Quantitative measurement of Li ion concentration and diffusion coefficient in all-solid-state lithium ion batteries

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The Li ion transport induced by applied voltage causes changes in the molar volume, which can be measured using electrochemical strain microscopy (ESM). In this way, we can study the ion conduction mechanism by observing electrochemical phenomena occurring in the batteries. However, in spite of the many uses of ESM in battery research, there are little discussion about how to analyze quantitatively the lithium ion concentration and diffusion coefficient from ESM signals. In this study, we visualize the Li ion conduction channel of solid electrolyte for lithium batteries using ESM and show how to calculate the Li ion concentration from ESM signals. We use Fick's second law to calculate the diffusion coefficient as a function of space and time. These calculated diffusion coefficients are compared with those measured from impedance spectroscopy. Our study can provide the link between local and macroscopic properties as well as insight into the Li ion transport mechanisms at the nanoscale, which can guide the design of next generation Li ion batteries with better performance.