Nanophosphate technology for HEV applications

2008 DOE Merit Review

Andy Chu, Ph.D.

A123Systems

February 25, 2008

2002

- 5 people
- $100,000 DoE Phase I SBIR from FreedomCar
- 0.5g of material from MIT

2006

- Q2 2006: successful launch of power tool product
- Q3 2006: A123's HEV development proposal submitted to USABC
- Dec 2006: USABC HEV program started (3-year, $15M, 50-50 cost share)

Today

- Dec 2007: HEV cell in pilot production
- Engaged in multiple automotive programs
- Established as significant force in automotive battery business

Purpose of HEV Program

Goal: meet all FreedomCar requirements for a 25kW HEV pack

- Focus on barriers to commercialization

HEV development program

- 3-year contract, starting December 1, 2006
- $15M, with a 50-50 cost-share

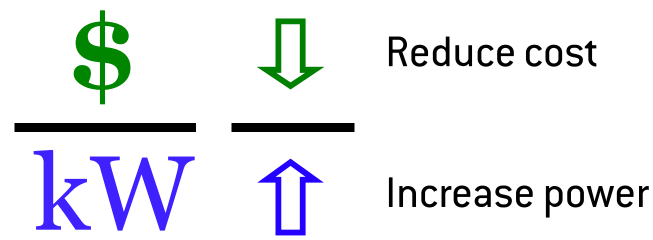
Gap Analysis

Characteristics (EOL)	Units	A123 BOP		FreedomCar 25 kW goal
Discharge Pulse Power (10s)	kW	25		25
Regenerative Pulse Power (10s)	kW	20		20
Total available energy (over DOD range where power goals are met)	kWh @ 1C rate	>>0.3		0.30
Round trip energy efficiency	%	>90		>90
Cycle life for specified SOC increments	25Wh cycles	>300k expected		300k
Cold Cranking Power @ -30 *C	kW	<5	GAP	5
Calendar Life	years	15 (expected)		15
Maximum System Weight	kg	<40		40
Maximum System Volume	liters	<32		32
Production price @ 100k/yr	$	>2000	GAP	500
Maximum allowable self-discharge rate	Wh/day	<<50		50
Temperature range:				
Equipment operation	*C	-30 to +52		-30 to +52
Equipment survival	*C	-46 to +66		-46 to +66

Approach

Biggest gap is in price-performance ($/kW)

- Reduce cost
- Increase power
- Verify cycle and calendar life
- Verify abuse tolerance



Improving power
reduces system cost
by lowering BSF.

Major tasks

- Materials Development
- Electrode Development
- Cell Development
- Module Development

Key Accomplishments

Increase power, reduce cost:

- Designed high-power (Ultra) electrode using Nanophosphate
- Cylindrical HEV (32113) cell designed and in pilot production
  - Design has been frozen and is being validated
  - A123 has been awarded production programs using this cell
- Reduced projected pack cost by ~40%
  - Materials processing and selection
  - Cell fabrication process development, increased yields
  - Increased cell power, decreased BSF
- Demonstrated improved low temperature performance

Key Accomplishments, cont.

Verify life, abuse tolerance:

- Verified superior abuse tolerance
  - Extensive abuse testing performed
  - 32113 passed UN testing and is approved for unregulated transport
- Developed calendar life model, based on 26650 results

