Electro-chemo-mechanics of the Structural Water Driven Battery-to-Pseudocapacitor Transition in Tungsten Oxides

The presence of structural water in tungsten oxides leads to a transition in the energy storage mechanism from battery-type intercalation (limited by solid state diffusion) to pseudocapacitance (limited by surface kinetics). This talk will demonstrate that these electrochemical mechanisms are linked to the mechanical response of the materials during insertion of protons, and will present a pathway to utilize the mechanical coupling for local studies of electrochemistry. Operando atomic force microscopy (AFM) dilatometry was used to measure the deformation of these redox-active energy storage oxides, and to link their local nanoscale deformation to the global current response. This technique revealed that the local mechanical deformation of the hydrated tungsten oxide is smaller and more gradual than the anhydrous oxide, and occurs without hysteresis for the intercalation and de-intercalation processes. The ability of layered materials with confined structural water to minimize mechanical deformation likely contributes to their fast energy storage kinetics and opens up a new avenue for the design of energy storage materials for fast charging applications.

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