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Electrochemically induced stresses in energy storage materials

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ABSTRACT

The volume changes that are associated with composition changes in a solid can induce significant stresses when these expansions or contractions are physically constrained. These phenomena are important in a variety of energy-related materials, where they lead to complex interactions between electrochemical and mechanical driving forces. We have employed in situ measurements of these stresses along with a variety of other in situ and ex situ characterization methods, to obtain critical information about how the relevant mechanisms operate in different types of materials. One example is ceria electrolytes in solid oxide fuel cells, where oxygen potential gradients across the electrolyte can lead to large stresses. These stresses, caused by differences in the oxygen content of the ceria, are significantly enhanced by grain boundary contributions that can be interpreted with space charge effects. In Li ion battery (LIB) electrodes, Li insertion and removal can also lead to very large stresses and complex deformation behavior. One area of interest here is the solid-electrolyte interphase (SEI) layer, where we have recently shown that substantial near-surface stresses occur during SEI formation on graphitic carbon anodes. These results imply that stresses can be engineered during SEI formation, to enhance the stability of these critical passivation layers. Another concern in is the mechanical integrity of interfaces in composite electrode structures. Here, we have used patterned thin film structures to understand the response of bi-material interfaces during Li cycling. The integrity of these interfaces is critical for cycling stability and capacity retention in rechargeable LIBs.