TESTING BY NATIONAL LABS

Abuse testing of 26650s at Sandia

FY 2007 Annual Progress Report *Energy Storage Research and Development*

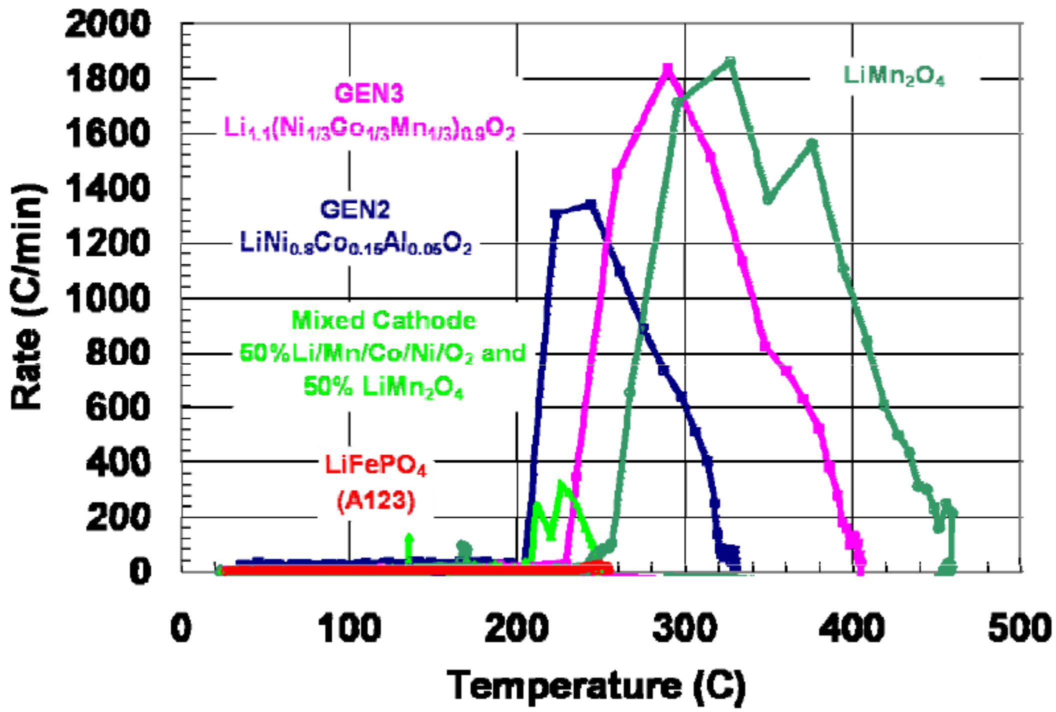


Figure III-37. Thermal ramp profiles showing high rate runaway for oxygen generating cathodes and low rate runaway for $LiFePO_4$ cathode.

"$LiFePO_4$ cells showed heat generation onset near 220°C followed by a low-rate thermal runaway at 240°C (Figure III-37). The heating rate was the lowest measured for any cell chemistry and was likely due to the lack of oxygen release from the cathode."

Thermal Ramp Testing

Additional details regarding Sandia testing

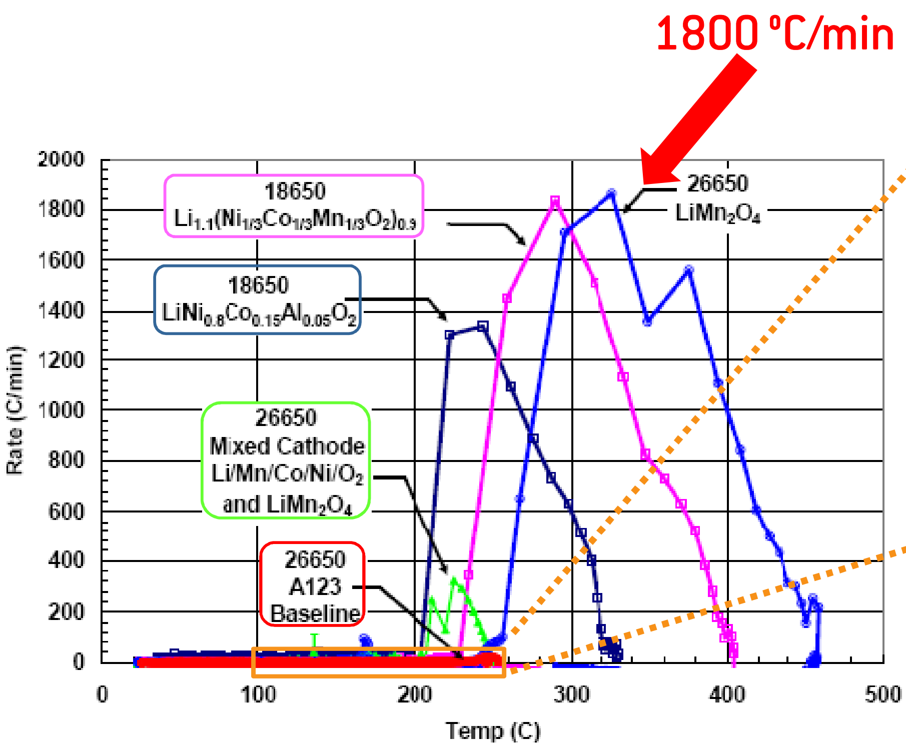


Figure 6: Heating rate profile comparison including additional common cathode compositions in 18650 cells.

