

Study of Patterned $\text{La}_{0.8}\text{Sr}_{0.2}\text{MnO}_3$ Electrodes for Solid Oxide Fuel Cells

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Electrode kinetics greatly influence the overall performance of solid oxide fuel cells, especially at low temperatures. Still, little is known about the nature of electrode reactions. In this study, patterned electrodes of well-defined geometry were successfully deposited on electrolyte substrates through microfabrication techniques. The ratio of three-phase boundary (TPB) to surface of electrode can be readily changed by 4 orders of magnitude, producing electrodes with vastly different characteristics. Impedance measurements reveal a quantifiable relation between the TPB length of an LSM electrode and the cathodic interfacial resistance, implying that TPBs are the dominating sites for electrode reactions.

There currently exists no theory or evidence to prove the size of the actual reaction zones using either metallic or MIEC electrodes in fuel cells. The objective of this study is to explore the actual electrode reaction zone through the use of micropatterned electrodes. Standard photolithographic techniques were used to deposit LSM electrodes with consistent surface area and varied triple phase boundary lengths. At the same time, the methodology and techniques developed for metallic electrodes are being extended to investigations of MIEC electrodes.

The SEM micrograph of the patterned electrodes shows that no abnormal boundaries exist at the electrode/electrolyte interface. These micrographs reveal that no significant disruptions exist along the TPB interface. Consequently, the actual TPB lengths closely resemble the theoretical TPB length calculated from mask specifications.

The triple phase boundary length was found to be inversely proportional to the interfacial resistance for LSM electrodes with low TPB length in which the width of the electrode strips and the gaps between adjacent strips are greater than the effective width of the TPB. The results attained at electrodes with longer TPB length and elevated temperature indicate that the linear relationship between the TPB length and the interfacial resistance is no longer true, implying that the width of the electrode strips or the gaps between adjacent strips are no longer greater than the effective width of the TPB. While the results confirm the linear relationship of TPB length to interfacial resistance at low ratios of TPB length to surface area, this relationship breaks down as bulk conduction through the MIEC electrode becomes significant

These initial findings were based solely on the use of dense LSM electrodes, but continued research is underway to expand the reach of this investigation into other mixed conducting electrodes, composites and three-

dimensional structures. These further investigations should provide additional insight into active reaction sites, reaction mechanisms and better electrode architecture of mixed conducting electrodes. It is evident that this process can be used to determine the active area for a variety of electrodes leading to direct improvements in electrode design.

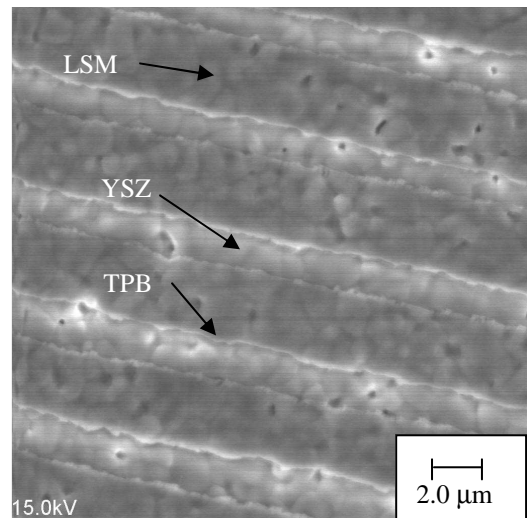


Figure 1. SEM micrographs showing LSM patterned microelectrodes with well-defined TPB length. Some surface roughness can be seen, though it does not appreciable change the amount of TPB length.

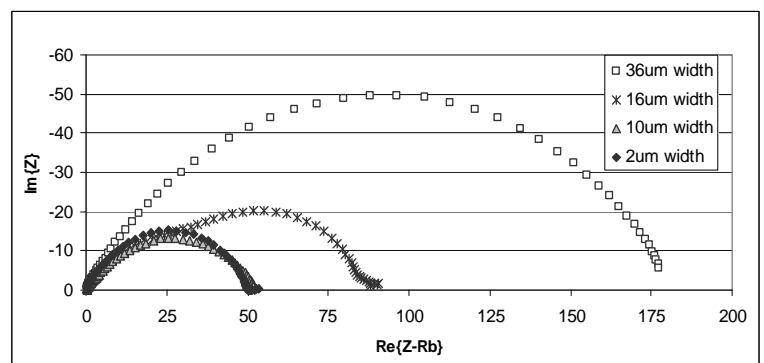


Figure 2. Impedance spectra for the interfaces between a YSZ electrolyte and LSM patterned electrodes of the same surface area but different TPB length.

Acknowledgement: The authors wish to acknowledge the financial support of this research by DoE-NETL (Grant DE-FC26-02NT41572).

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