

MULTISCALE SAFETY TESTING OF SILICON-GRAPHITE ANODES PAIRED WITH NMC811 CATHODES

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Background

Project Goal

Use **microcell safety testing** and **18650 abuse testing** to understand how Si content impacts the **safety of Si/graphite anodes** when paired with an energy dense cathode while balancing safety and performance.

Current Practice

Large format batteries subjected to destructive tests require larger quantities of materials and infrastructure to safely conduct, **slowing the rate at which testing proceeds.**

Why SNL?:

SNL has **established expertise in many forms of battery testing** and staff with experience in microcell safety testing.

Innovation

This work **bridges the gap** between small-scale electrode-only safety testing and full-cell testing, **improving the speed and efficiency of safety testing.** Earlier work from SNL has demonstrated the value of this approach.

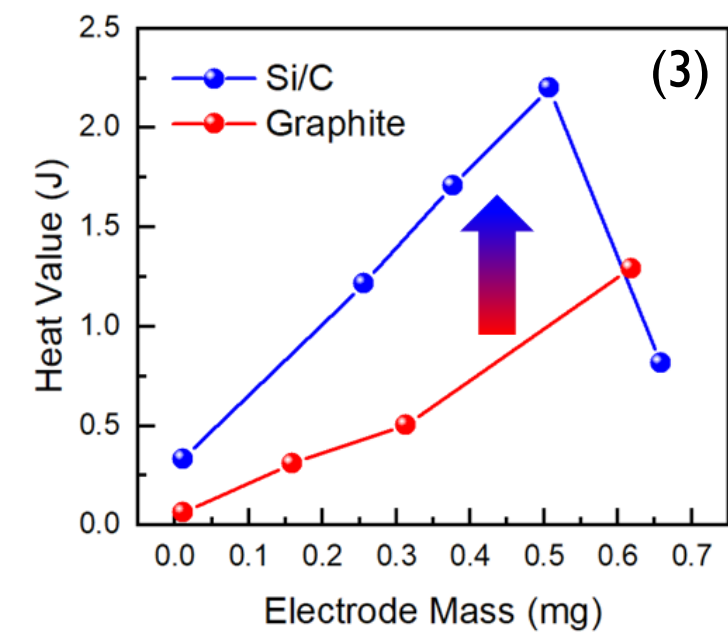
Impact

These results will be interesting to: battery scientists, safety researchers, and battery manufacturers. This provides **foundational knowledge to improve the safety of two emerging battery chemistries.**

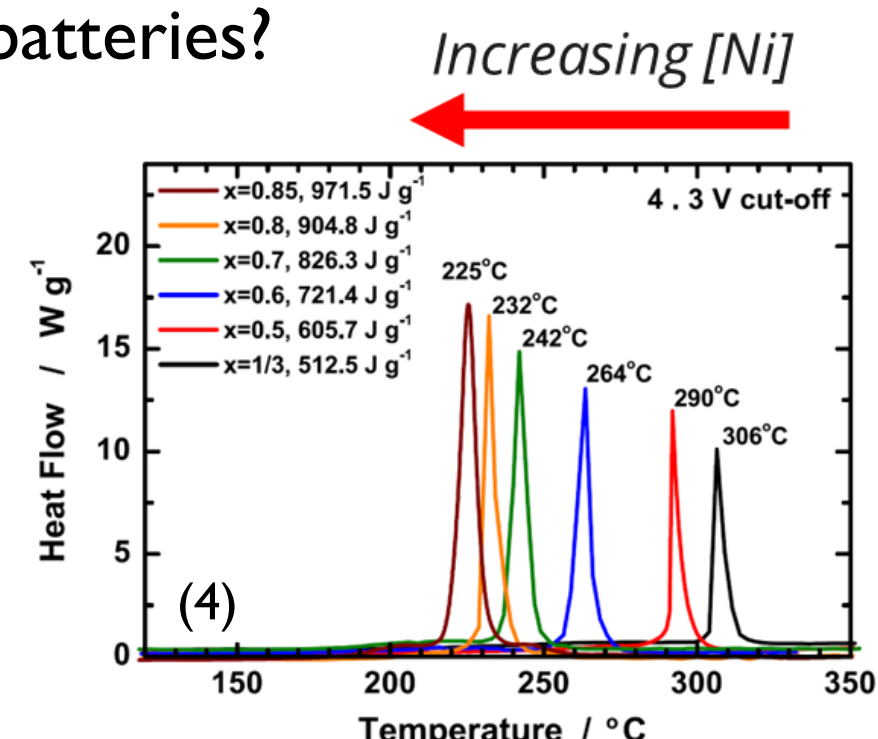
Alignment

This **innovative** microcell approach improves our ability to study the safety of emerging battery chemistries, improving the **security** and **reliability** of future energy technologies. Inherently safer batteries reduce cost, allowing for the development of more **affordable** energy storage technologies.

