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Power Source Technology Group at Sandia National Laboratories: Current Programs and Future Directions

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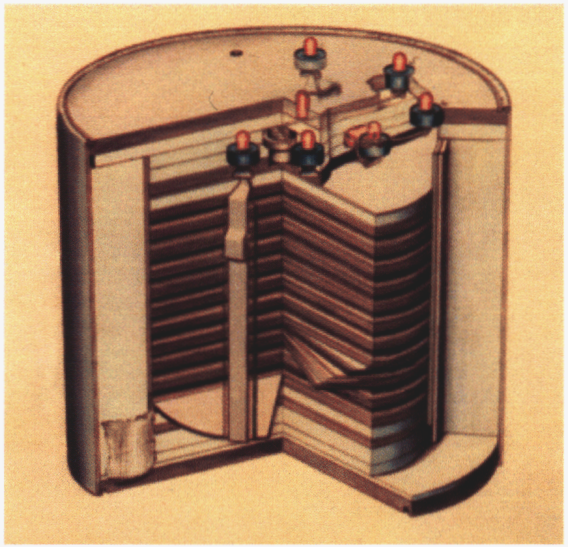
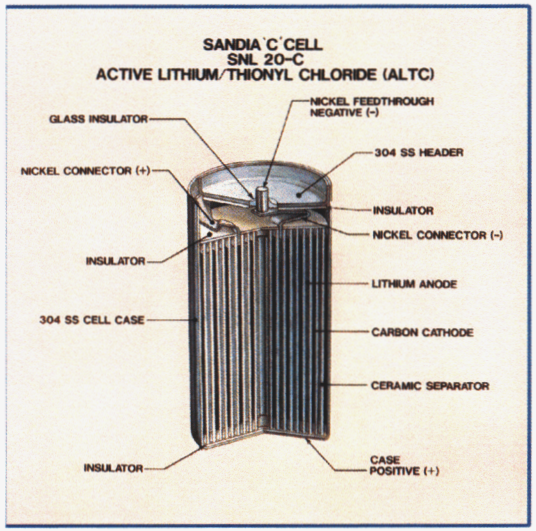
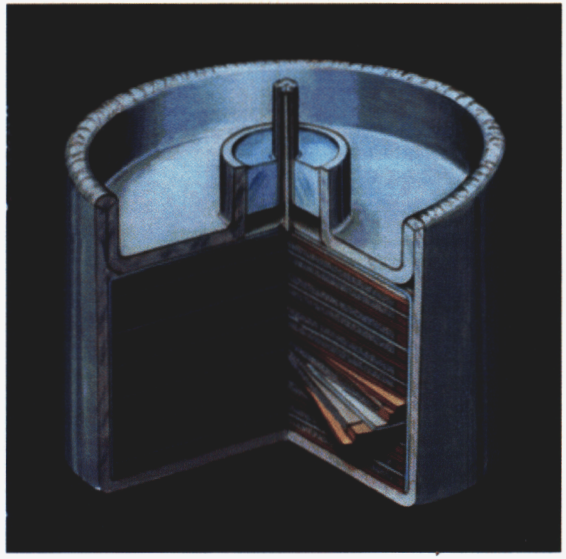
Power Sources Are a Critical Enabling Technology For Defense and Energy Applications







Thermal Batteries

- Telemetry
- Command enable/disable
- Long life
- Custom designed

Lithium Primaries and Rechargeables

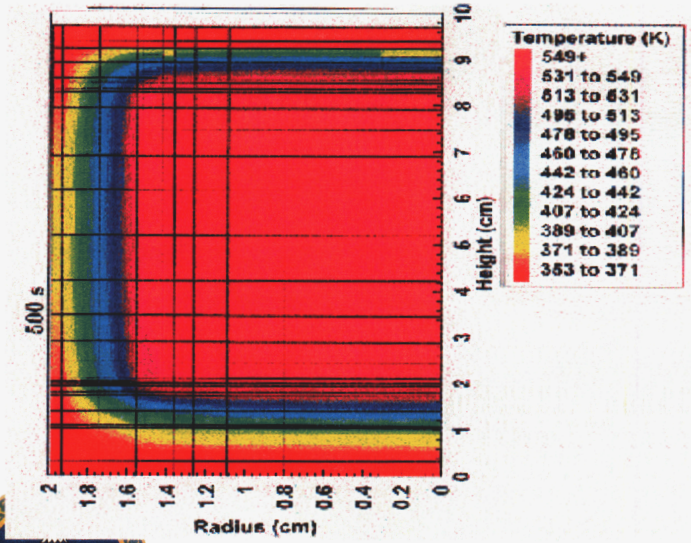
- High energy
- Limited life
- Monitoring functions
- Renewable Energy
- EV & HEV

