Electro-chemo-mechanics and SOFC materials: $(Pr,Ce)O_{2-\delta}$, a model system case study

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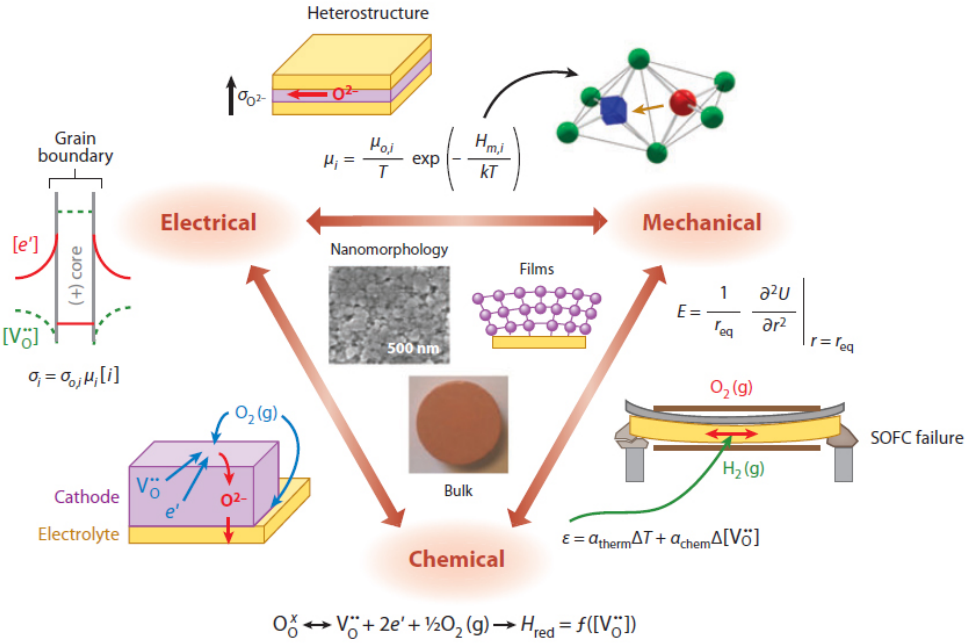
Solid oxide fuel cell (SOFC) electrolytes, such as acceptor doped CeO_2, when exposed to oxygen partial pressure (pO_2) gradients (air to fuel), become mixed ionic and electronic conductors (MIEC), thereby reducing the open circuit voltage, as well as dilating (chemical expansion), resulting in stresses that can lead to mechanical failure. In addition, many advanced MIEC SOFC electrodes exhibit changes in stoichiometry and hence mechanical and electrical properties with variations in SOFC operating conditions (i.e. T, pO_2, power demand). The coupling of these electro-chemo-mechanical phenomena (see figure) is therefore important to characterize with development of models capable of predicting optimum materials compositions and operating conditions.



Electro-chemo-mechanics (from H. L. Tuller and S. R. Bishop, "Point defects in oxides: Tailoring materials through defect engineering", Annual Reviews of Materials Research, vol. 41 (2011))

$Pr_xCe_{1-x}O_{2-\delta}$ (PCO) solid solutions are particularly interesting oxygen ion conductors to study given that both Pr and Ce exhibit valence changes, but under different pO_2 regimes, resulting in different transport regions (ionic vs MIEC), while undergoing chemical expansion. In this presentation, experimental data and models are developed for the chemical expansion, electrical conductivity, and optical properties of PCO using well-defined geometries. By carefully controlling the morphology and ambient conditions of the sample while using a variety of experimental techniques, key parameters of the material are isolated, allowing for a well developed understanding of the material properties.