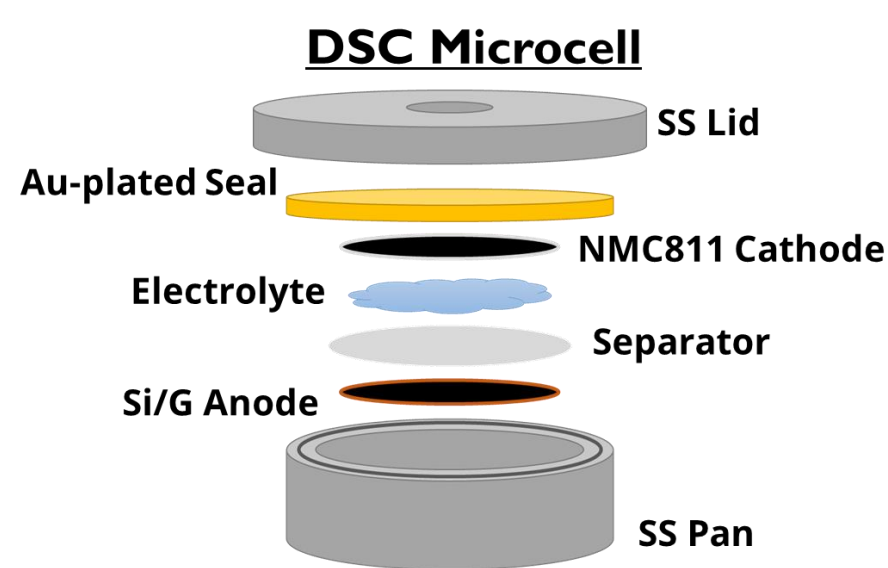
Before they're commercialized, can we determine the relative safety during thermal runaway for Si/graphite||NMC811 batteries?



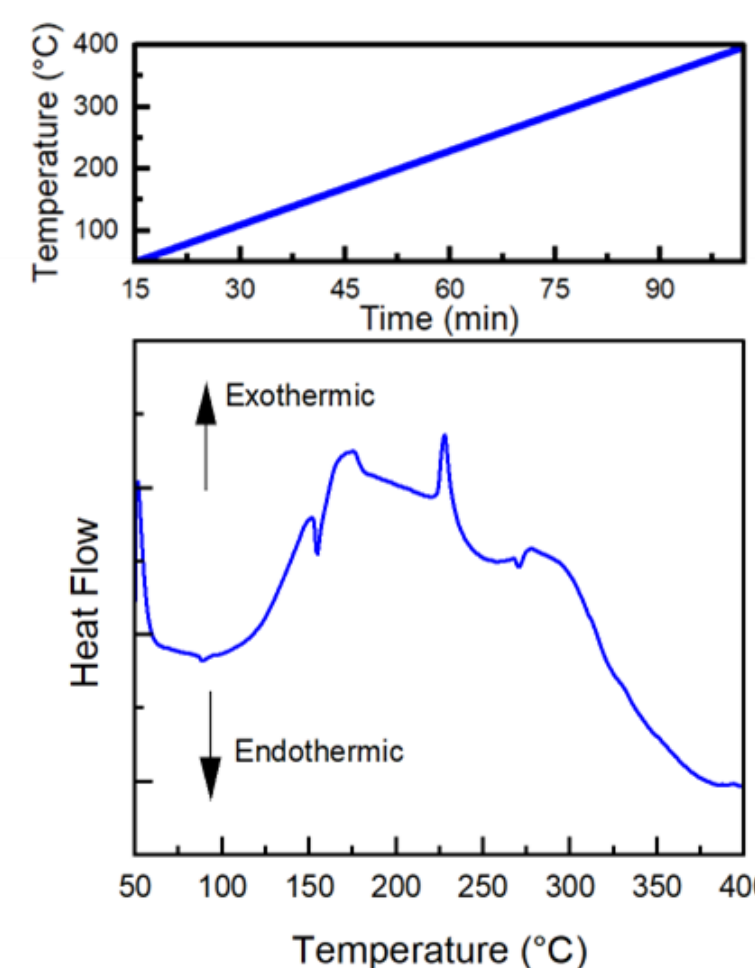
Increased energy density could be detrimental to safety in event of failure