Double Layer Capacitor

- Important component for hybrid systems
- Long life
- High power

The Power Sources Technology Group Supports A Wide Range Of Capabilities

- Thermal Battery Custom Designs
- Power Source Evaluation and Abuse Testing
- Power Source Materials Development
- Power Source Modeling
- Energy Storage Systems Analysis



Power Source Modeling

Power Source Abuse Testing

Materials Processing

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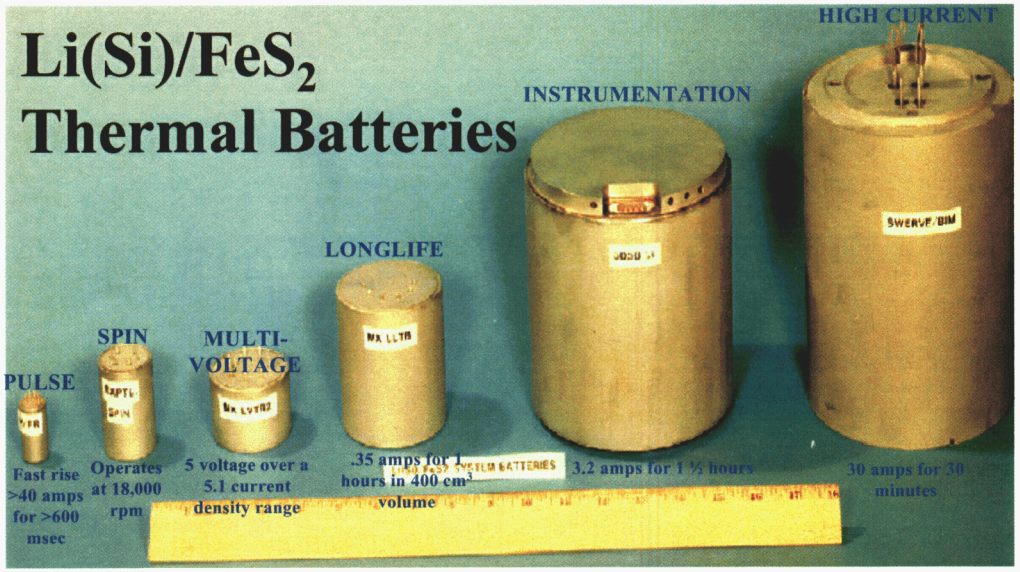
Required Battery Characteristics For Sandia Applications

- **Very High reliability: 0.9995**
- **Very good predictability**
- **Low self-discharge rate**
- **Little or no corrosion or degradation**
- **Maximum energy in a given volume**
- **Useful voltage and rate**

Lithium batteries

best meet this combination of requirements & manufacturability.



