Robust Multifunctional Energy-Storage Structures

The introduction of electric vehicles (EVs) has enabled an environmentally friendly means of transportation, but the state-of-the-art Lithium-ion batteries add significant weight to vehicles both in the form of battery weight and supporting systems. The main reason is that current battery packs serve only one purpose, that of energy storage. Current EV batteries do not carry any structural loads or absorb collision impact energy, as the EV's structural components perform both these functions. We propose a unique and novel solution to enable capabilities that are not currently being offered by the existing EVs:

1. Development of multifunctional energy-storage structures with load-carrying capabilities and reduced weight
2. Cell-to-system multifunctional design and optimization (mechanical + thermal + manufacturing)

Traditional EV Design

- Structural Chassis (Steel)
- Battery Protection (Steel)
- Battery Enclosures (Aluminum)

Multifunctional Energy Storage Composites

- High Energy Density
- Structural Robustness
- State-awareness

- Energy Density > 150 Wh/kg
- Specific Energy > 330 Wh/L
- Cycle Life > 1000 cycles
- Comparable mechanical properties to automotive structural materials
- Crashworthiness per NHTSA Standard
- Battery State-of-Health Awareness
- Structural Health Monitoring

Multifunctional Energy-Storage Structures

- In-plane Load
  - Improved in-plane load transfer and stiffness

- Buckling Resistance
  - Higher buckling resistance under in-plane compression

- Bending Rigidity
  - Good flexural load-carrying capability

- Electrochemical
  - Good electrochemical performance of Li-ion battery

Conclusions

The Structures and Composites Laboratory has developed an innovative ‘multifunctional energy-storage structures’ approach based on MES Composites. Our current progress and small-scale prototype modules have shown that MES Composites are viable and have the potential to significantly reduce the gross weight over classical EVs, while maintaining the energy efficiency and improving the mechanical properties.

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Bibliography


Further Information

Structures and Composites Laboratory (structures.stanford.edu)
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- MES Composites
  - Reinforcement Anchors
  - Li-ion Battery Electrodes
  - Composite Facsheet

11.1V MES Module
Powering a Fan

In-plane Load
Improved in-plane load transfer and stiffness

Buckling Resistance
Higher buckling resistance under in-plane compression