DSC Analysis and Microcells

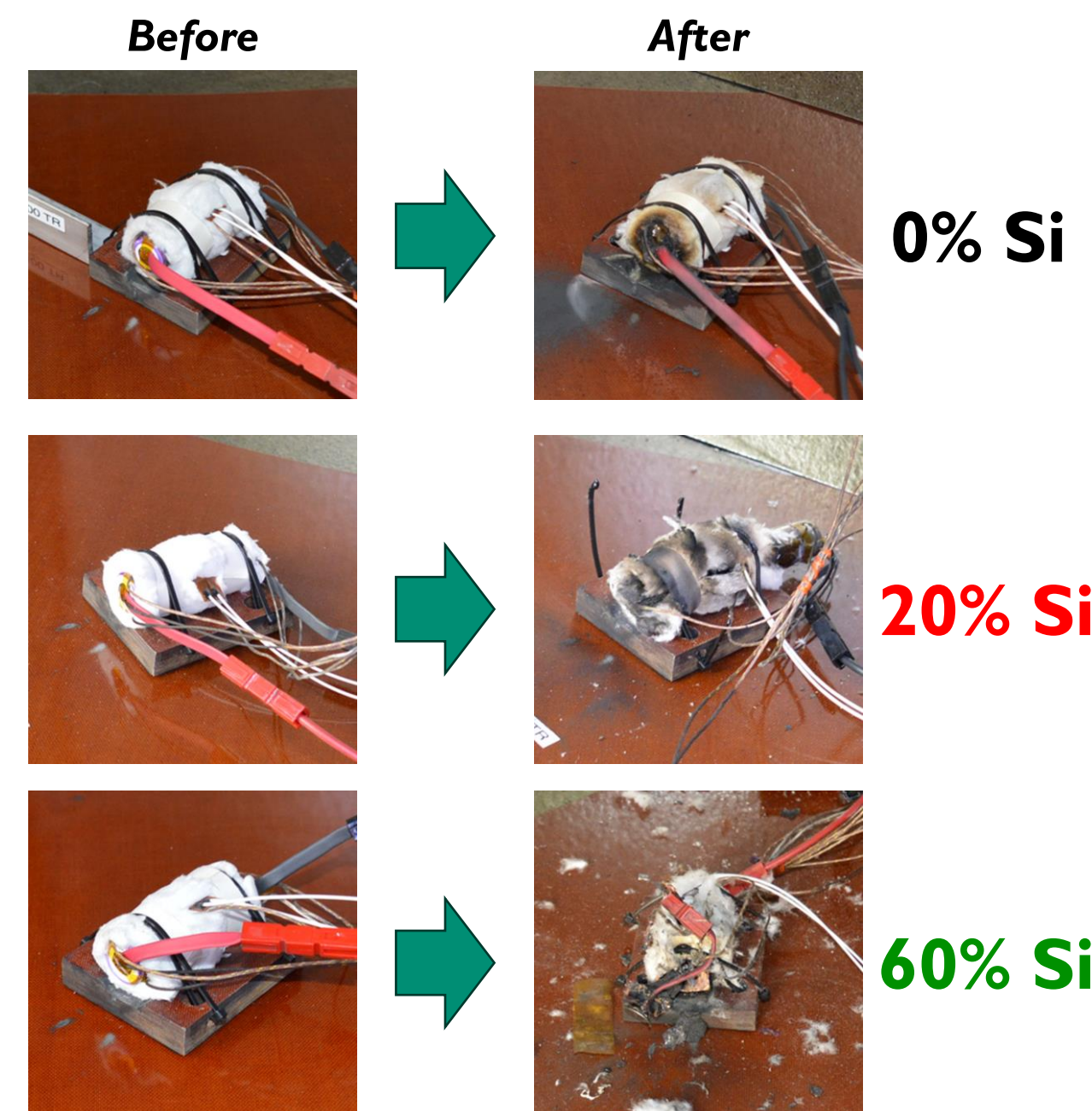
