

# Temperature Regulation for Li-ion Cells

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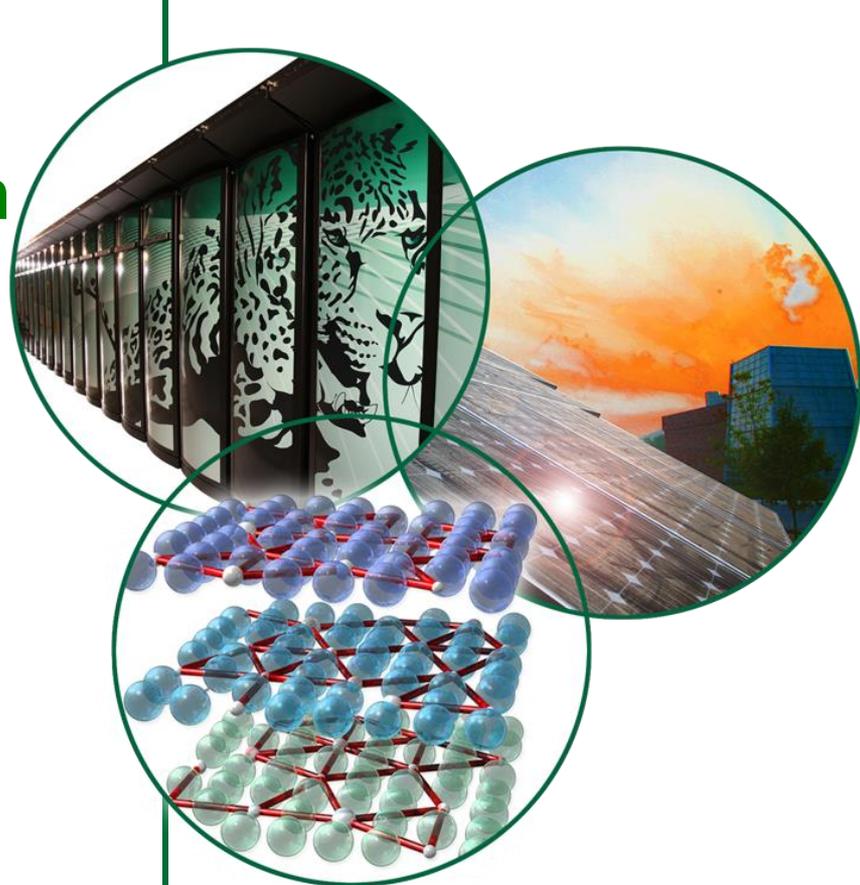
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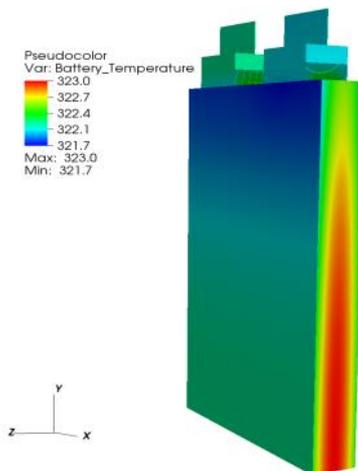
