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STUDENT EDITORIAL

INTERCONNECT COATING FOR SOLID OXIDE FUEL CELL TECHNOLOGY TECHNOLOGY



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Solid oxide fuel cells (SOFCs) are electrochemical devices that convert chemical energy directly into electrical energy. An SOFC stack consists of several important components, including the anode, electrolyte, cathode, and interconnect. The interconnect provides an electrical connection between cells and helps separate and distribute the fuel and oxidant gases. Metallic materials such as ferritic stainless steel are commonly considered for interconnect applications because of their suitable mechanical properties, electrical conductivity, and compatibility with SOFC operating temperatures [1], [2].

However, metallic interconnects can undergo oxidation and chromium evaporation during high-temperature operation. Chromium species released from the interconnect may migrate to the cathode and cause chromium poisoning, resulting in performance degradation [3], [4]. Therefore, a protective coating is applied to the interconnect surface to reduce oxidation, prevent chromium migration, and maintain good electrical conductivity. The coating should also have a thermal expansion coefficient (TEC) similar to that of the interconnect to minimize cracking and spalling (Figure 1).

Properties of Interconnect Coating

An effective interconnect coating should have high electrical conductivity, good oxidation resistance, thermal stability, and a suitable TEC compatibility.

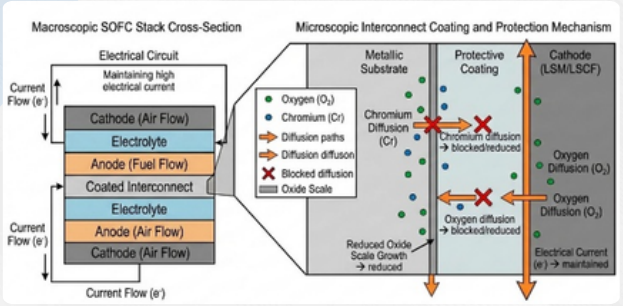


Figure 1: Schematic of SOFC Interconnect Coating and Protection Mechanism

High electrical conductivity is important because the interconnect transfers electrical current between individual SOFC cells. If the coating has high electrical resistance, it can increase the area-specific resistance (ASR) and reduce the overall performance of the SOFC stack [5], [6].

The coating should also provide a protective barrier against oxygen diffusion and chromium migration. This helps reduce the formation of chromium-based oxide scales, which normally exhibit low electrical conductivity. Good compatibility between the coating and the metallic substrate is also necessary to prevent cracking, delamination, and spalling during high-temperature operation [7], [8].

Applications of Interconnect Coating in SOFC Technology

Protective coatings are mainly applied to metallic interconnects to improve their oxidation resistance and reduce chromium volatilization. Stainless steels such as AISI 441 and Crofer 22 APU have been investigated using different coating materials, including $(Co,Mn)_3O_4$, $LaFeO_3$, Ce/Co, and Y-based coatings. These coatings can reduce oxide-scale growth and chromium evaporation compared with uncoated stainless steel [7], [9].

Two important coating groups are spinel and perovskite coatings. Spinel coatings such as $Cu_{1.3}Mn_{1.7}O_4$ have shown promising electrical conductivity and low ASR. Perovskite coatings have also demonstrated good electrical and protective properties, although some require high sintering temperatures. Therefore, both coating systems have the potential to improve the performance and durability of metallic SOFC interconnects [10].

Spinel Coating

Spinel oxides are among the most widely studied protective coatings for metallic SOFC interconnects.

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They can provide good adhesion to stainless-steel substrates, high electrical conductivity, good thermal stability, and suitable TEC compatibility [7]. Examples of spinel coatings include $NiCr_2O_4$, $MnFe_2O_4$, $CoFe_2O_4$, and $Cu_{1.3}Mn_{1.7}O_4$. Among these materials, $Cu_{1.3}Mn_{1.7}O_4$ has been reported as a promising coating because of its relatively low ASR.

Different deposition methods have been used to produce spinel coatings, including screen printing, electrophoretic deposition (EPD), sol-gel, and magnetron sputtering [11]. The reported performance varies depending on the coating composition and fabrication method. For example, $Cu_{1.3}Mn_{1.7}O_4$ produced by EPD showed an ASR of approximately 0.00613 Ω cm², while $(Mn,Cu)_3O_4$ produced by magnetron sputtering showed an ASR of approximately 0.011 Ω cm².

