High-Resolution Imaging Probe for STRAFI Studies of Solid-Materials

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Introduction

Examining the physical properties of solid materials as they are being utilized would provide useful information to improve and further develop their functions. *In situ* studies are often difficult to execute since many techniques are destructive or alter the structure from their original states. Magnetic resonance methods are often utilized since they are non-invasive allowing for a true representation of their mechanisms. A material that has garnered much attention for *in situ* studies is lithium ion batteries. The charge-discharge mechanism of Li-rechargeable batteries is important to understand so that their energy capacitance, efficiency and cycle lifetime can be improved. Most often, however, high resolution images are not easily attainable with conventional MRI methods since extremely strong gradients are not producible with typical setups. An alternative approach to MRI is stray field imaging (STRAFI) where the strong magnetic field gradients (> 50 T/m) in the fringe field of a superconducting magnet are exploited. In this work we have produced a high-resolution STRAFI probe to study solid materials. In addition to the strong gradients, hardware design, shaped pulses and power levels are examined for enhancing image resolution.

Figure 1: Broad band STRAFI probe for material imaging.

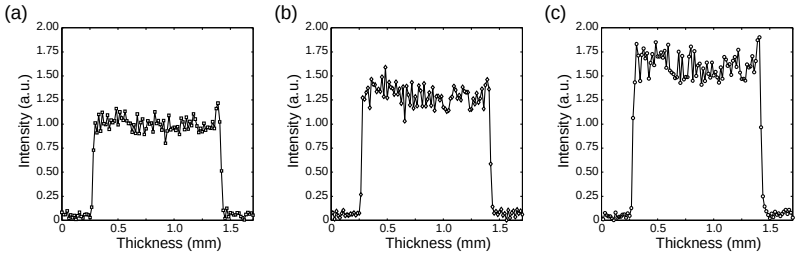

Figure 2: 1D ^{7}Li STRAFI of concentrated LiBr in D_2O using (a) Rectangular, (b) Gaussian and (c) Sinc shaped pulses.

Experimental

Experiments were performed on a 19.6 T magnet with a Bruker DRX console using a custom single channel broadband probe (**Figure 1**). Shaped pulses were generated using Bruker's shaped pulse tool. LiBr solutions and $LiCoO_2$ electrodes were prepared in house.

Results and Discussion

Figure 2 shows the 1D ^{7}Li profile of a LiBr solution using shaped pulses. The uniform excitation profiles from the Gaussian and Sinc pulses reduce the amount of excitation in adjacent slices, typically produced by side lobes of the excitation profile, allowing us to obtain an image resolution of ~15 µm. With high resolution achievable, a battery phantom with electrodes ~0.25 mm thick is easily resolved (**Figure 3**). The presence of metal disks do not affect the image profile showing the possibility of studying batteries *in situ* with STRAFI.[1]

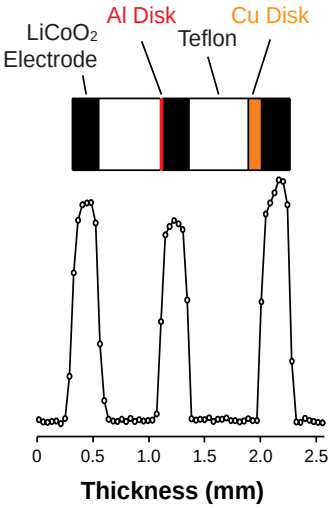

Figure 3: 1D STRAFI profile of a battery.

Conclusions

STRAFI provides a powerful alternative to MRI when studying solid material samples. Such a high-resolution 1D imaging method can be applicable to other systems including thin films and layered systems.

Acknowledgements

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References

[1] Tang, J.A., *et al.*, J. Magn. Reson., **225**, 93-101 (2012).