Transmission electron microscopy of electrochemical processes in aqueous solution

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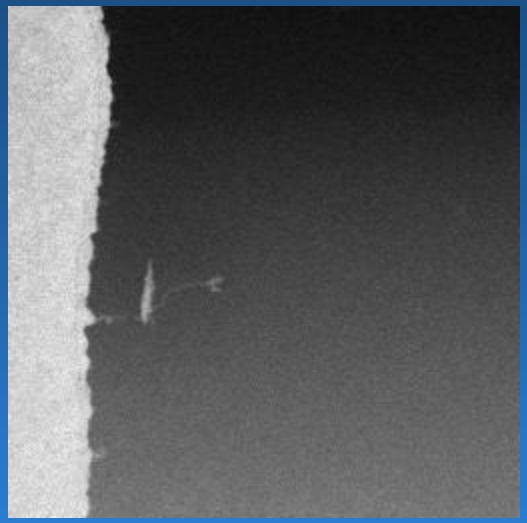

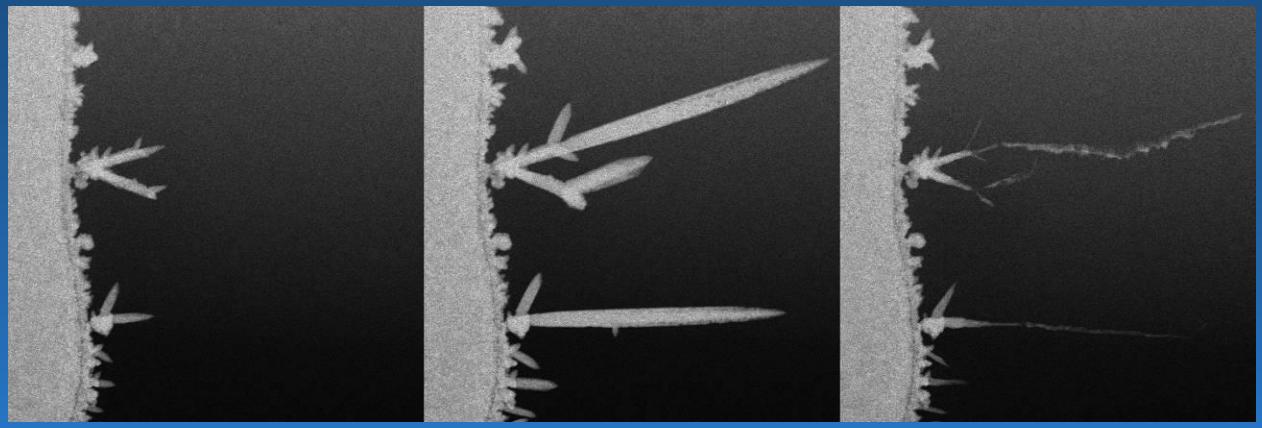

[Left and above] Movie and time series showing formation and dissolution of lead dendrites on a gold electrode from an aqueous $Pb(NO_3)_2$ solution.

Electrochemical processes occurring at atomic length scales (e.g. dendrite nucleation) determine the power density, lifetime, and ultimate utility of chemical batteries. However, the high vapor pressures of common electrolytes such as water have historically prevented the use of electron microscopy for the *in situ* imaging of operating electrochemical cells.

Using a transmission electron microscope and vacuum-tight, electron-transparent environmental chambers, we have imaged the plating and stripping of lead from a solution of lead (II) nitrate in water. Our measurements demonstrate for the first time that it is possible to directly image not only the deposits, but also the time-variation of the background concentration of solvated ions.

[Below] Frame illustrating direct imaging of Pb^{2+} ions (brighter regions) that are pushed into solution as Pb dendrites are stripped from the Au electrode.