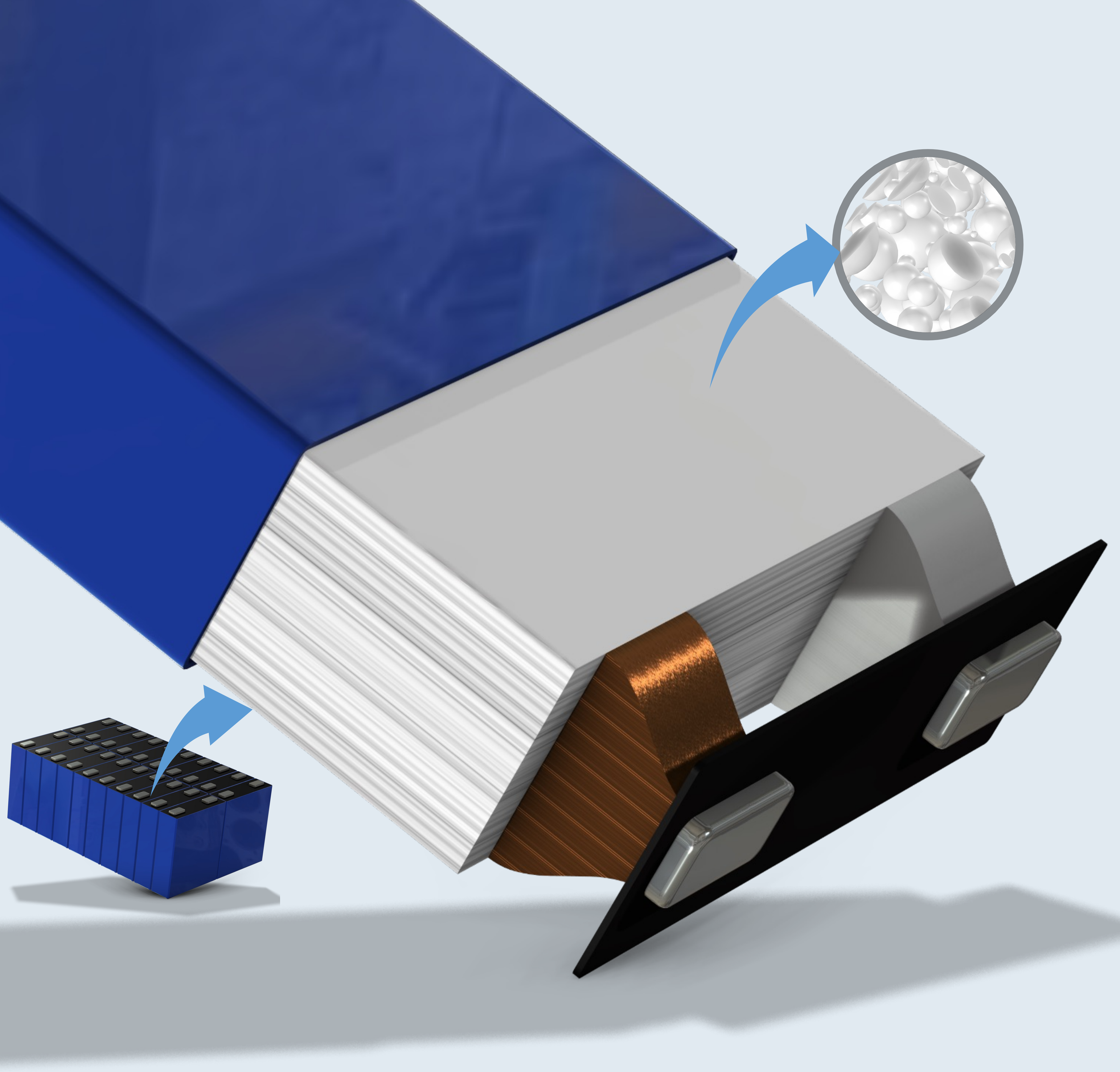

Impact of Battery Operation and Manufacturing Process on Battery Performance over Lifetime

Building simulation model components for a decision-making support tool

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Introduction and Goals

Global Lithium-ion battery demand is expected to grow 27% annually to 4700 GWh by 2030. Growing battery applications are mobility (electric vehicles) and energy storage systems. Efficiency, longevity, recyclability are critical design targets to meet sustainability targets.

High fidelity simulation is needed to support the technology development and to shorten time to market.

