Multiscale Analyses of Damage and Failure in Solid Oxide Fuel Cells: Optimization of Themomechanical Behavior

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The mismatch in thermo-mechanical properties of the constituents of a layered structure often results in the formation and growth of defects such as interfacial cracks that can also branch into the matrices, and it can also cause warping of the assembly. The PEN (positive-electrolyte-negative) component in a Solid Oxide Fuel Cell (SOFC) constitutes a multi-layer structured material with the anode and the cathode components of the PEN being highly porous (~35%). The main objectives of this work are two folds: 1) To develop a state-**of-the-art computational tool** for failure analysis of the PEN and interconnect based on fracture mechanics. This will enable optimal design of efficient, low cost and reliable/durable SOFCs. 2) To analyze the 3D morphology of SOFCs using **x-ray computed tomography** that will guide in the fabrication of more reliable SOFCs. The **image processing** includes three-dimensional analyses of images of PENs that are constructed using X-ray computed tomography (CT). There are two sets of problems that are being investigated: I) *Micro*-Analyse*s* of interfacial cracks between any two of the three layers, interfacial crack branching into the porous medium (anode or cathode), cohesive crack in each of the layers and interaction between a Crack in the electrolyte and the anode with voids of various sizes. II) *Meso- Analyses of m*ultiple cracks in the electrolyte with cathode and anode having effective properties and multiple crack with multiple voids. The outcome of these analyses, among other things, included determination of the critical crack size for a given stress distribution from thermal mismatch, the effect of microstructure variables on reliability and failure, the effect of porosity, effect of pore size, and effect of material properties, and direct assessment of

the PEN right after the sintering processing, through image processing (CT) and failure analysis.