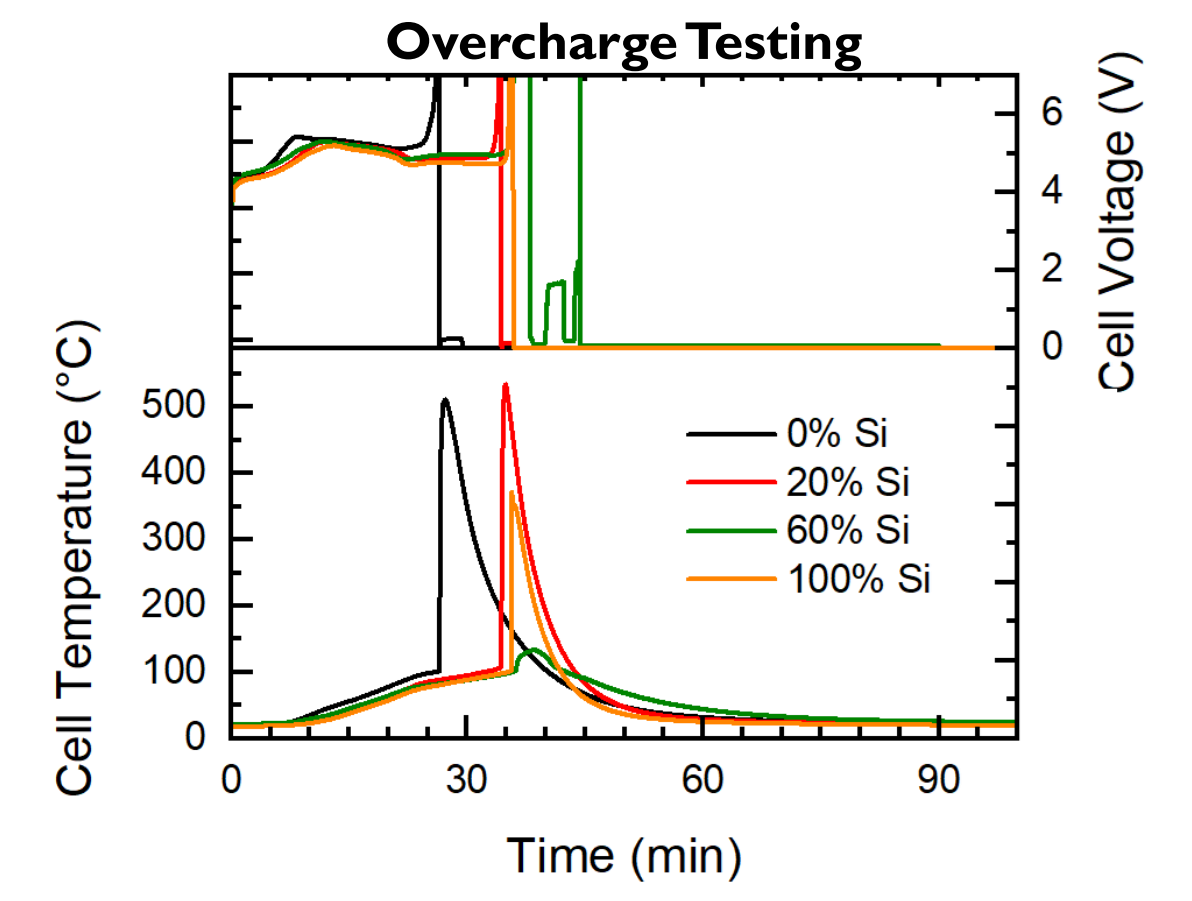
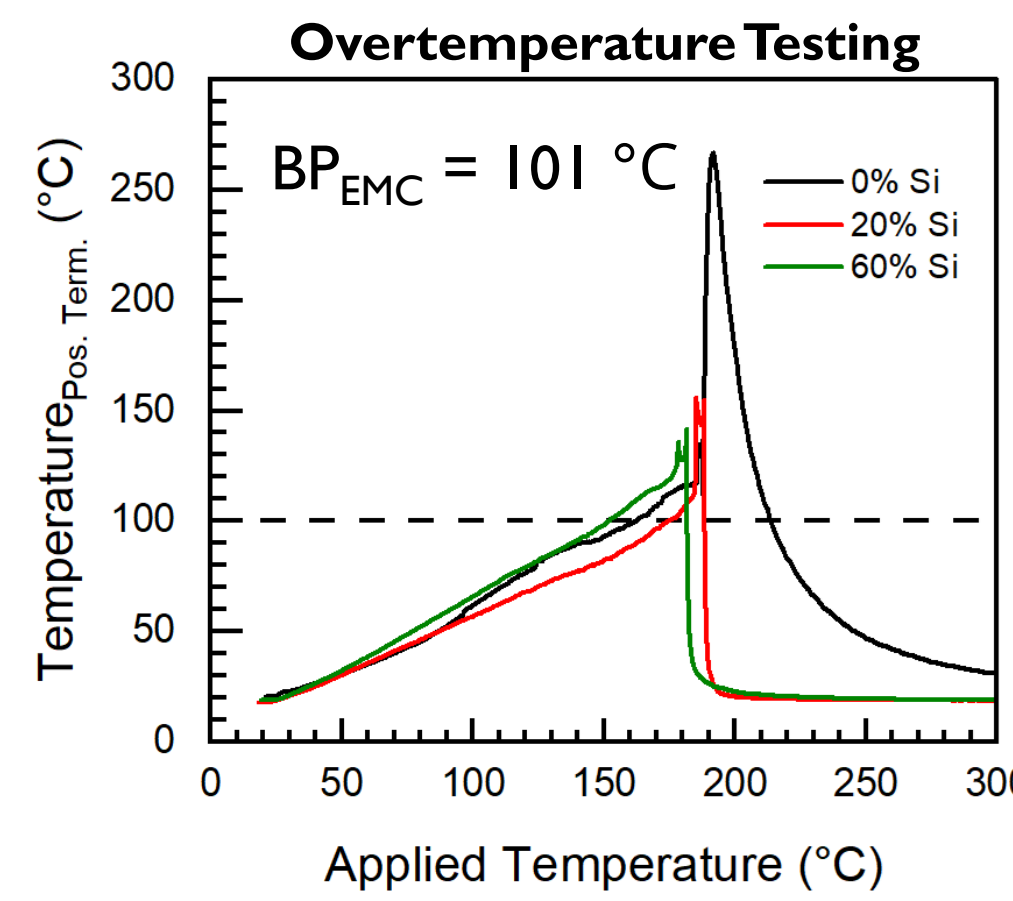