We exemplify the use of COMSOL Multiphysics® in building model components for decision-making support tools for:

(1) Battery cell design and subsequently battery pack design

(2) Assessment of busbar welding process heat propagation

(3) Busbar weld resistivity quantification

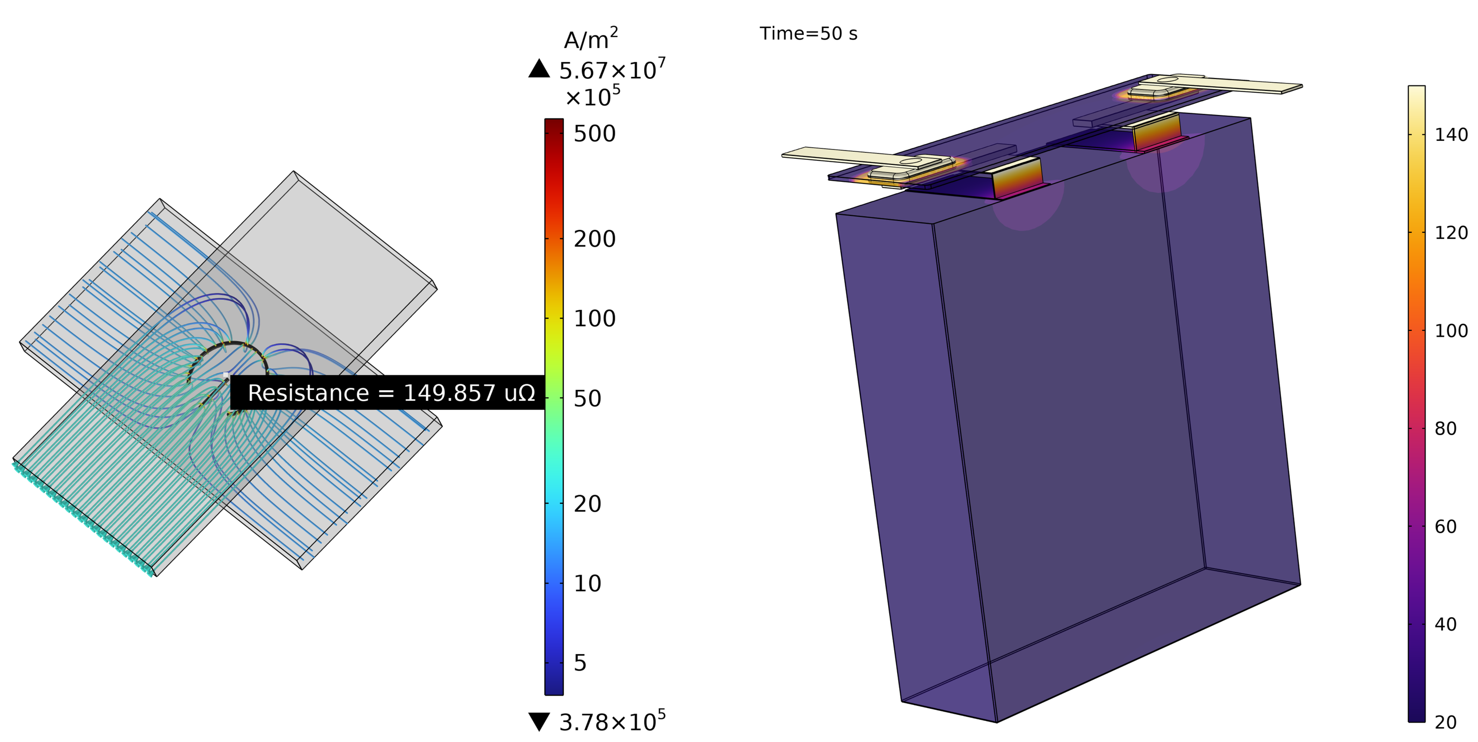

FIGURE 1. Left: Current transport between busbar and battery tab. Right: Worst Case Scenario for Heat Propagation of Energy during Laser Welding.

Methodology

Lithium liquid electrolyte batteries are governed by lithium diffusion, current transport, ionic conductivity, heat transfer, and electro-chemical reactions (intercalation and degradation) [1, 2]. The model was setup in COMSOL Multiphysics®.

Battery chemistry parameters were identified using extensive time series data covering various conditions (current, temperature, and state-of-charge) by minimizing the squared mean potential deviation:

$$F_{cost} = \frac{1}{M}\sum_{i=1}^{M} \frac{1}{N}\sum_{j=1}^{N} \left(U_{i,j} - \tilde{U}_{i,j}\right)^2$$

For busbar heat propagation, an upper temperature threshold of 70 °C was used to avoid detrimental impact on performance.

Results

(1) A single parameter set was identified with excellent match to experimental data. The characteristics are summarized below:

Battery	Conditions	F_{cost}
Fresh	6	$0.012[V^2]$
75 cycles	2	$0.667[V^2]$

(2) A laser weld using process parameters 2 m/min, 9 kW, Ø10 mm circle was simulated and the volume fraction of battery chemistry experiencing ≥ 70°C during the process was found to be negligible.