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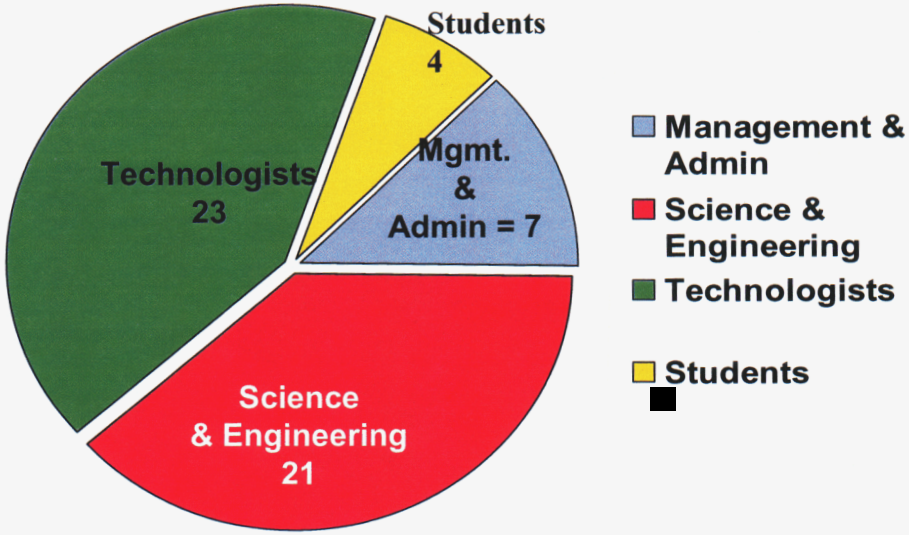
Meeting Our Customer Needs Builds Core Competencies

- Understanding Electrochemistry Fundamentals of Battery Performance
- Advanced, High-Performance Power Source Designs.
- Developing Extensive Test, Modeling and Evaluation *(safety and performance)* Capabilities
- Wide Range of Skills <u>Differentiates Us</u> From Other US National/Government Labs:
  - *Research and Development*
  - *Engineering*
  - *Production Qualified*

