Design, Fabrication, and Testing of Multilayered Microfabricated Solid Oxide Fuel Cells (SOFCs)

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Microfabricated solid oxide fuel cells were investigated for portable power applications requiring high energy densities [1]. The thickness of the electrolyte, the travel length of oxygen ions, was reduced down to ~150nm. The tri-layers (yttria-stabilized zirconia (YSZ) as an electrolyte and platinum-YSZ cermet as cathode/anode) were sputter-deposited on a silicon wafer, and then they were released as square plates by KOH etching the silicon through patterned silicon nitride masks on the back side. High intrinsic and extrinsic (thermal) stresses due to fabrication and operation (25-600°C) [2], respectively, require careful thermomechanically stable design of µSOFCs.

First, material properties of the ultra-thin YSZ were characterized experimentally and found to be significantly different than those of bulk YSZ [3]. Second, based on the obtained properties, maximum stresses in the plates at 625°C were analyzed using non-linear von Karman plate theory [4]. The stresses showed three regions with sidelength variation: an un-buckled regime, a buckled regime with high stresses, and post-buckling regime with lower stresses (see Figure 1). The µSOFCs were fabricated in the post-buckling regimes with ~80-~180µm sidelength and total ~450nm thickness. With the plates buckled as shown in Figure 2, the µSOFCs produced power output of 0.008mW/cm, lower than the expected power from their electrochemical test. Given the high-performance predicted for the underlying nano-structured ultra-thin electrolyte, anode, and cathode layers, additional studies are needed to improve specimens and test setup and to assess µSOFCs’ long-term operational stability.

REFERENCES: