

Impact of Vertical Temperature Gradients on the Electrical Behavior of High-Power NMC Prismatic Lithium-Ion Cells

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Motivation

Inaccurate power forecasts in BMS pose risks to safety and battery lifespan due to overloading.

- High currents in high-power Li-Ion cells cause heat buildup and temperature gradients.
- BMS typically assume homogeneous cell temperature, neglecting internal temperature gradients.

Aim:

- Develop a test setup to induce controlled, inhomogeneous temperature distributions along the cell height.
- Investigate the effect of vertical temperature gradients on the electrical properties of the cell.

Experimental Setup

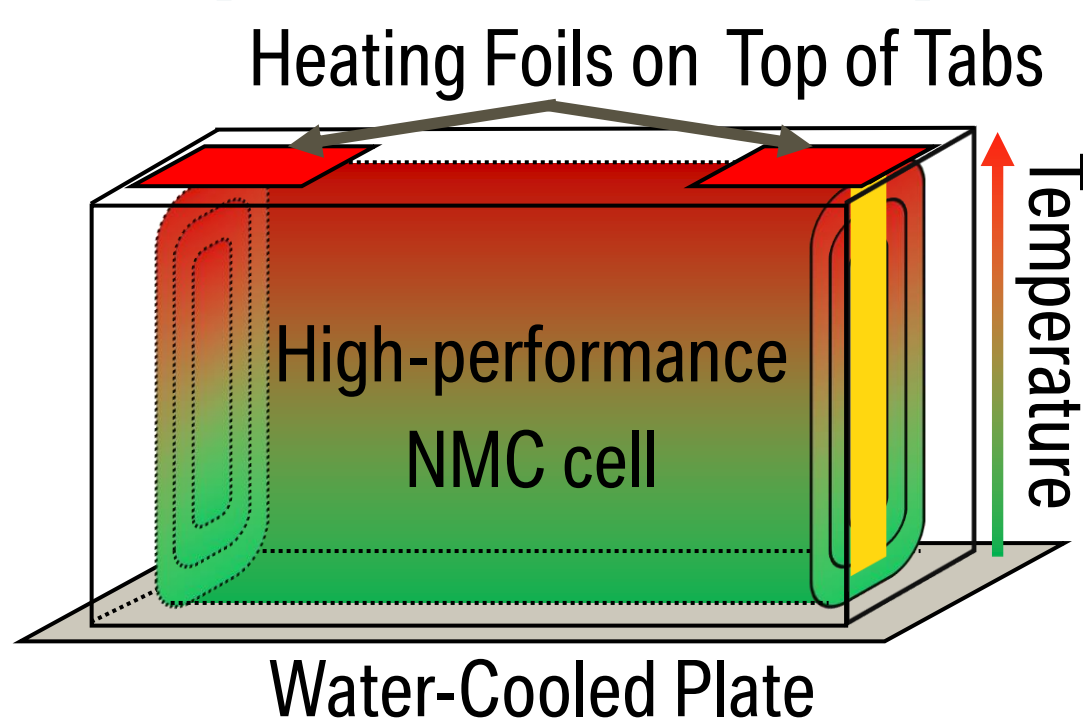


FIGURE 1: Schematic measurement setup.