Power Sources Technology Group (PSTG) Has Experienced Staff and Major Facilities

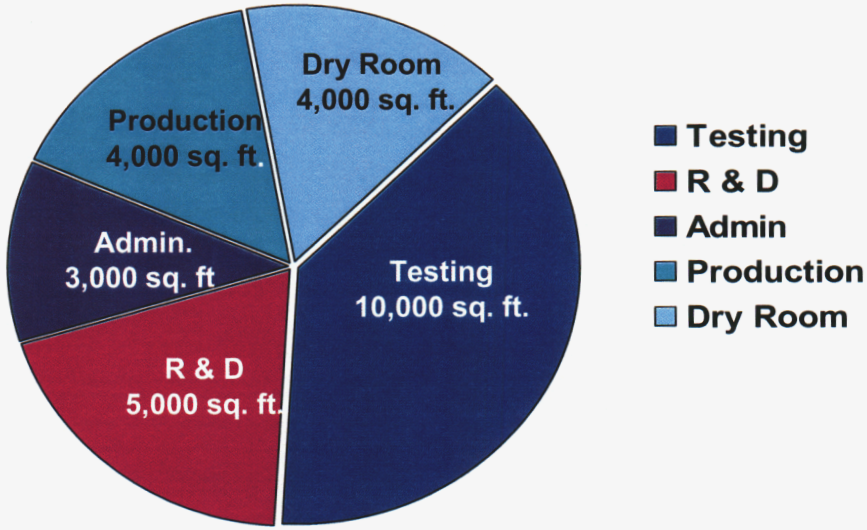
Staff



Total of 55 People

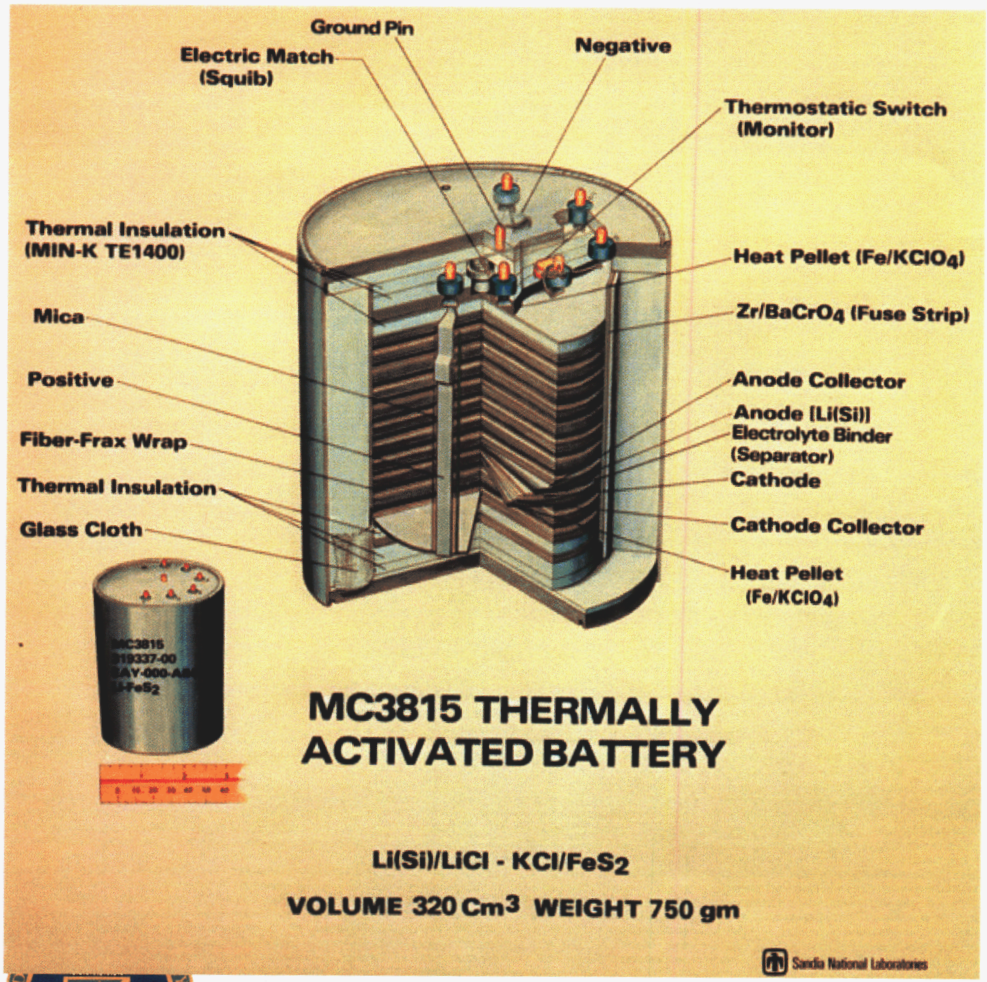
(49 Sandians)

Facilities



Total: 26,000 sq. ft.

Power Sources Are Used in Many Defense Systems



- Sandia's PSTG is the Design and/or Production Agency for all DOE Defense power sources
- We design, develop, test, produce, and support the stockpile for many unique components
- We research improved materials, processes, designs, and chemistries
  - Li(Si)/FeS_2 is baseline chemistry for "thermal batteries"
- We prototype and manufacture thermal batteries and other power sources

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Energy Programs

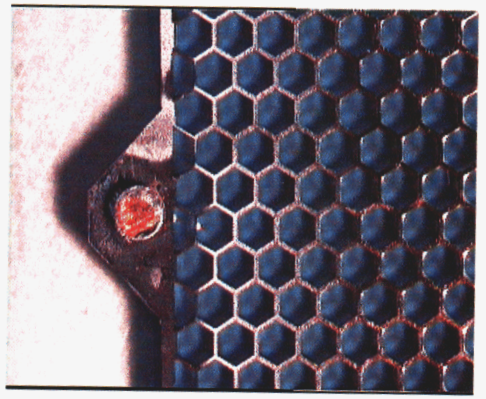
- DOE/Energy & Renewable Energy Applications
  - Internal R&D efforts in Microbatteries.
  - Advanced Technology Development for Hybrid Electric Vehicle battery evaluations & applied R&D.
  - Abuse Testing of HEV Batteries (Cell and Module Level tests)
  - Energy Storage Systems Program.
  - DOE/Basic Energy Science funding on advanced materials.
- Industry & University
  - NIST/ATP funding of CRADA with Ultralife Battery Co.
    - carbon anode materials development.
  - Materials/electrode studies with Eagle Picher Tech., Enser, etc.
  - Collaboration with Indiana Univ. on nanostructured composite electrolytes.
  - Support of small companies (SBIR funding).
- Other Federal Agencies
  - NASA Safety Studies.