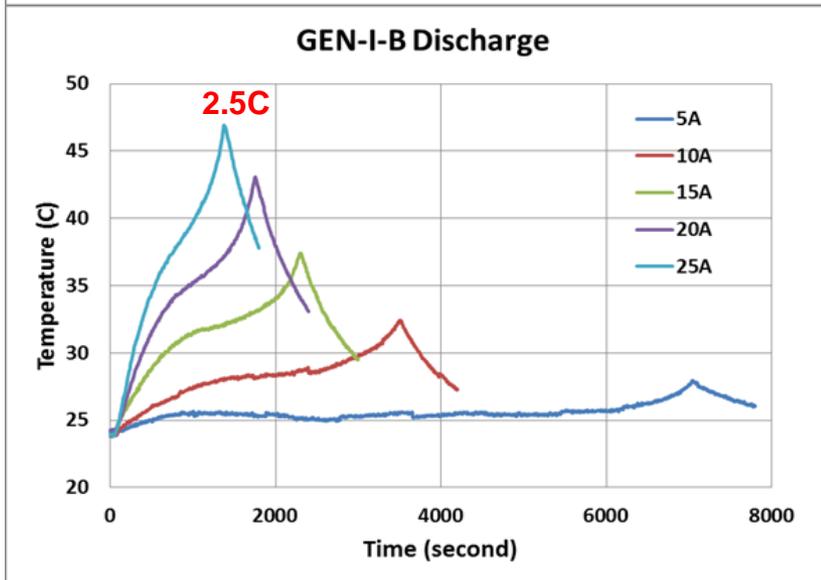
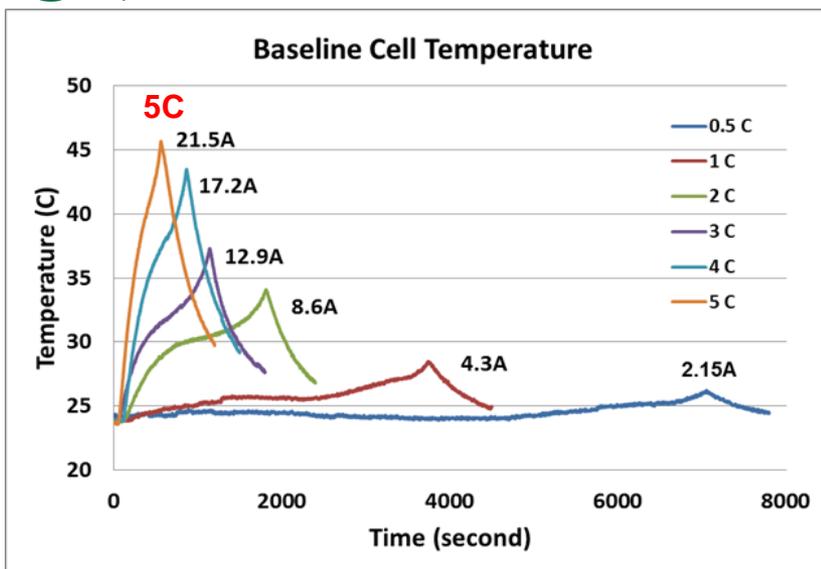
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# Thermal Management Challenges in Large, Thick Cells



