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Decoupling thermal, chemical, and mechanical strain components in thin films MEREDITH SILBERSTEIN, ETHAN CRUMLIN, YANG SHAO-HORN, MARY BOYCE, MIT Mechanical Engineering — Many electrochemical systems have performance which is affected by internal strains due to thermal and/or chemical stimuli. The bi-material curvature method is a means to quantify these thermal and chemical strains and their coupling with mechanical stress. In this method, a thin layer of the material of interest is deposited on a substrate of intermediate thickness. The composite assumes a curvature that depends on the mismatch strains between the substrate and film. The Stoney formula provides an explicit expression for the film stress as a function of the elastic substrate properties, film and substrate thickness, and curvature. Here we study two distinct materials systems: Nafion used as the polymer electrolyte in low temperature fuel cells, and epitaxial perovskite thin films used as a catalyst for the oxygen reduction reaction in solid oxide fuel cells. The thermal, chemical, and mechanical strains are quantitatively determined as functions of temperature and atmospheric conditions by monitoring the curvature evolution with changes in these parameters. The extent of coupling of the thermal and chemical strains with mechanical stress is evaluated by conducting the experiment at multiple substrate thicknesses.

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