Multifunctional Battery Chassis Systems for Automotive Applications

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High Energy Battery & Safety

• **High Energy Density**

240 Wh Li-ion cells

10 x 24 W-CFL bulbs for 1 hour

200g of TNT

• **Safety Issues:** thermal runaway, explosion, corrosion, fire, etc.

80 kWh Capacity EV

Accident set a Tesla on fire

Boeing 787 battery thermal runaway
High Energy Battery & Safety

Lithium ion battery explosion due to nail penetration test
Current OEM’s Solution

Active materials

Metallic casing

Higher Energy Density

Greater Energy Requirement

More Protection

Heavier Weight

Yet a bigger casing

Weight

Cost

Just to be put in another case

Robust Multifunctional Battery Chassis Systems for Automotive Applications
High Purchase Cost

Battery cells

Battery & thermal management system

Protection packaging

Electric Vehicles
High Purchase Cost

U.S. electric vehicle price as a function of range in 2012

Projection on EV cost reduction
Source: RANGE Program FOA, ARPA-e, DOE, 2013
To design a multifunctional battery chassis system that, apart from storing electrical energy, helps to carry the vehicle body weight during normal operation and provides sufficient crash protection to the vehicle and the batteries.
Concept Overview

- Efficiency
- Low Cost
- Robustness

Robust Multifunctional Battery Chassis Systems for Automotive Applications
Innovative Streamlined Manufacturing Process

Robust Multidisciplinary Design & Optimization (MDO) Process

Advanced Battery Cells
- HCMR™ cathodes (>200mAh/g)
- High capacity Si-based anodes (>1000mAh/g)

Robust Thermal Management
- Temperature With No PCM-g
  - Melting Point
- Temperature With PCM-g
  - Temperature Remains Constant During Melting

Braided Composite Structure
- Crash Energy Absorption (kJ/kg)
- Aluminum, CFRP, SMA/CFRP

Multifunctional Sensor Network

Technology Innovation

Frontal Impact
- SMA-CFRP hybrid structure
- Multifunctional Battery System
- Structural Load

Robust Multifunctional Battery Chassis Systems for Automotive Applications
# Technology Impact – Efficiency

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<th>Non-battery</th>
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<tr>
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<td>Battery System</td>
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<td>Cells</td>
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<td>Cell Materials</td>
<td>Casing</td>
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<td></td>
<td>Enclosure</td>
<td>Lower Chassis</td>
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<td>Other</td>
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- *Red boxes represent target weight saving components*

**Existing Car Battery**
- ~60 kWh
- ~1000 lb

**Multifunctional Battery**
- Cell Materials
- Alloy Casing
- Enclosure
- Lower Chassis

Target weight reduction: 40%
Robust Multifunctional Battery Chassis Systems for Automotive Applications

Technology Impact – Robustness

Coupon Testing: CFRP Failure Starts, SMA still holds

Novel SMA-CFRP design in crumple zones
Continuous SMA wire braided in

Preliminary simulation shows promising results

Crush Simulation

Load profile for composite tubes
CFRP/SMa Hybrid
CFRP Only
Conclusion

Accomplished Tasks

• Material characterization on different components of the system

• Preliminary system design outlines how batteries works with each structural components

Future Work

• Study system interface and integration properties

• Develop MDO algorithms for optimal design

• Fabricate the integrated battery chassis system


AllCell Technologies

Envia Systems

Structures and Composites Laboratory
Thank You!