**A 4.3 Ahr NMC Cell Equivalent to NMC 25 Ah Cells**

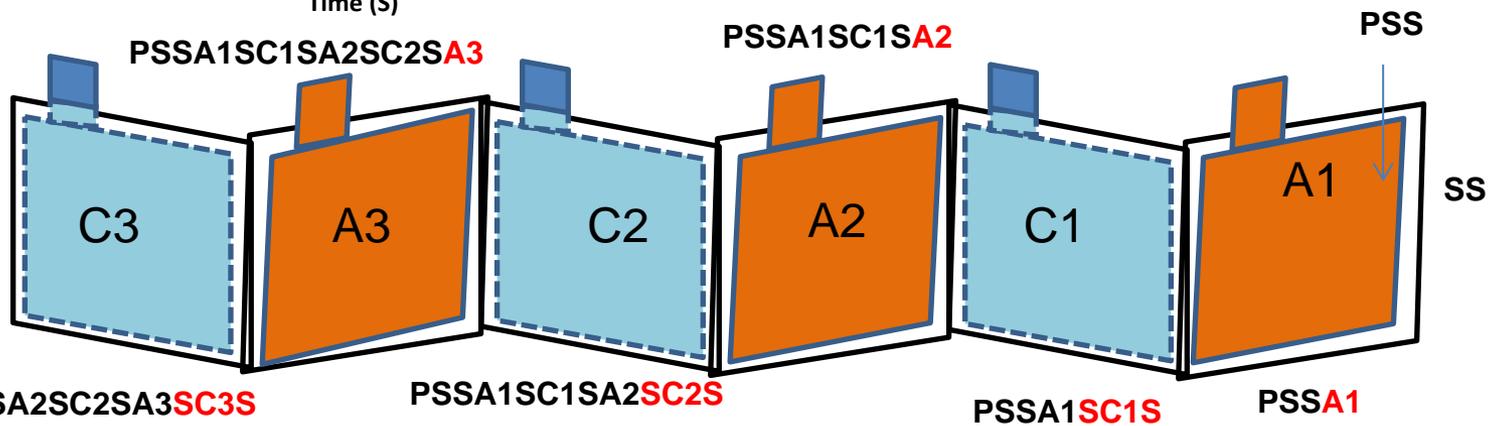
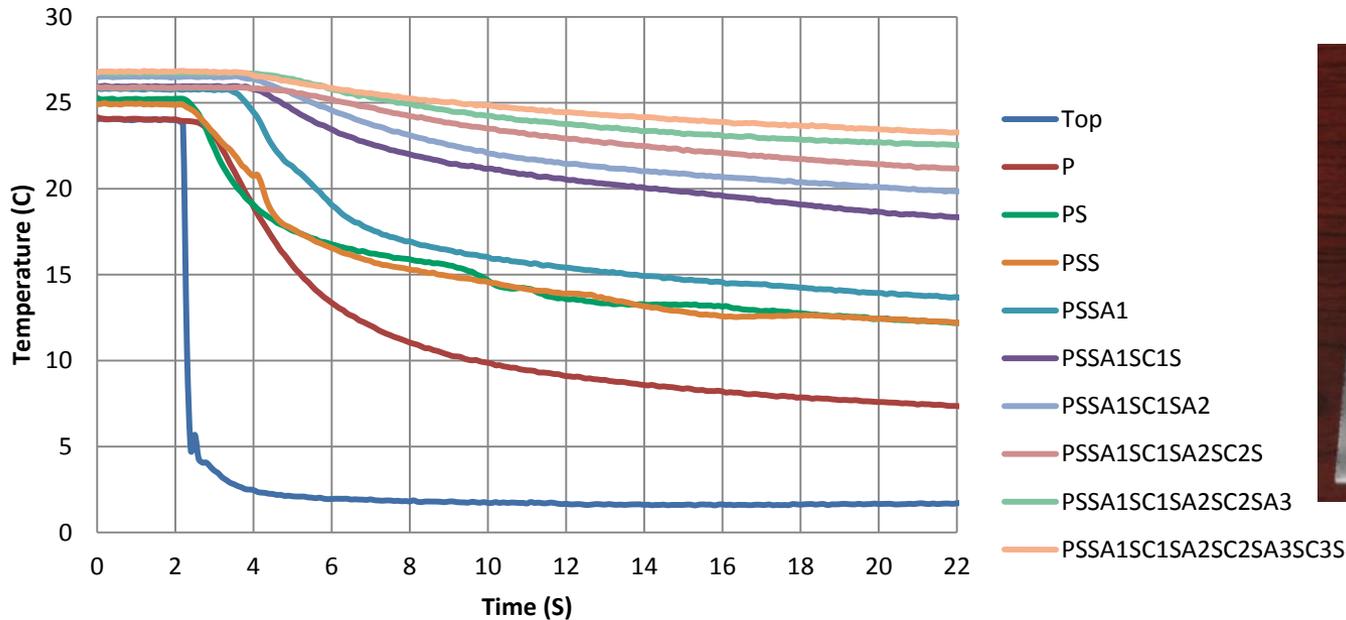


Thermal management of bigger and thicker cells, high capacity cells, at higher C-rates requires new design: **Additional thermal tabs are used for heat transfer!**



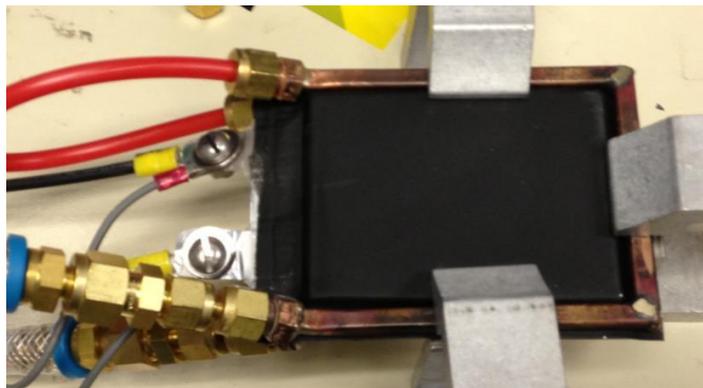
# Cooling from Pouch Surface is Very Ineffective!

