Scientific Achievement
Correlated full theoretical capacity (and intermediate phase formation) with uniform insertion and extraction of the second Li\textsuperscript{+} in solid state synthesized ε-Li\textsubscript{x}VOPO\textsubscript{4}, a promising multi-electron lithium ion battery (LIB) cathode, by depth-profiling the the low voltage region.

Significance and Impact
Isolated disrupted kinetics in the high voltage reaction as the major hurdle in realizing its full 2 Li\textsuperscript{+} capacity.

Research Details
- Used a combination of soft and hard x-ray spectroscopy techniques, both ex-situ and operando, to depth profile the vanadium redox within the low voltage window.
- Confirmed the predicted intermediate phases, Li\textsubscript{x}VOPO\textsubscript{4} (x =1.5 and 1.75) from density functional theory using x-ray spectroscopy.

Findings: Our ex-situ and operando depth-profile studies combining soft and hard absorption / photoelectron spectroscopy techniques confirmed full and homogenous second Li\textsuperscript{+} insertion and extraction between ε-LiVOPO\textsubscript{4} and ε-Li\textsubscript{2}VOPO\textsubscript{4} in the low voltage regime. These studies isolated the origin of the Li-ion gradient and capacity loss observed in ε-Li\textsubscript{x}VOPO\textsubscript{4} (x = 0 - 2) as originating solely from disrupted kinetics in the high voltage regime. One can cycle between ε-LiVOPO\textsubscript{4} and ε-Li\textsubscript{2}VOPO\textsubscript{4} without significant capacity loss.

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