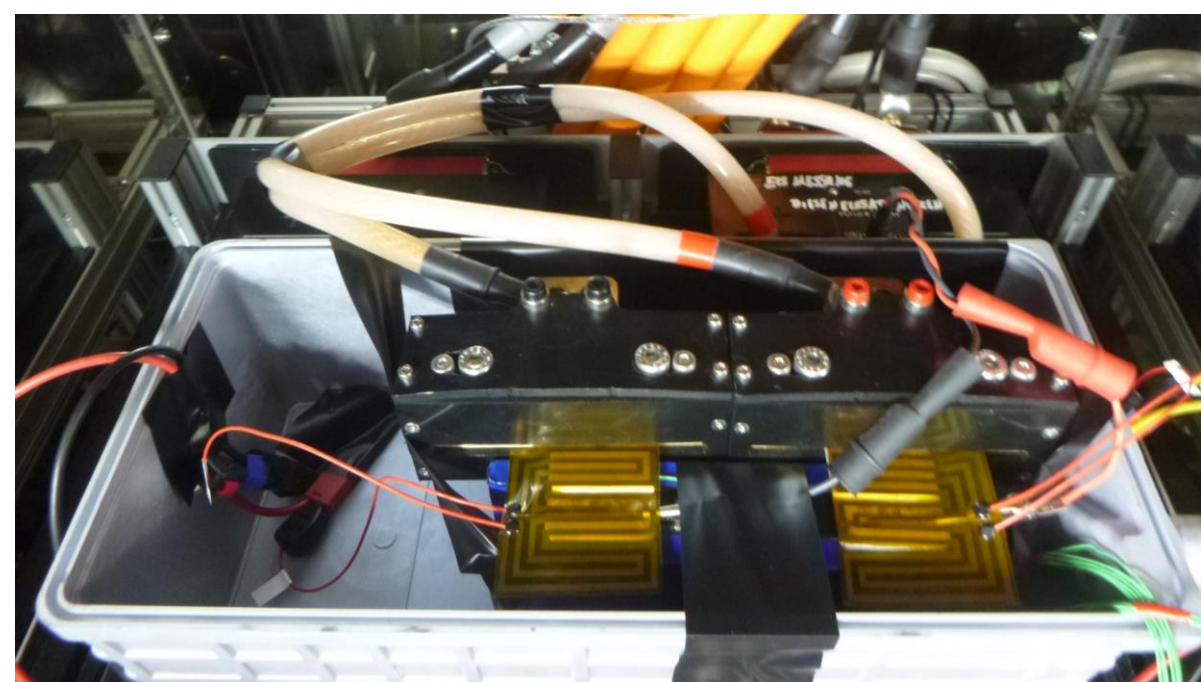


FIGURE 2: Lab measurement setup.

Key Features

- Independent temperature control at the cell bottom and each cell tab.
- Temperature accuracy: within $\pm 1^\circ\text{C}$ at each control point.

