The inherent brittleness of ceramics has caused manufacturers to be hesitant in selecting them for potential fuel cell applications such as automotive electrical subsystems. To reduce the internal ohmic loss of the conducting electrolyte, it is fabricated as thin as possible (10µm for lab scale cells to 100µm for commercial cells). Therefore, planar solid oxide fuel cells rely on either the anode or cathode as the structural-supporting member. In order to supply oxygen efficiently to the electrode/electrolyte interface, the electrodes typically contain 30 – 50 vol. % open porosity. This high level of porosity significantly reduces the mechanical performance of the structure.

Work being performed at University of Missouri – Rolla is focusing on modifying the structure of electrodes using an underlying zirconia honeycomb laminated to the zirconia electrolyte, as shown in Figure 1. The structure increases the strength of the electrode structure and should allow for thinner electrodes, increasing gas transport to the electrolyte and reduced overpotential. In addition to improved mechanical performance, the design may alleviate problems due to NiO formation at moderated temperatures (<700°C) experienced in SOFCs that have Ni-YSZ anodes [1]. Currently, nickel-based anodes must be protected from oxidation by flowing forming gas (N₂/H₂) during cool down [2].

In a previous study of 13 samples consisting of 70% open cells, a biaxial flexure strength of 244 MPa ± 80 MPa was achieved for a zirconia honeycomb [3]. A distribution plot is giving in Figure 2. Honeycomb theory based on the bending moment of the cell walls predicts biaxial flexure strengths significantly lower than the bulk material for high volume fractions of open cells as shown in Figure 3 [4]. An equivalent material to that tested would be expected to have a biaxial strength of only 67 MPa. To resolve this discrepancy, the honeycomb structure was analyzed using Object Oriented Finite Element Analysis (OOF) [5]. It is shown that the greatest stresses originate at the corners of the cells, where the cell walls meet.

The results from OOF analysis are compared to samples consisting of 70%, 82.5%, and 90% open cells. Initial results of a 70% open cell structure compare favorably to test results. A 0.02% biaxial strain results in 235 MPa maximum stress in a plate containing no hexagonal cells. A plate containing a 70% open cell hexagonal honeycomb has a maximum stress of 360 MPa, near the fracture strength of the zirconia material.

References
5. National Institute of Standards and Technology, Center for Theoretical and Computational Materials Science.