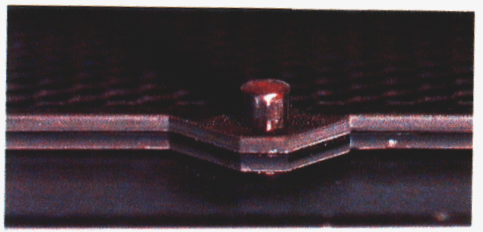
Power Sources Staff Are Collaborating Across Sandia to Develop MicroPower Sources

5 Projects working on *new materials and novel cell designs*

- **Nanosatellite Power**
  - Integrated structural battery system with other power components
- **Si Integrated Planar Battery**
  - Power supplies for MEMS devices.
- **Ceramic Thin Film Battery**
  - Thin film battery system based on ceramics.
- **Si Nanoparticles**
  - Improved anode materials
- **BioMicro Fuel Cell**
  - Electrochemical couples and catalysts for biological fuels.
  - Mediators for natural catalysts.

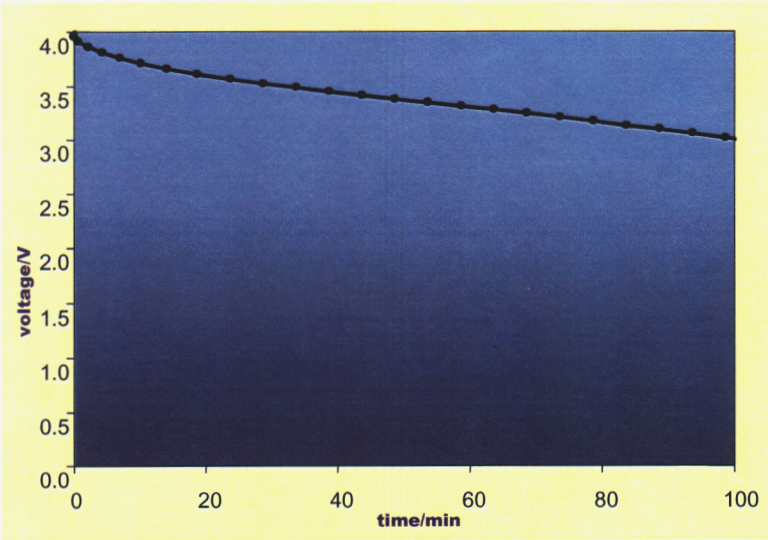
Top View of electrode - the wells will be filled with active electrode material.





Power Sources for MEMS Applications Is an Active Area of Investigation

- Progress on several fronts has been achieved:
  - New nanostructured materials developed
  - New methods for characterization have been developed
  - Methods for preparing oriented films developed
  - Processes for preparing battery structures have been developed.
  - Prototype battery structures have been prepared.
  - Prototype lithium-ion co-facial honeycomb battery in a parallel configuration has been assembled and tested.