## Ice Block Cooling Through the Pouch



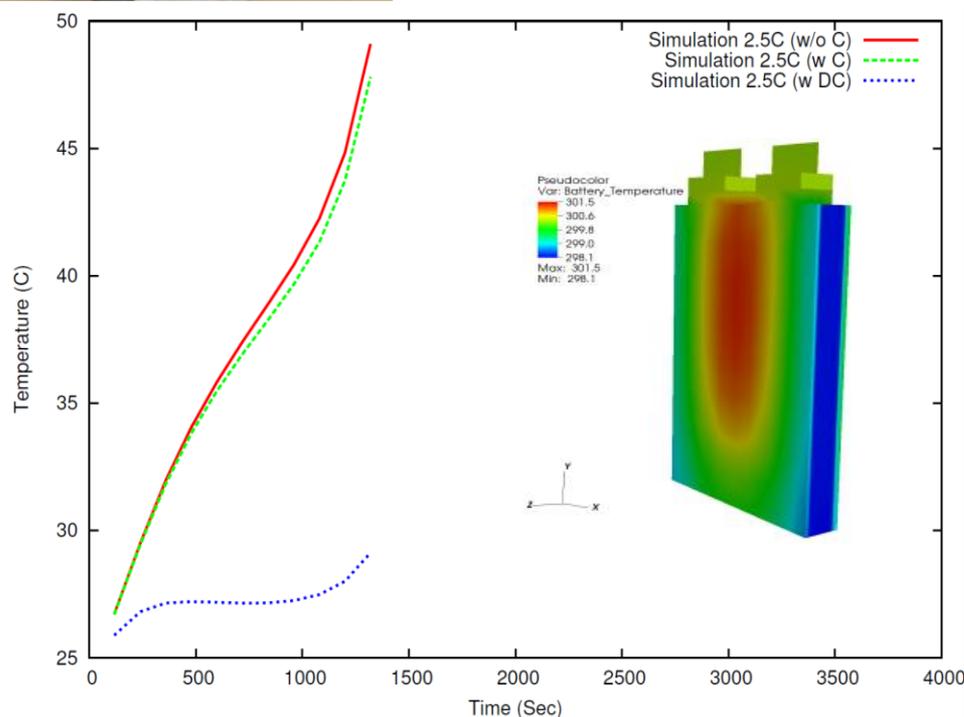
- Cooling from the surface is only effective few layers deep
- Confirms the need for alternative cooling

# Side Cooling of a New Cell with Thermal Tabs Using a Water Chiller



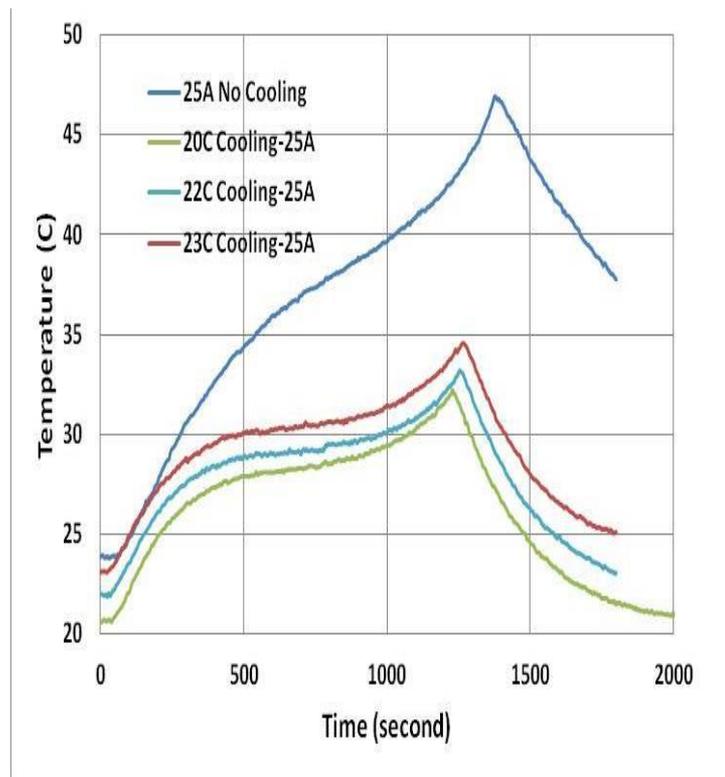
## Modeling Results

- 9.5 Ah NMC cell with thermal tabs
- Cooling temperature can be changed 20-24C
- Resolution: 0.1C
- For demonstration only and the designs can be further refined

