Precious Metal Thin-Films for SOFC Applications

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The use of precious metal thin-films as alternative cathode materials for SOFC applications is discussed.

Today, SOFC cost per kilowatt-hour, reliability, and performance degradation are the main barriers to commercialization (1). One area where gains in cell economy and performance might be made is the cathode. Lanthanum-Strontium Manganite (LSM) has a combination of electrochemical and mechanical properties which make it a good choice for SOFC an cathode material. However, it is expensive, difficult to apply uniformly, and has poor performance below 800^{o}C. To reduce cost/kilowatt hour, efforts to identify new lower temperature materials for SOFC cathodes are underway, but the philosophy is to focus on perovskite structures with Sr on the A site, and B site doping using transition metals such as Co, Fe, Ni, and Cu (2).

Alternatively, precious metal thin-film cathode materials can be considered. Such films can be applied to YSZ using electrochemical techniques then fired to develop a strong physical bond with the electrolyte. As they are noble metals, they are stable in the SOFC environment. They are pure electronic conductors, and as such can double as the cathode current collector, thus reducing cell components. Because they are known catalysts for hydrocarbon fuel such as methane, the possibility also exists for them to be used in fuel pre-processing. Additionally, the interfacial contact resistance is reduced via the strong physical bond between the metal and electrolyte. Electrochemical metallic thin-films have yet to be evaluated as potential cathode materials, and thus would represent an innovative change in fuel cell technology.

LSM cathodes are porous mixed conductors and provide high surface area and a true catalytic effect. Pd is a pure electronic conductor and will only support electrochemical work at the triple phase boundary. The model is shown in Figure 1. Points supporting electrochemical reaction are noted with the small circles. Clearly, the mixed conductor will be beneficial in such instances.

If the length scale for the pure electronic conductor is orders of magnitude less than that of the mixed conductor, it is possible that the electronic conductor might provide adequate cathode performance. In addition to being extremely thin, the precious metal coating can be controlled in terms of individual crystallite morphology and size.

By varying the plating solution chemistry, temperature, and applied voltage and current density, the kinetics of nucleation and growth can be engineered. This is shown in Figure 2. It can be seen that the grain boundary density is quite high at the base of the plating, which has obvious benefits in increasing the triple phase boundary density.

An added benefit of the metallic thin-film cathode is the potential for in-situ Catalytic Partial Oxidation (CPOX) and Steam Reforming (SR) of hydrocarbon fuels. This is particularly interesting for the case of micro-tubular SOFC designs where high-volume electrochemical processing techniques can be applied.

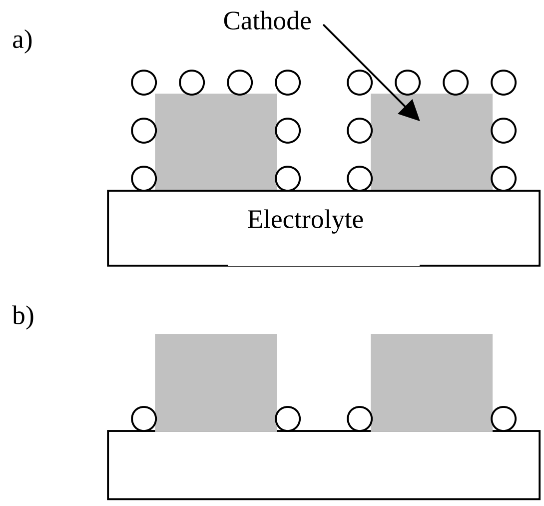

Fig. 1. Representation of an SOFC cathode for a) mixed (ionic and electronic) and b) pure electronic conductor cases.

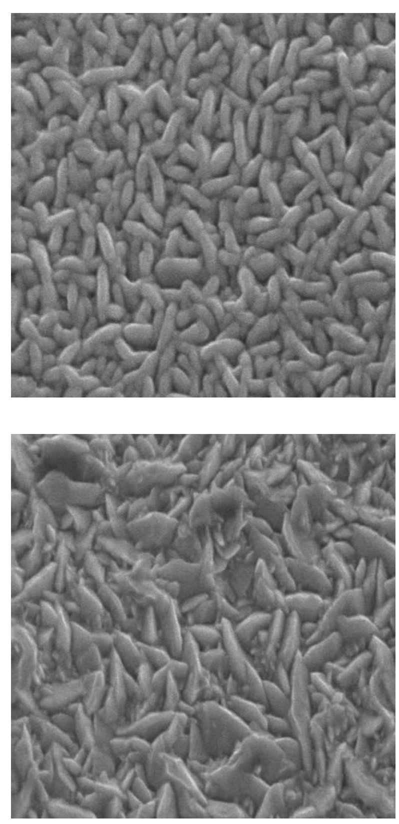

Fig. 2. SEM images of Pd coating surface at different plating conditions (10,000x).

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