The A123 cell that showed flame had a self-heat rate 1/100th that of the metal oxide competitors.

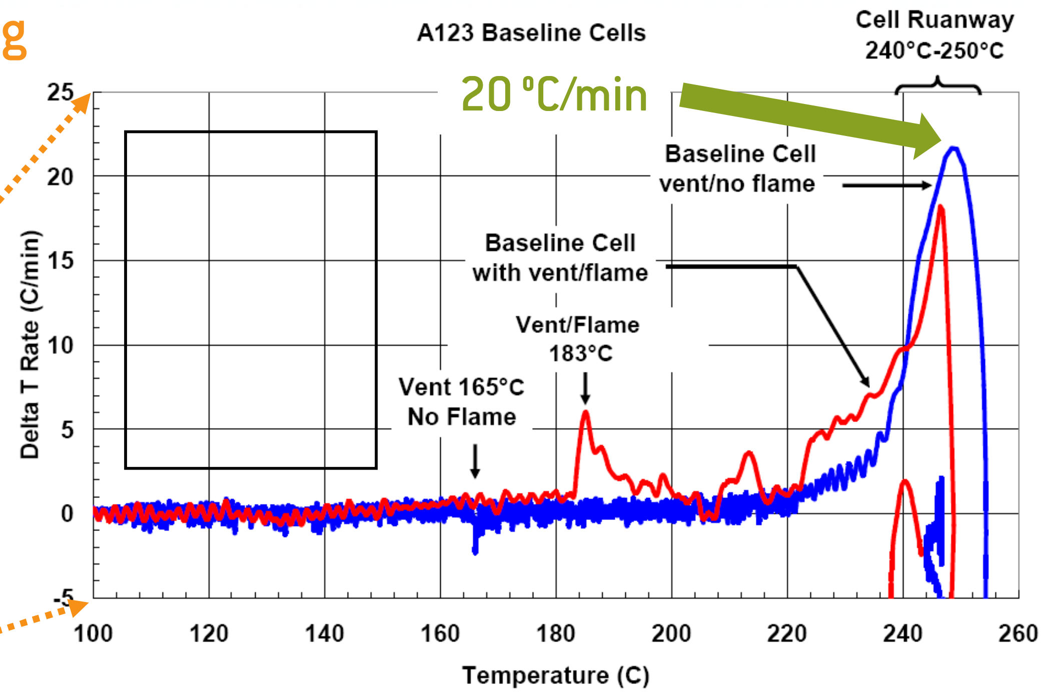


Figure 4. Heating rate profiles for two A123 baseline cells, one cell with burning vent gases.

For additional comparative purposes, thermal ramp data for cells with two other common Li-ion chemistries are shown in Figure 6. These measurements were performed using 18650 cells with about 950 mAh capacities. The chemistries shown are for $Li_{1.1}(Ni_{1/3}Co_{1/3}Mn_{1/3}O_2)_{0.9}$ (NMC) and $LiNi_{0.8}Co_{0.15}Al_{0.05}O_2$ (NCA). The NCA cells show the lowest onset temperature for runaway at 205°C while the NMC material is more stable with a runaway at 230°C. Both of these cathode chemistries showed heating rates greater than seen for the nanophosphate material although detailed quantitative comparison is not possible due to differences in cell thermal properties and capacitances. Table 1 summarizes the relative cell performances. The significant reduction in cell heating rates for the nanophosphate material is attributable to the lack of oxygen decomposition from the cathode material. However, increasing anode reaction with the electrolyte can still occur at higher temperatures leading to a low-rate thermal runaway of the cell as has been observed.

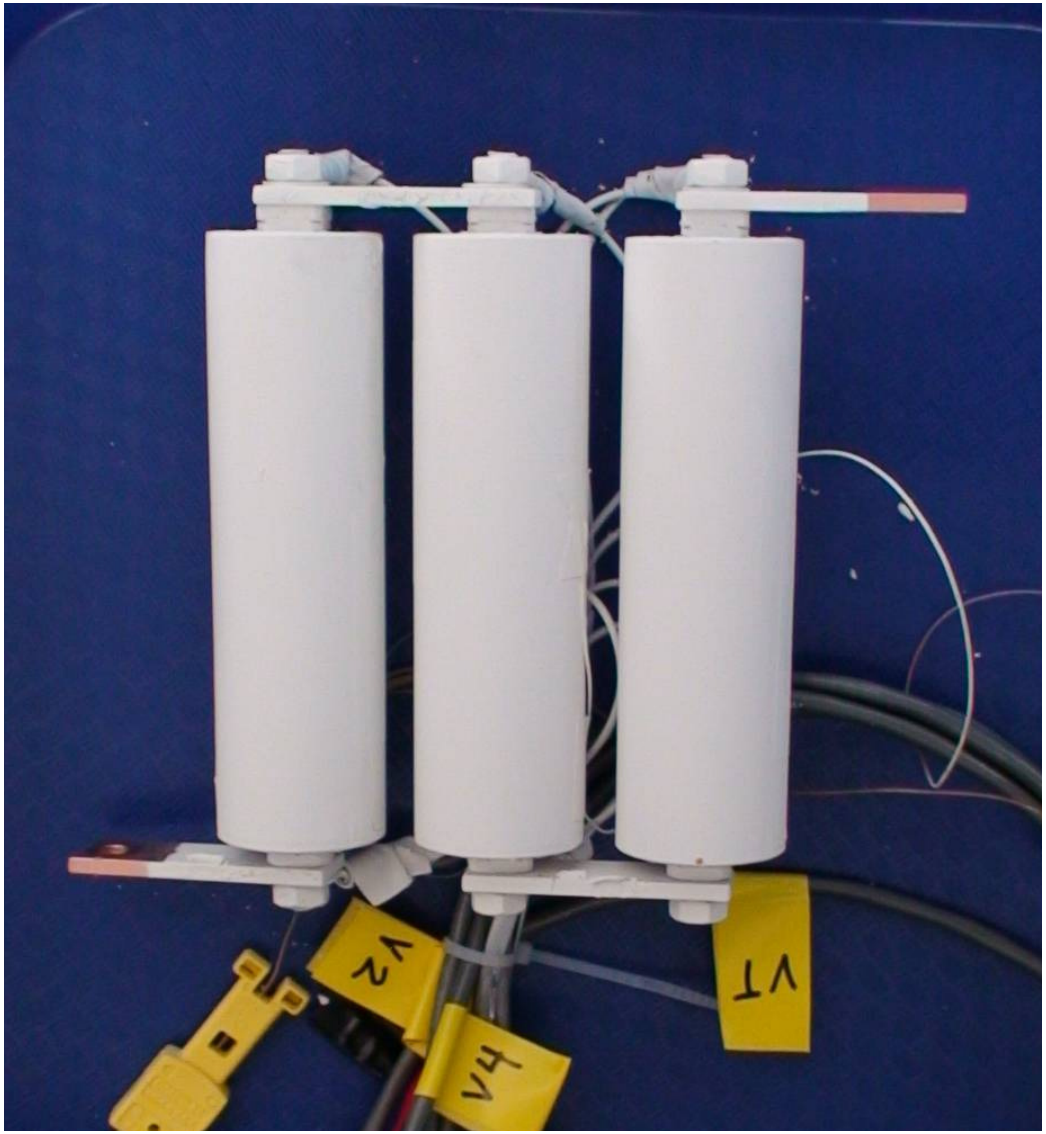
Thermal Characterization of A123 Cells

ANR 26650 M1 & ANR32113 Ultra (Initial Result)