Results

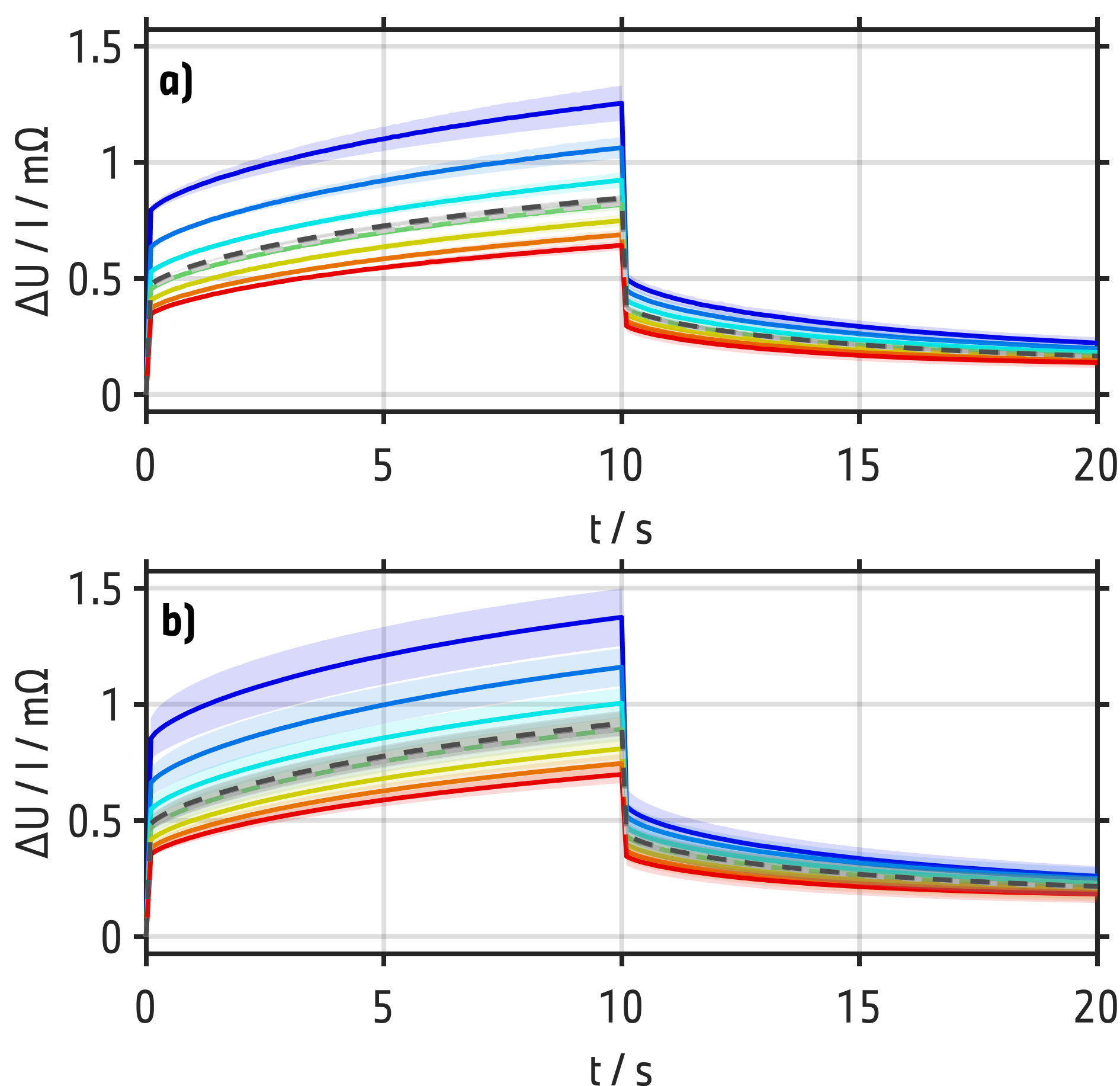


FIGURE 3

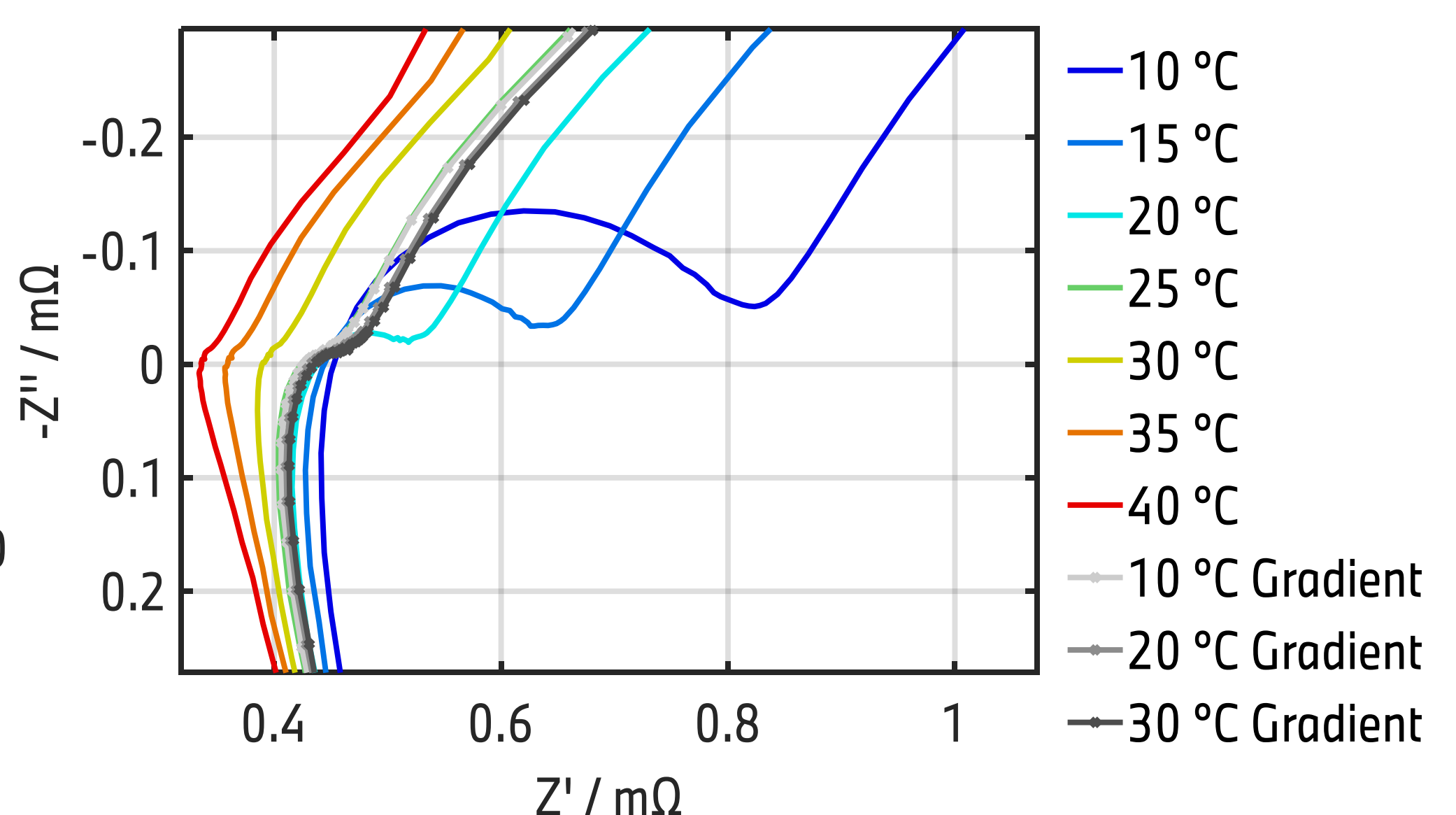


FIGURE 4

Figure 3: Pulse response normalized by current, showing temperature-induced $\Delta U/I$ behavior.

(a) $\Delta U/I$ responses at 50% SoC with $\pm 1\sigma$ bands across C-rates.

(b) $\Delta U/I$ responses at 5C with $\pm 1\sigma$ bands across SoC.

Figure 4: Nyquist impedance spectra at homogeneous and inhomogeneous cell temperatures.

Conclusion & Outlook

- Cells with temperature gradients behave similarly to cells at their corresponding mean temperature.
- Local hotspots may remain undetected, increasing aging and safety risks.
- Develop a segmented electrical cell model to account for temperature non-uniformity.
- Incorporate temperature gradients into State-of-Power (SoP) estimation.