Discharge Curve for Co-facial Honeycomb Array

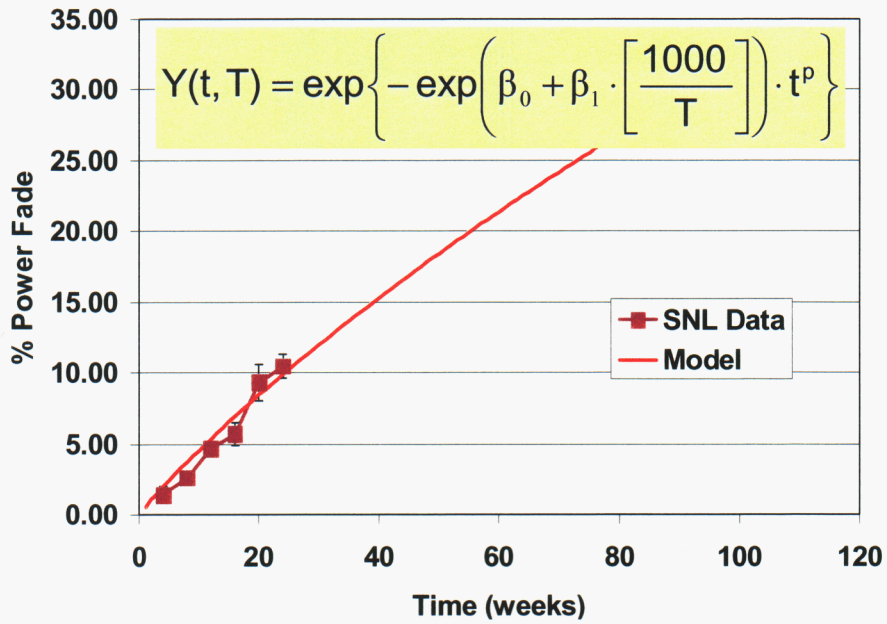
at Room Temperature

0.1 mA/cm employing $LiCoO_2$/MCMB

SNL has Responsibility for HEV Accelerated Life Prediction and Abuse Tolerance Testing

- **DOE's Advanced Technology Development (ATD) Program addresses the three barriers that remain for lithium ion batteries in hybrid electric vehicles -**
  - **high cost, short calendar life, and poor abuse tolerance.**

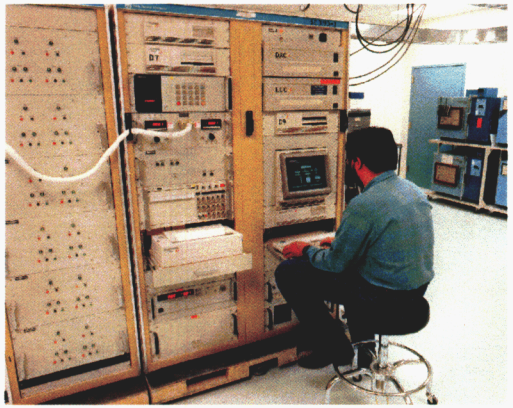
- **Accelerated Life Test (ALT) Goals**
  - The purpose of this task is to develop a method to predict lithium-ion battery life.
  - We plan to correlate test results with quantitative diagnostic measurements of the degradation mechanism(s) to make life predictions.
- **Abuse Tolerance Goals**
  - Understand mechanisms that lead to poor abuse tolerance
    - Thermal Runaway
    - Gas Generation
  - Propose solutions and evaluate alternatives.



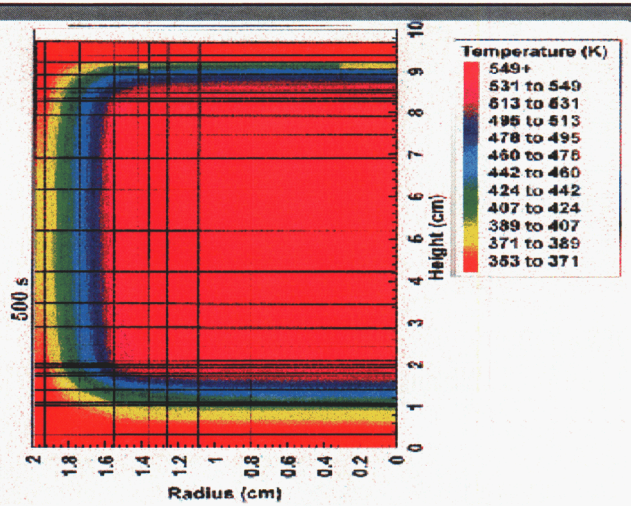
Comparison of model prediction at 25°C, 60% SOC to cell power fade data

The Power Sources Technology Group Supports A Wide Range Of Capabilities

- Meet Defense Needs as well as Advanced Energy Applications (~40% of our work)
- Capabilities extend from state-of-the-art R&D to Production.
- Diverse customer base.
- Highly integrated and leveraged with other groups at SNL.

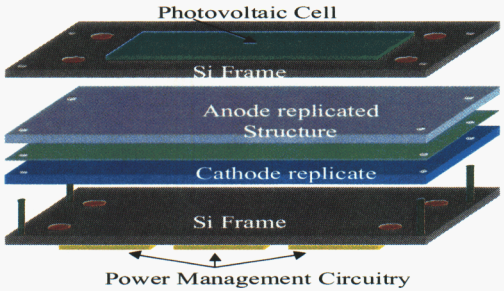


Power Source Testing



Power Source Modeling

Materials Processing



Microbattery Development