Differential Scanning Calorimetry (DSC)
Increase external temperature of sample sitting on thermocouple;
measure amount of heat required to increase the temperature of the sample relative to a reference

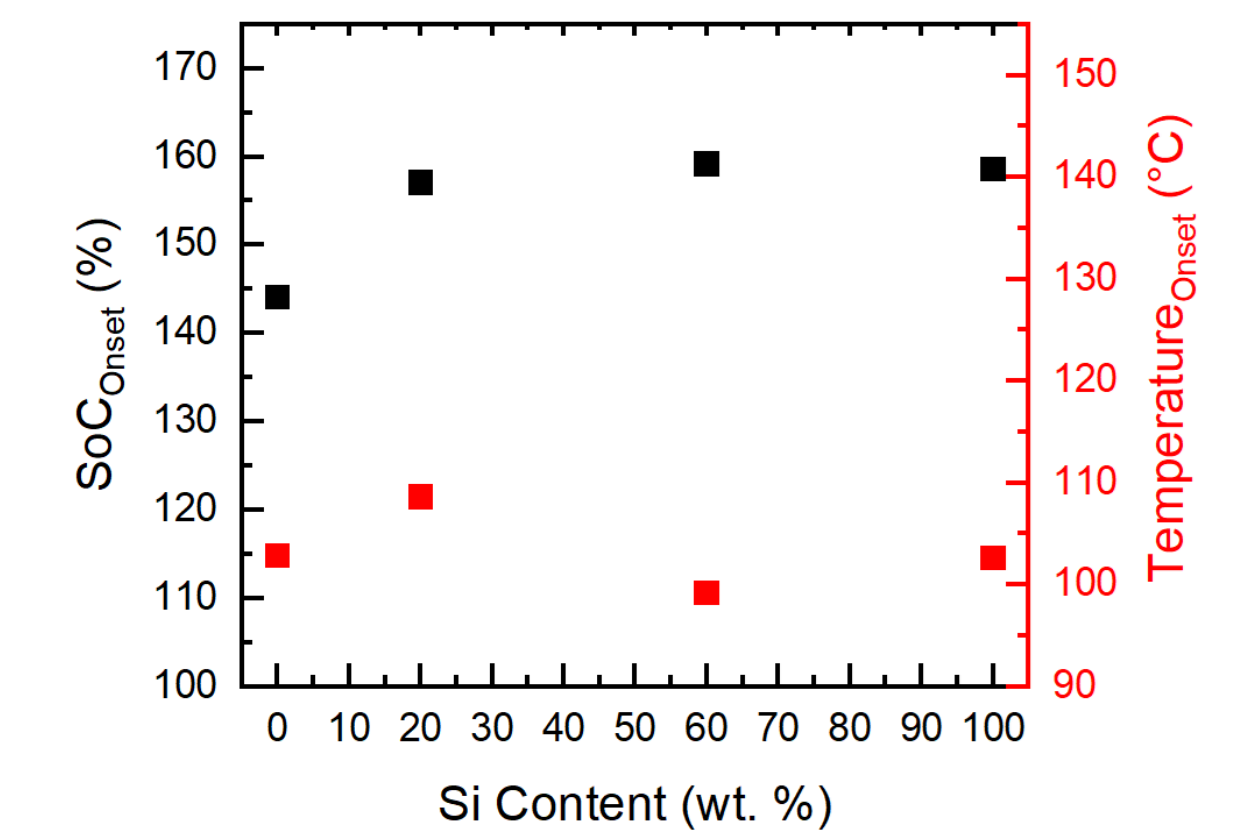


18650 Overcharge Results