Perovskite Coating

Perovskite oxides are another group of materials investigated as protective coatings for metallic interconnects. They are attractive because of their good electrical conductivity at high temperatures and potential thermal compatibility with metallic interconnects [12]. Various perovskite materials have been investigated using coating techniques such as spin coating, dip coating, screen printing, and chemical immersion processes.

However, some perovskite coatings require relatively high sintering temperatures. High processing temperatures can create compatibility problems with other SOFC components and may affect the overall manufacturing process [13]. Despite this limitation, several perovskite coatings have demonstrated low ASR values. For example, LSC produced by spin coating at 800 °C showed an ASR of approximately 0.0028 Ω cm², while LSM-coated SS 444 produced by dip coating showed an ASR of less than 0.01 Ω cm².

Benefits of Interconnect Coating

The application of protective coating provides several benefits to SOFC metallic interconnects. The main advantage is improved oxidation resistance, which reduces the growth of oxide scales during high-temperature operation. The coating can also reduce chromium migration from the metallic substrate and consequently minimize chromium poisoning at the cathode. These improvements help maintain the electrical and electrochemical performance of the SOFC stack [7].

Another important benefit is the reduction of electrical resistance at the interconnect interface. A conductive coating can maintain good electrical contact while limiting the formation of poorly conductive chromium-based oxide scales [13]. In addition, good coating adhesion and thermal compatibility can improve the durability of the interconnect during long-term operation and thermal cycling.

Challenges and Future Prospects

Although interconnect coatings provide significant advantages, several challenges remain. The coating must simultaneously provide high electrical conductivity, oxidation resistance, chromium retention, and good adhesion to the metallic substrate [7].

Differences in TEC between the coating and interconnect can cause thermal stress, which may lead to cracking, delamination, or spalling during repeated heating and cooling.

Future research should focus on developing coatings with improved electrical conductivity, better chromium-retention ability, and lower processing temperatures. Optimization of coating thickness and deposition methods is also important because techniques such as screen printing, EPD, dip coating, sol-gel, and magnetron sputtering can produce different coating characteristics. The development of composite or modified spinel and perovskite coatings may provide further improvements in SOFC interconnect performance.

Conclusion

Interconnect coatings are an important approach to improving the performance and durability of metallic interconnects in SOFC technology. These coatings protect the metallic substrate from oxidation, reduces chromium migration, and helps maintain low electrical resistance. Therefore, suitable coatings can contribute to better long-term stability and efficiency of SOFC stacks.

Among the different materials investigated, spinel and perovskite coatings have shown promising performance. Spinel coatings provide good electrical and thermal properties, while perovskite coatings offer good electrical conductivity and oxidation protection.

However, further research is required to improve coating compatibility, reduce processing temperature, and enhance long-term stability for practical SOFC applications.

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- Integrating Materials Engineering and Mechanical Joint Integrity for Containment Assurance
- Interconnect Coating for Solid Oxide Fuel Cell Technology
- Bridging Advanced Energy Materials and High-Accuracy Manufacturing



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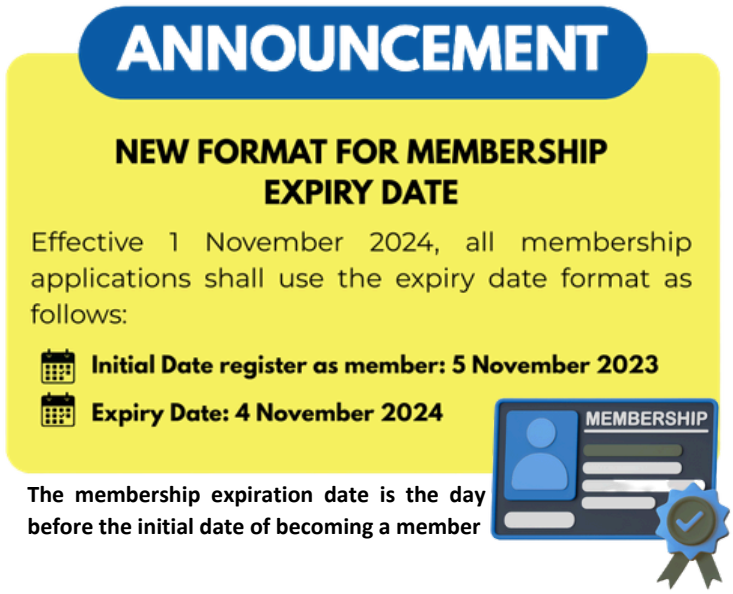
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