Nanostructured vanadium oxide anodes for thin film solid-oxide fuel cells

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Thin film solid oxide fuel cells can exploit microfabrication techniques to produce fuel cells with electrolyte thicknesses of the order of 100 nm. The smaller resistance of the electrolyte allows lowering the operation temperature to the 400-600°C range. There is general consensus in the field that reduction in the operating temperature can potentially broaden the scope of applications for solid oxide fuel cells.
State-of-the art thin film solid oxide fuel cell anodes however still lack practical performance stability for applications that require stable operation over extended periods of time. Oxide-based anode materials are expected to be more stable than metallic anode materials, but require mixed ionic and electronic conductivity and good catalytic properties.
Vanadate anodes have shown promising properties in previous studies, including relative insensitivity to hydrogen sulfide, making them interesting candidates for direct natural gas operation [1].

In this work, we investigated the performance and stability of nanostructured vanadium oxide anodes for thin film solid oxide fuel cells. In-situ in-plane electronic conductivity measurements in oxidizing and reducing environments revealed a limited stability window of vanadium oxide, with a significant decrease of the electronic conductivity at temperatures higher than 340°C (Figure 1).
Vanadium-oxide anodes were synthesized on thin film solid oxide fuel cell membranes and their performance evaluated with 5%H_2-Ar humidified fuel. The polarization losses of vanadium oxide were found to be higher compared to platinum. Indeed, at all temperatures in the range 300 to 360°C, the open circuit potential difference was 400 mV lower for the vanadium oxide fuel cells (Fig. 2). However, the maximum power density of the vanadium oxide anode fuel cells was found to be relatively similar to that of the porous platinum anode fuel cells (Fig. 3). The performance and stability of vanadium oxide fuel cell anodes for direct natural gas operation and experimental strategies to create composite electrodes will be further discussed.

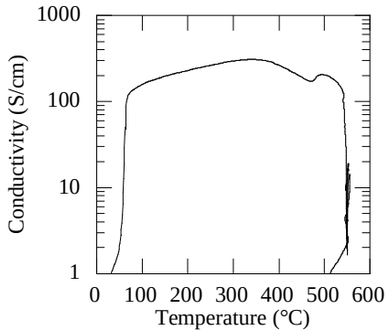

Figure 1: In-plane conductivity of vanadium oxide thin film deposited on yttria-stabilized zirconia. Temperature ramping rate of 10°C/min.

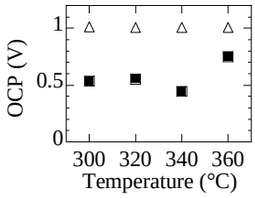

Figure 2: Dependence of the open circuit potential difference on the temperature for vanadium oxide anode fuel cells (squares) and porous platinum anode cells (triangles).

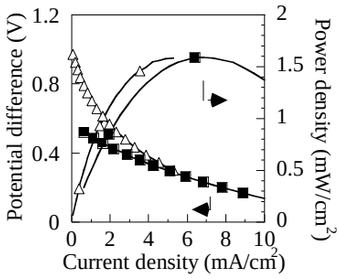

Figure 3: Performance of vanadium oxide anode thin film solid oxide fuel cells (squares) compared to reference porous platinum anode cells (triangles): potential difference and power density versus current density at 320°C in humidified H_2/Ar.

References

1. C. Peng, B. Wang, A. Vincent, *J. Mater. Sci.* **47** (2012) 227.

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