Scandia and ceria stabilized zirconia (10 mol% Sc2O3 â€" 1 mol% CeO2 â€" ZrO2, SCSZ) has superior ionic conductivity in the intermediate temperature range for the operation of solid oxide fuel cells, but it does not exhibit good phase stability in comparison with yttria stabilized zirconia (8 mol% Y2O3 â€" ZrO2, YSZ). To maintain high ionic conductivity and improve the stability of the electrolyte, layered structures with YSZ outer layers and SCSZ inner layers were designed, along with the referential electrolytes containing pure SCSZ or YSZ. The three-, four- and six-layered electrolytes were manufactured by tape-casting, lamination, and pressureless sintering techniques. Selected characterizations were employed to study the structure, morphology, impurity content and the density of the electrolytes. Furthermore, in situ annealing experiments with structural characterization were carried out to study the phase transition and lattice distortion at 350 Â°C and 275 Â°C for SCSZ and YSZ, respectively, where the dynamic damping occurred when Youngâ€™s modulus was measured.

In YSZ/SCSZ electrolytes, thermal residual stresses and strains were generated due to the mismatch of coefficients of thermal expansion from each layer of different compositions. They could be adjusted by varying the thickness ratios of each layer in different designs of laminates. The theoretical residual stresses have been calculated for different thickness ratios. The effects of thermal residual stresses in layered electrolytes were studied. The biaxial flexure tests of electrolytes with various layered designs were performed using a ring-on-ring method at both room temperature and 800 Â°C. The flexural strength was increased in the electrolytes with layered structure in comparison with electrolytes without compositional gradient. Such an increase of strength is the result of the existence of residual compressive stresses in the outer YSZ layer. In addition, the effect of thermal residual stresses on the Weibull distribution at room temperature was established, and it verified the values of residual stresses present at the outer layers. The high ionic conductivity was maintained with layered electrolyte designs in the intermediate temperature range. The ionic conductivity of layered electrolytes exhibited 10% â€" 25% improvement due to the stress/strain effects, and the largest improvements in a certain electrolyte was found to nearly coincide with the largest residual compressive strain in the outer YSZ layer.

In addition to studies of electrolytes, mechanical properties of porous Ni/SCSZ cermet were studied. The anode materials were reduced by 65 wt% NiO â€" 5 wt% SCSZ and 50 wt% NiO â€" 50 wt% SCSZ porous ceramics in the forming gas. Youngâ€™s modulus as well as strength and fracture toughness of non-reduced and reduced anodes has been measured, both at room and high temperatures. High temperature experiments were performed in the reducing environment of forming gas. It was shown that while at 700 Â°C and 800 Â°C the anode specimens exhibited purely brittle deformation, a brittle-to-ductile transition occurred for heating above 800 Â°C, and the anode deformed plastically at 900 Â°C. Fractographies of the anode specimens were performed to identify the fracture modes of anodes tested at different temperatures.