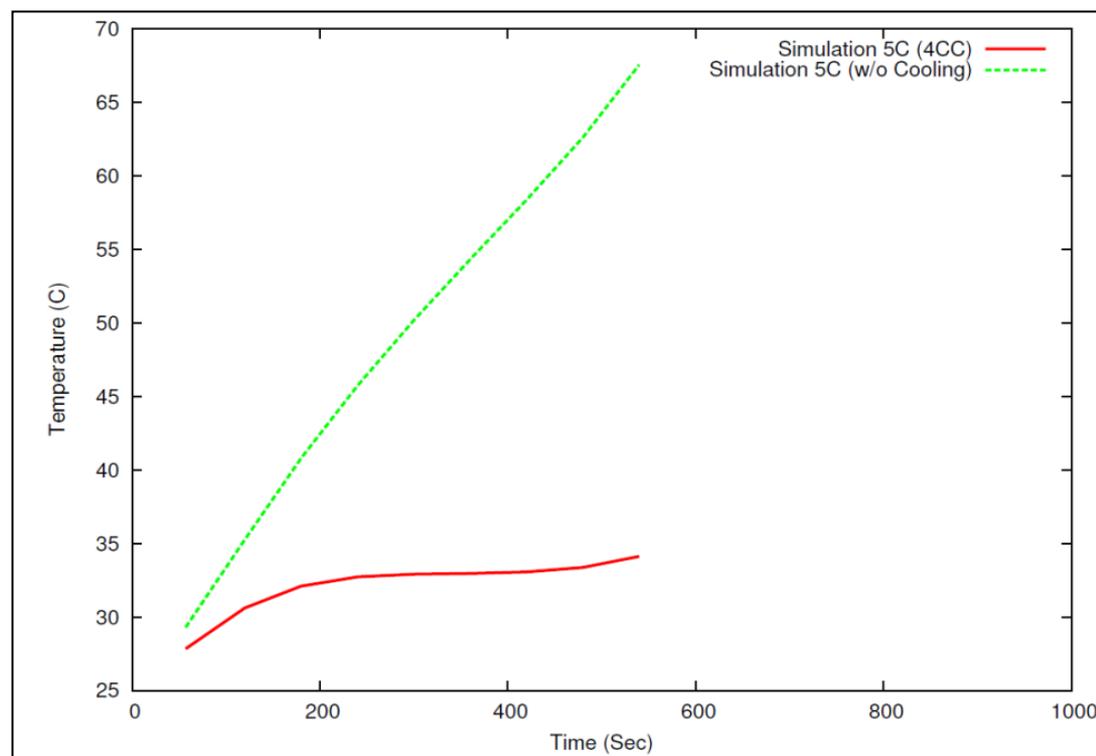


# Side Cooling Results: Experiment and Modeling

## 2.5C Experiment



## 5C Discharge Modeling



- Experiments have additional resistance due to uneven contact that is not included in the simulations
- Idealized boundary conditions can be achieved through engineering and thus improved cooling

# Future Work and Test Matrix

## 2014 Plan:

- High C-rate cooling tests
- Cycling comparison:
  - a. Baseline cell
  - b. Thick cell (no cooling)
  - c. Thick cell (surface cool)
  - d. Thick cell (side cool)
- Modeling work:
  1. Form factors
  2. Various cell design
  3. Cooling options
- Technology-to-market

## Benefits:

**Side cooling should improve lifetime/safety in current designs and allow for a new generation of bigger cells with acceptable thermal behavior.**

## Test Matrix

Test	Test Protocol	Cell Type
Thin	1-Cycle (1C to 5C discharge)	A
Thick	1-Cycle (1C to 5C discharge)	B
Thick with side cooling	1-Cycle (1C to 5C discharge)	C
Thin with no cooling	Cycling (1C charge, 5C discharge till 80%)	A
Thick with no cooling	Cycling (1C charge, 5C discharge till 80%)	B
Thick with standard surface cooling	Cycling (1C charge, 5C discharge till 80%)	B
Thick with side cooling	Cycling (1C charge, 5C discharge till 80%)	C

## Three Types of Cells:

- |  |  |  |
|--|--|--|
| A. Thin cells: Thin  |  |  |
| B. Thick cells: Thick  |  |  |
| C. Thick cells with side-cooling layers: Thick with Side-cooling |  |  |