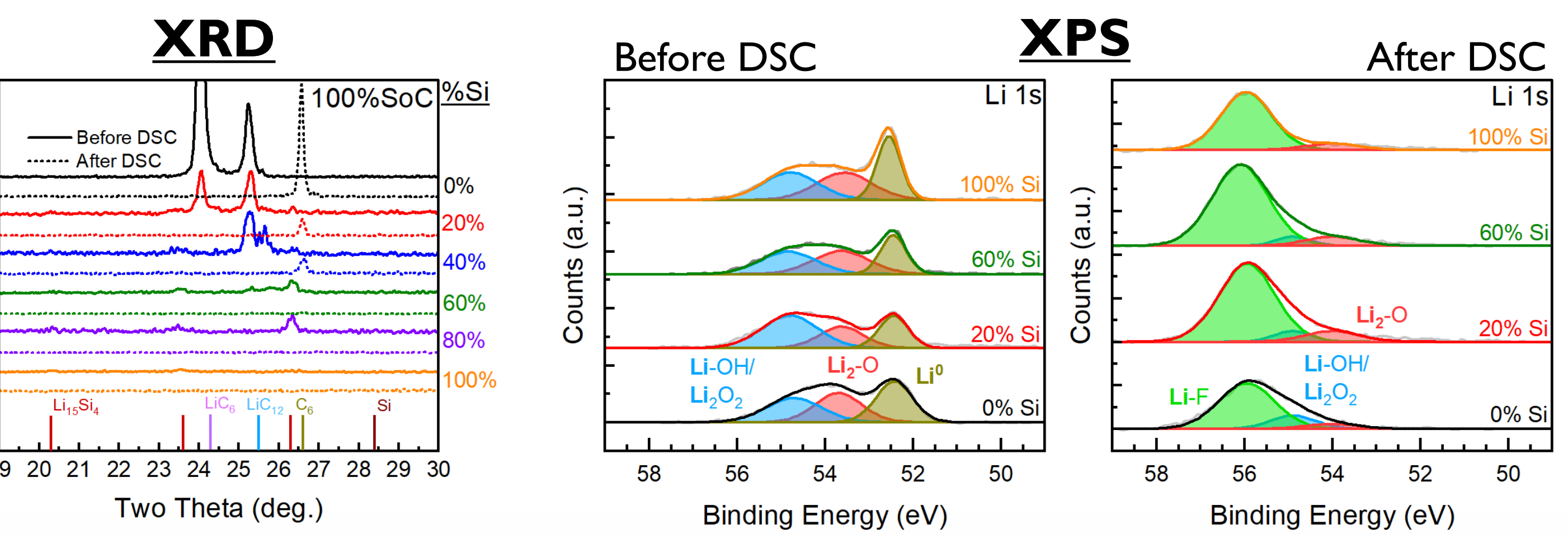
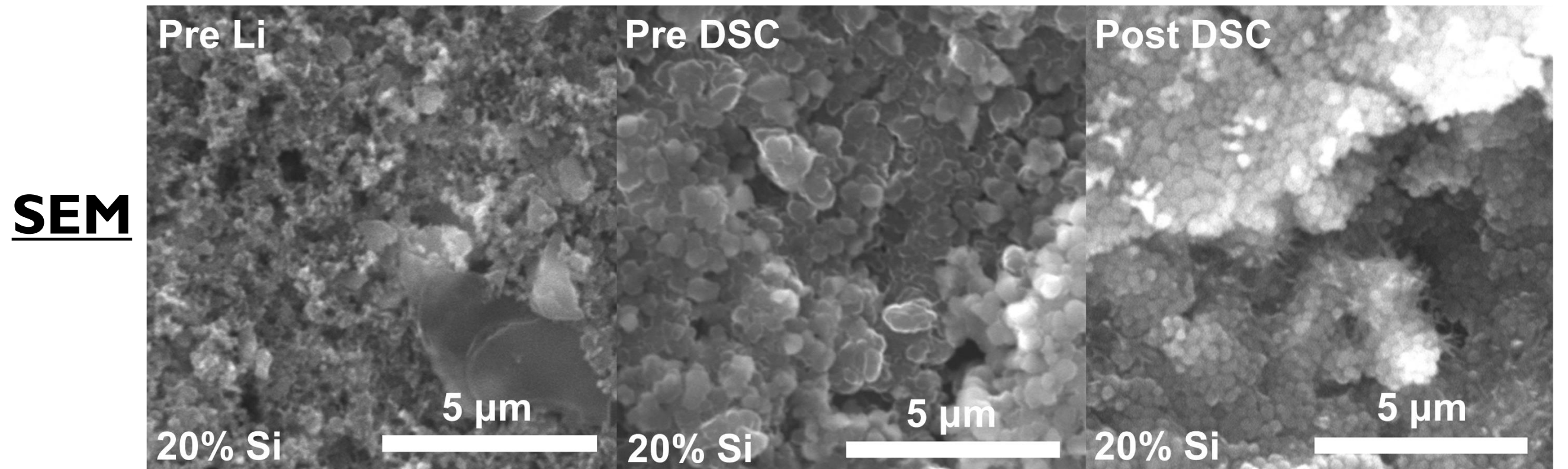
Testing of SiG||NMC811 18650 batteries with 1.0 Ah total capacity



Overcharge induces heat generation, but additional Si increases the overcharge capacity of the cell