(3) Keyhole geometry arising from the welding process has significant but quantifiable impact on the tab/busbar joint resistivity.

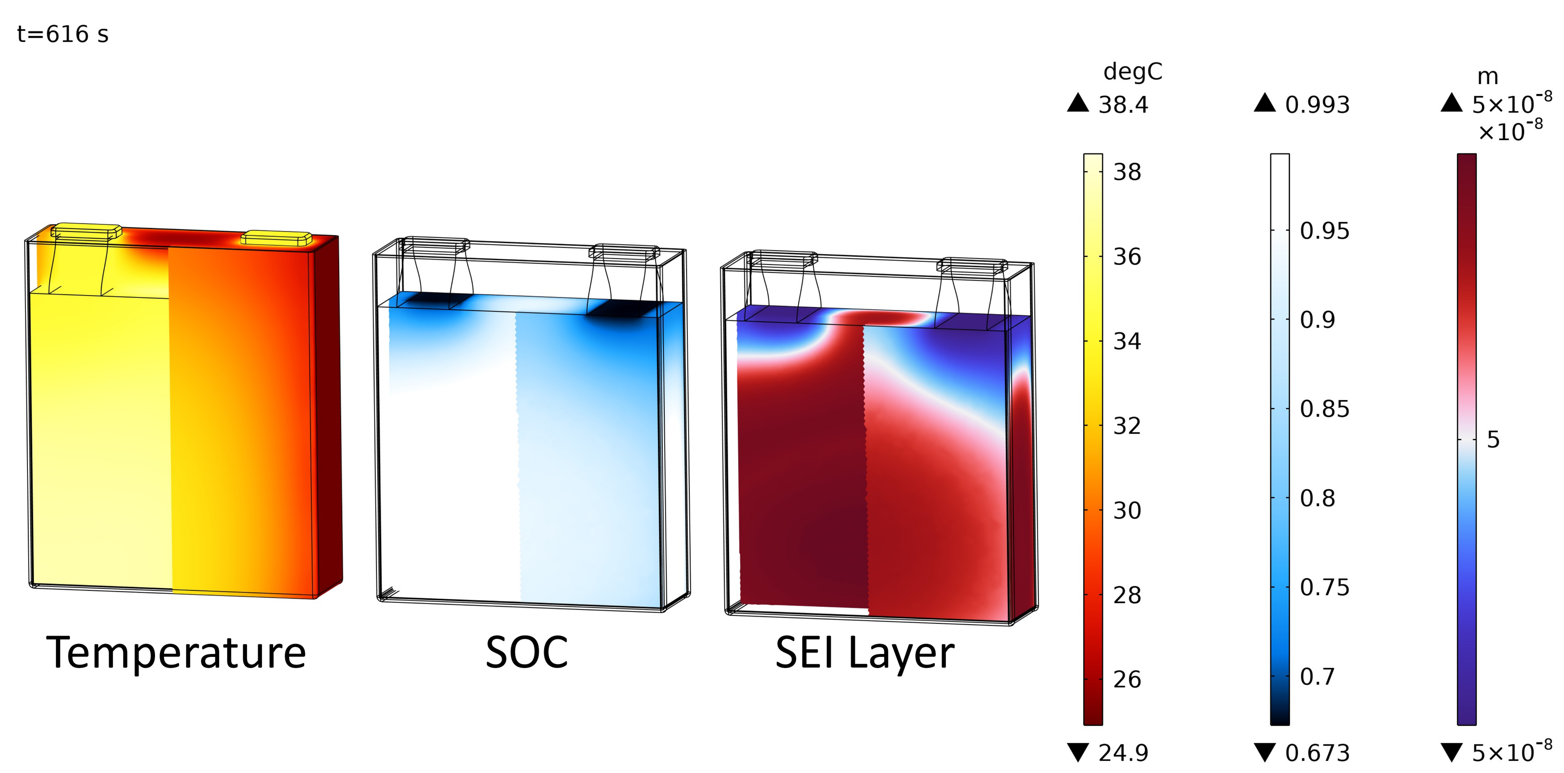

FIGURE 2. Temperature, state of charge (SOC), and the SEI layer thickness during a single discharge. Constant room temperature boundary condition on far-right end of the battery.

REFERENCES

1. Doyle, M.; Fuller, T.F.; Newman. Journal of the Electrochemical Society, 140(6): 1992, 1-35.
2. Safari, M.; Morcrette, M.; Teyssot, A.; Delacourt, C. Journal of the Electrochemical Society, 156 (3): 2009, A145-153.

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