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POS-16 Using Atomic Force Microscopy to Characterize Energy Storage Materials

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In the quest for high performance materials for energy storage, a comprehensive toolbox of characterization techniques - both experimental and theoretical - is an absolute necessity. In recent years, many techniques have been increasingly focussed on combining observations of material structure, composition, and dynamics to develop a complete picture on how various material properties affect overall performance. This is generally achieved either by custom built hardware that incorporates several characterization techniques that can be performed consecutively, or by successive ex-situ measurements that each capture different information. There do exist, however, some emerging techniques that can capture both dynamic and structural information simultaneously, one of which is atomic force microscopy (AFM). The operating principle of AFM employs an extremely sensitive and highly localized force sensor (probe), which makes it a very good candidate for measuring local dynamic processes. Here we will present some of the leading work on various implementations of AFM and how they are applied to energy materials, including time-resolved electrostatic force microscopy (EFM), which enable the direct probing of charge transport processes with high spatial resolution.

In EFM-based techniques, the probe is used to detect changes in the local electric field, which can arise from a variety of processes including the movement of ions. By driving ionic transport with an applied potential and acquiring the response signal over time, it can be used to directly measure the bulk ionic conductivity of a substrate and - if done at varying temperatures - the local activation energy and hopping barriers. Using this time-resolved technique on a heterogeneous sample, we have observed spatial variations in the response signal on the order of 50nm, demonstrating the true power of this technique. The topographic images obtained also allow for further characterization on the exact same physical regions of the sample, which eliminates the effects of averaging over large macroscopic areas.
These measurements allow us to directly peer into the relationship between local structure and dynamics with the spatial and temporal resolution not previously available with many standard approaches. This has lead to the maturation of AFM into a staple in the characterization toolbox for energy materials.

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