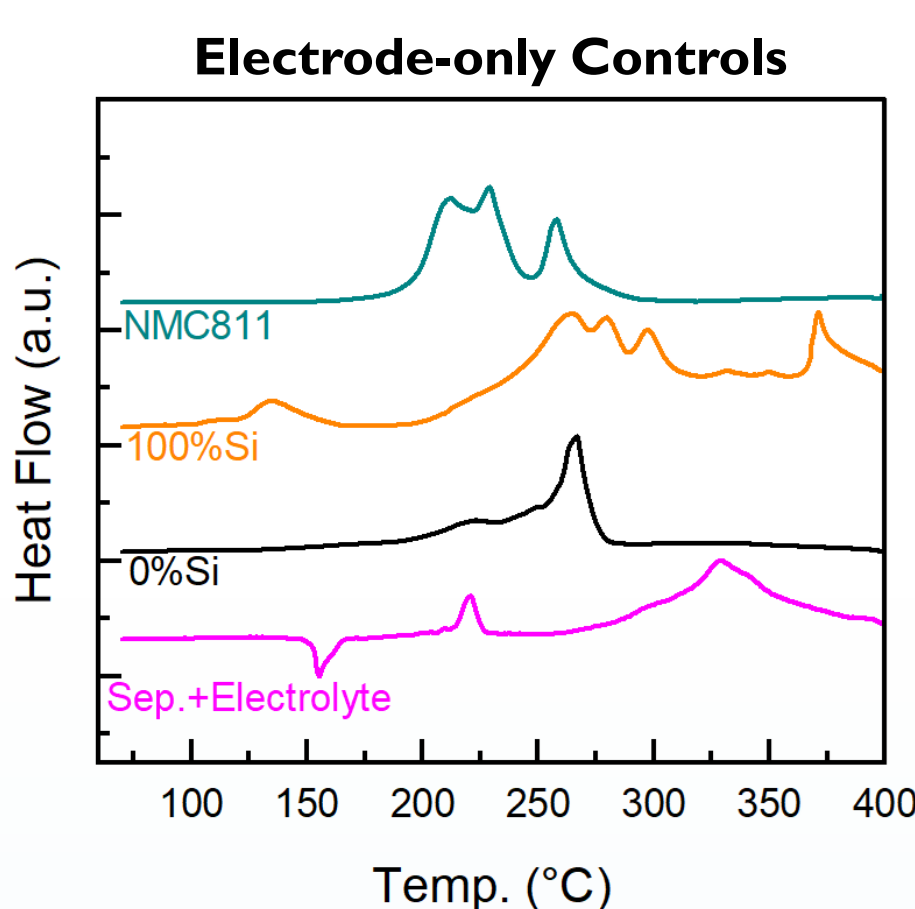


Materials Characterization

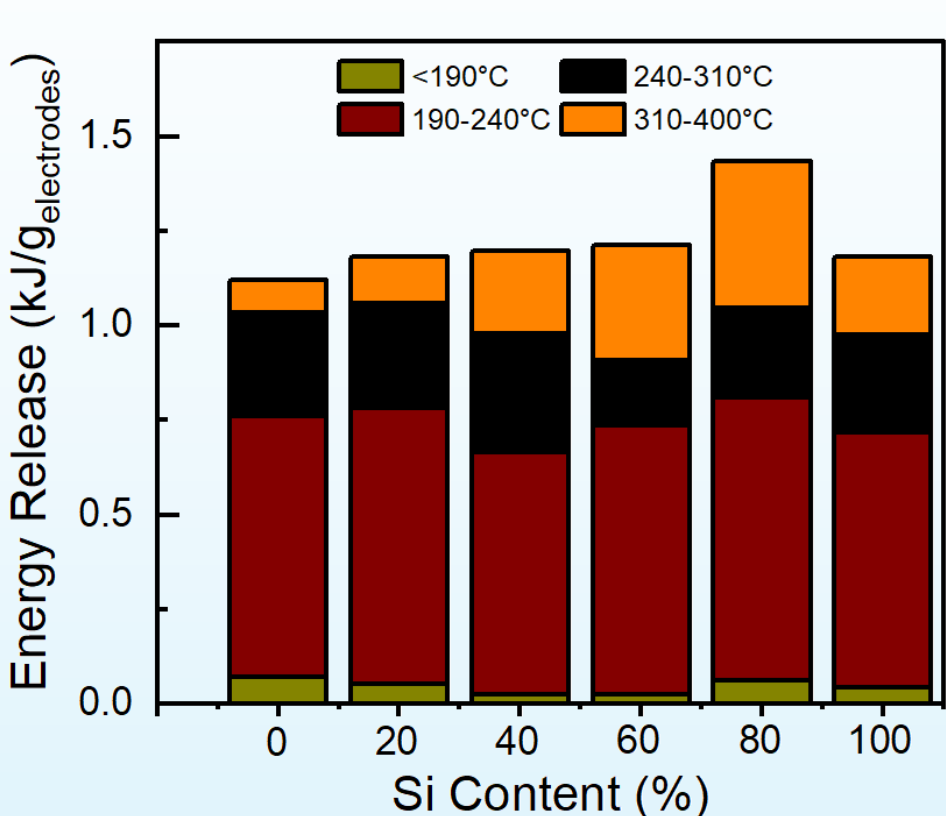
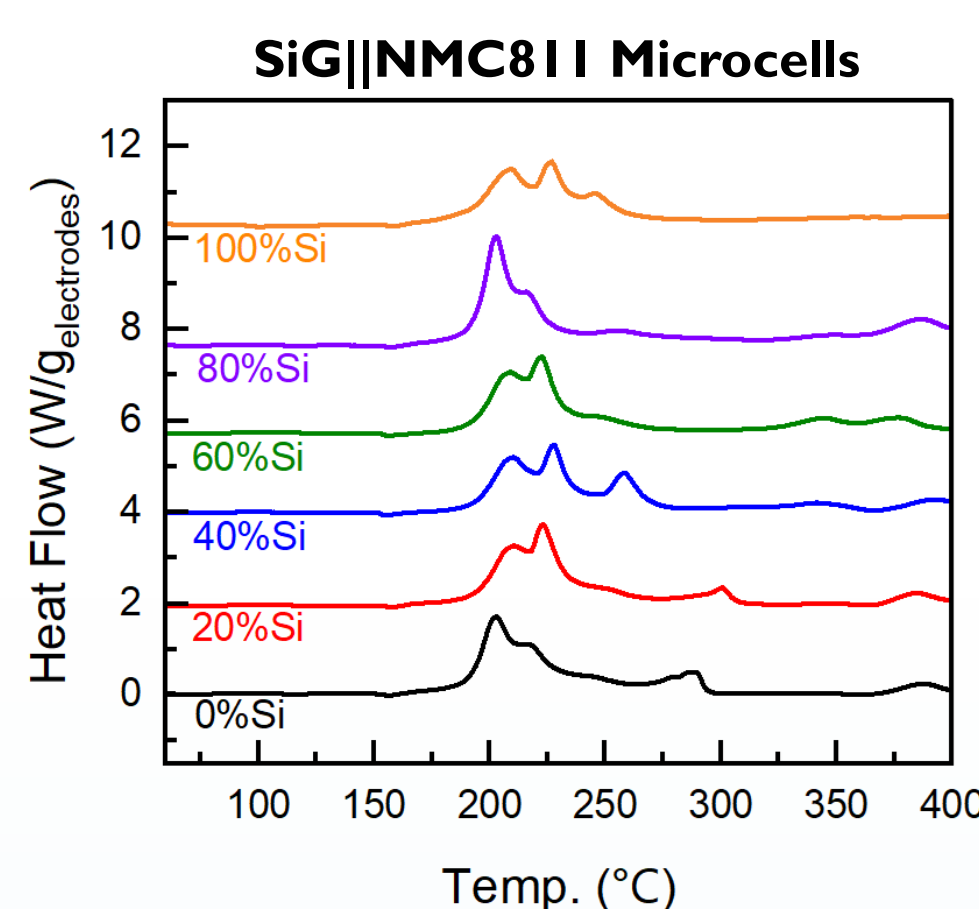


