Characterization of SOFC ELECTROLYTES FOR IMPROVED MECHANICAL ROBUSTNESS

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INTRODUCTION

The FlexCell™ is the latest generation electrolyte-supported planar SOFC from NexTech Materials Ltd.

FlexCell™ Innovation: A honeycomb-type structure provides a thicker support mesh with thin active area.

Whole Electrolyte

Brittle electrolytes can withstand considerable bending.

Thin regions are more electro-chemically efficient for improved performance.

Electrolyte Material

Elastic properties are obtained using ASTM 1875-08, a sonic resonance technique.

Support Structure

A small-scale repeating geometry models the support structure.

78 small-scale geometries were selected by varying:

1. Width of each hex, w (mm)
2. Space betweem hexes, b (mm)
3. Radius of corner fillets, r (mm)
4. Thickness of membrane, tm (mm)
5. Thickness of support mesh, ts (mm)

Each small-scale geometry is modeled under uniaxial tension using FEA.

“Effective” properties are computed relative to those of a uniformly thick solid.

Reduction in stiffness with increased active area.

Electrolyte color coded to show “effective” material types.

Each large-scale geometry was selected by varying:

1. Stiffness applied to active regions, Eeq (GPa)
2. Support rib and frame dimensions, (mm)
3. Radius of corner fillets, (mm)

Large-scale geometry is modeled with shell elements under structural and thermal loading using FEA.

Stress response to out-of-plane pressure loading.

The relatively stiffer ribs appear to carry more stress, but unlike the active area the stresses are unmagnified.

Load Transfer

An individual cell model is used to evaluate the electrolyte within the context of a stack.

Current-collecting, corrugated foams in the cell transfer loads onto the electrolyte.

Foam properties in the model are changed over several iterations until the load-displacement behavior matches the experimental data.

Cell models consider variations in foam geometry to characterize stress distributions in electrolytes.

Changes in foam geometry may reduce loads (and therefore stresses) imposed on electrolyte.

Load frame data. Contact simulation. Material property inputs. Load displacement results.

Schematic of a planar SOFC stack assembly.

Rectangular bar specimens are suspended in a furnace, and excited over a range of frequencies.

Certain frequencies exhibit resonance. The resonant modes are reproduced via FEA.

First 5 resonant modes obtained using ANSYS.

The “effective” properties can be used for larger scale modeling.

The “effective” properties are validated with 4-point bending of representative samples.

The elastic properties are used as inputs for the structural and thermal models below.

Elastic Modulus, E (GPa)

Temperature, T (°C)

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First 5 resonant modes obtained using ANSYS.

Large cells which are mechanically robust have a higher porosity density.