A123 Quarterly Review Meeting
A123 Systems,
Boston, MA
January 16, 2008

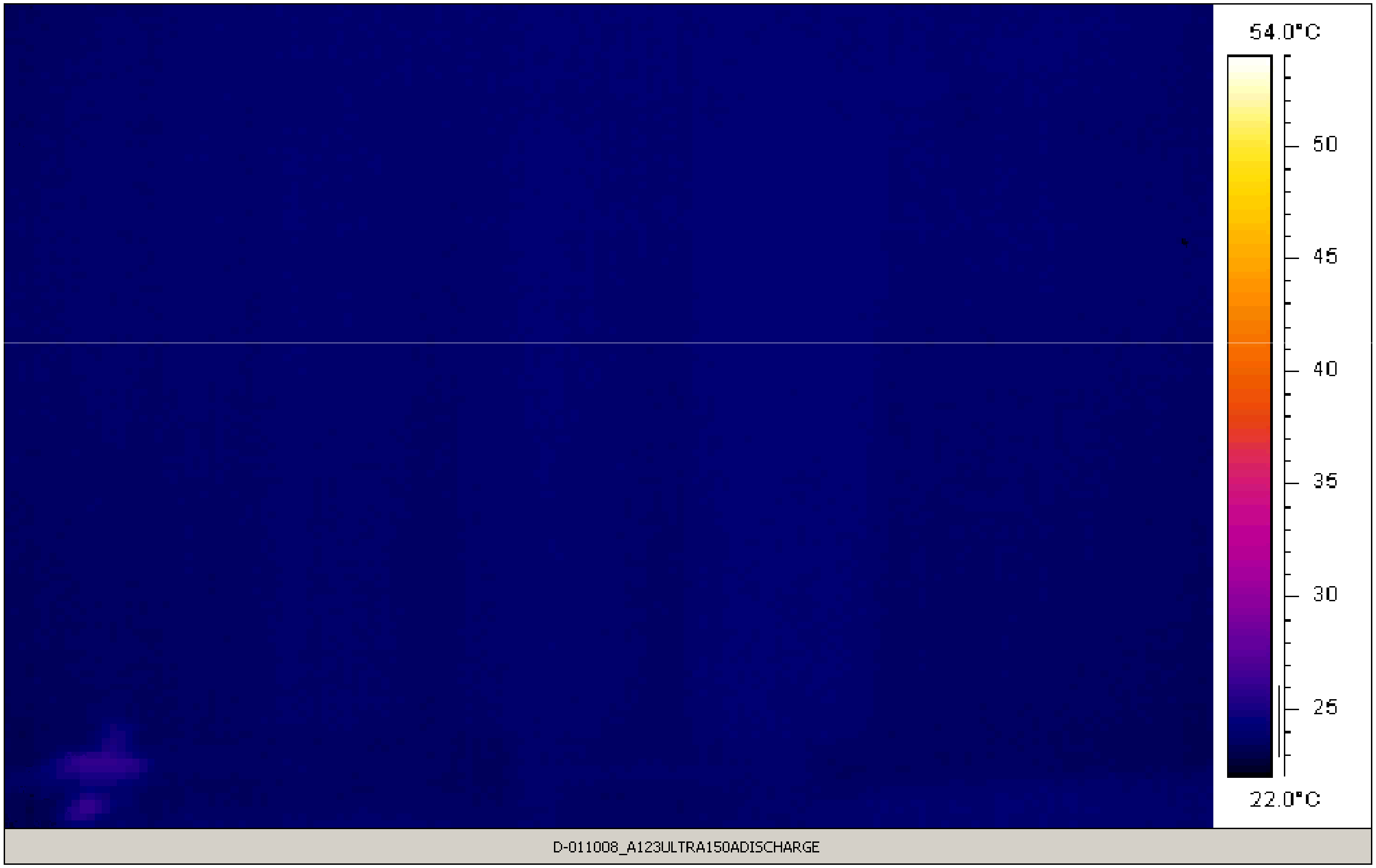
Kandler Smith (kandler_smith@nrel.gov)
Presented by
Ahmad Pesaran (ahmad_pesaran@nrel.gov)

