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Analysis of Long-range Interaction in Lithium-ion Battery Electrodes

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Recent years have witnessed a phenomenal increase in research efforts in energy storage for vehicle electrification. Lithium-ion batteries (LIB) are leading the race. Effective electrode design is critical to meeting the energy density and power capability of LIBs. A typical LIB electrode is composed of a combination of active material, conductive additive, polymeric binder, and void space that is filled with an electrolyte [1,2]. The conductive additives are necessary to improve the overall electrode electrical conductivity. The long-range conduction where electrons are carried through the electrode to the current collectors is an important determinant. The influence of conductive additives to improve the long-range conductivity depends upon percolation through the electrode. Furthermore, the active material morphology and the relative constituent phase (active material, additive, binder, electrolyte) fractions should have significant bearing on the long range interaction.

In this work, we are probing the influence of electrode microstructural variability in terms of active particle morphology and conductive additive to binder ratio on the LIB electrode long range interaction. The computational approach comprises a stochastic microstructure reconstruction method and evaluation of effective electrical conductivity.

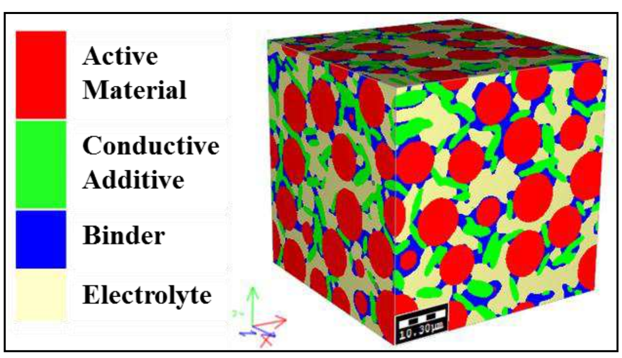

Figure 1: Representative reconstruction of 3D LIB electrode microstructures consisting of spherical active material, binder, conductive additive, and electrolyte.

Computational results for effective conductivity are shown to be in agreement with those of Liu et al. (see [2]) at least in terms of expected trends based on the experimental data.

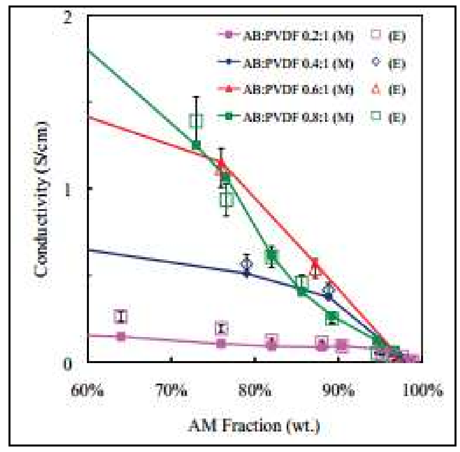

Figure 2: Impact of volume fraction of active material and the ratio of conductive additive to binder on the effective electrode conductivity based on experimental trials (adapted from Ref [2]).

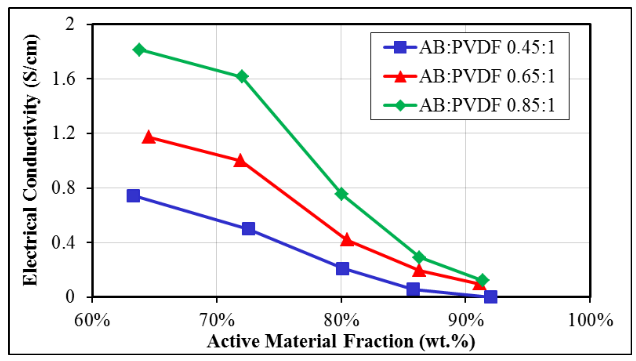

Figure 3: Impact of volume fraction of active material and the ratio of conductive additive to binder on the effective electrode conductivity based on the current computational trials.

Finally, in this work we emphasize the effect of electrode composition and active material morphology on the effective long-range conductivity of LIB electrodes.

References

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