, showcasing the importance of composite engineering in achieving long-term performance stability.

This study emphasizes the critical role of material innovations such as Nb doping, composite formation, and advanced fabrication techniques like electrospinning and co-sputtering in advancing SOFC technology. These strategies address key challenges, including thermal stability, oxygen ion transport, and CO_2 tolerance, paving the way for efficient and durable SOFC systems suitable for intermediate-temperature operation.