32113 Thermal Imaging



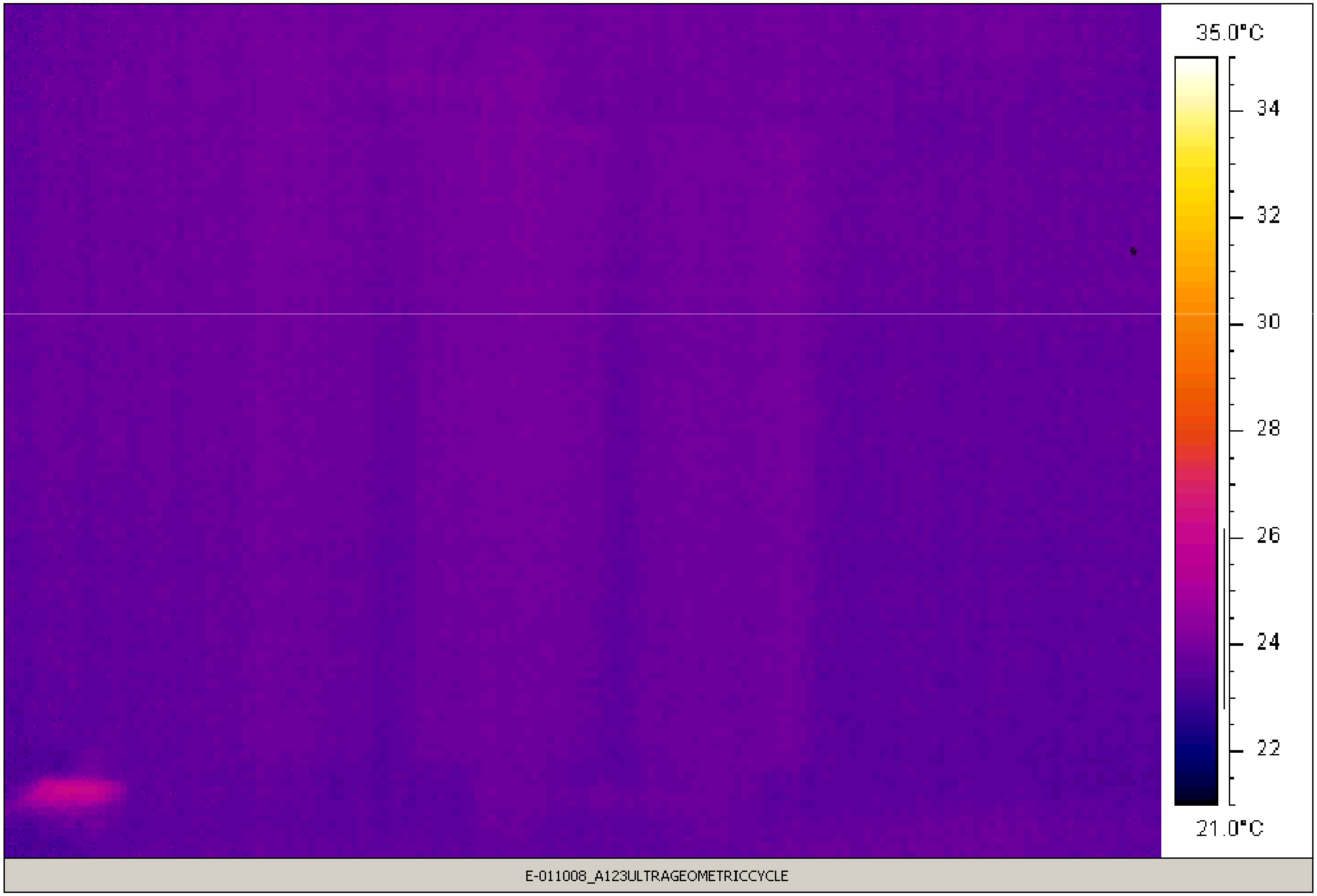
150A Discharge from 100% SOC

- *Removed entire 3.52Ah capacity (same as 1C) in 84.6 seconds*



Geometric Cycle – Front View

- *16C discharge 2s, 8C charge 4s, repeated for 20 min*
- *40.4A RMS current (similar to US06 cycle)*
- *Initial SOC is 50%*



Plans for 2008

A123 SYSTEMS

Continue development of higher-power, lower-cost HEV cell

- Materials selection and new materials development
- Electrode optimization
- Cell design
- Process, cell fabrication development

Verify calendar and cycle life, through long-term testing

Improve low-temperature power

PHEV Program Overview

PHEV development program

- 3-year contract, expected to start March 2008
- $12.5M, with a 50-50 cost-share

Major tasks

- 10-mile battery development
- 40-mile battery development

Summary

A123 has developed an HEV cell, which is in pilot production

- USABC funding has accelerated development

Significant progress has been made in:

- Increasing power, including at low temperature
- Decreasing cost

Verified abuse tolerance

Work continues to develop a higher-power, lower-cost HEV cell

Acknowledgments

A123 SYSTEMS

A123 gratefully acknowledges the financial support from USABC (project DE-FC26-05NT42403) and technical support from the national labs