Microcell DSC Results

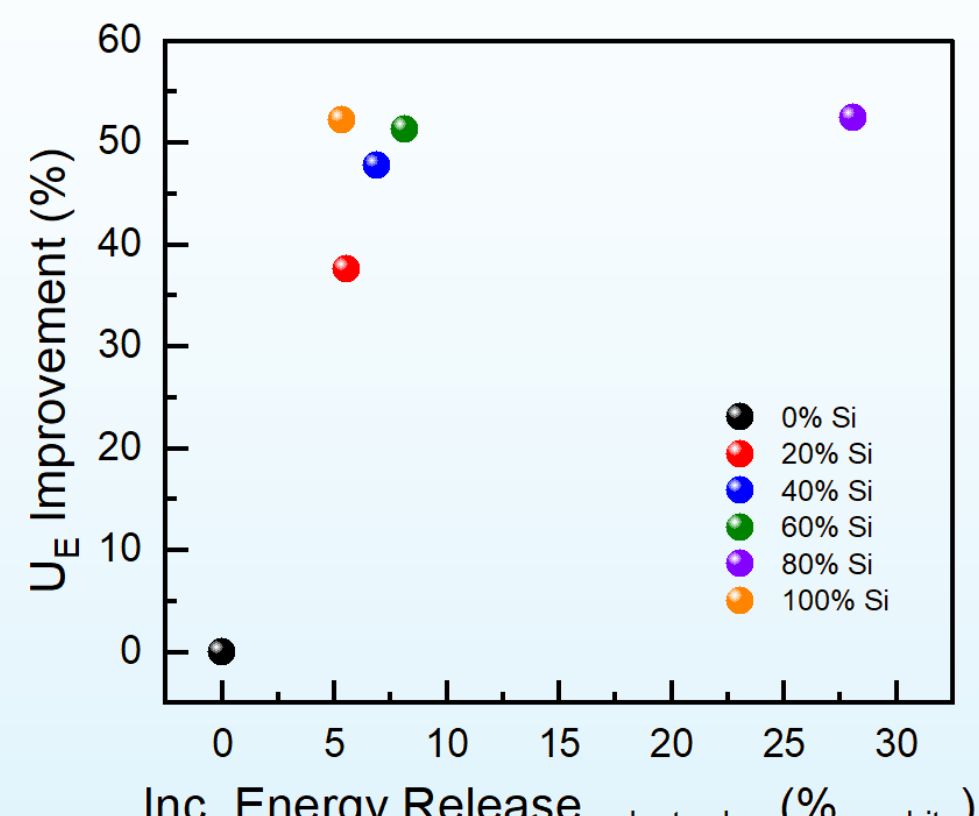
DSC testing of SiG||NMC811 microcell batteries with ~0.1 mAh total capacity



Microcell degradation behavior dominated by NMC811-related processes



Anodes with **20-40 wt.% Si** show best balance of energy density (U_E) and additional energy release



Conclusions + Future Directions

1. DSC of microcells enables determination of the relative safety of Si/G||NMC811 batteries at small scale
2. Comparison to 18650 testing shows Si increases SoC_{onset} , but also increases damage
3. Results further suggest **20% Si** may offer best balance of performance and safety

Where next?

- Explore comparisons of DSC results to accelerating rate calorimetry (ARC) of 18650s
- Expand to alternative cathode chemistries (e.g., $LiFePO_4$, $Li(NiCoAl)O_2$, etc.) to explore interplay between cathode and Si/G