NASA facts

Development of Lightweight CubeSat with Multi-Functional Structural Battery Systems

Composite Housing Enables Structure to Store Power and Save Weight of Batteries

This collaborative multi-disciplinary effort aims to develop a lightweight, 1-unit (1U) CubeSat (10x10x10 cm) which utilizes improved and fully integrated structural battery materials for mission life extension, larger payload capability, and significantly reduced mass.

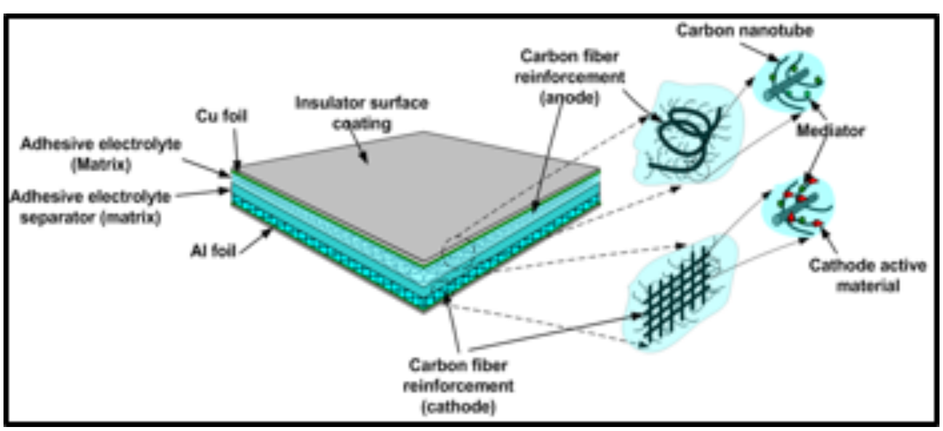
The electrolytic carbon fiber material serves the multifunctional capacitive energy system as both a lightweight, load bearing structure and an electrochemical battery system. This implementation will improve traditional multifunctional energy storage concepts with a highly effective energy storage capability.

The most significant issue with other state-of-the-art energy storage concepts is that the mechanical strength decreases when the battery performance compares with conventional batteries.

This project bridges the capability gap between mechanical and electrical systems by using “mediator” materials to support the carbon fiber structural materials. “Mediators” are molecules that have high electron transfer, and when incorporated into electrolytic carbon fiber, the mediators produce current operating in wide temperature ranges.

There is also greater emphasis on the microarchitectures of the structural design, such as utilizing the interstitial honeycomb cores for increased stiffness, which will further enhance the structural capability of the battery. For improving weight concerns, the key advantage is the replacement of impractical structural mass with useful material that provides additional energy. This improvement will decrease weight and extend spacecraft mission life, along with the inherent advantages of employing high strength-to-weight ratio materials in carbon fiber polymer composites. The success of this approach utilizes adhesive polymer electrolytes.

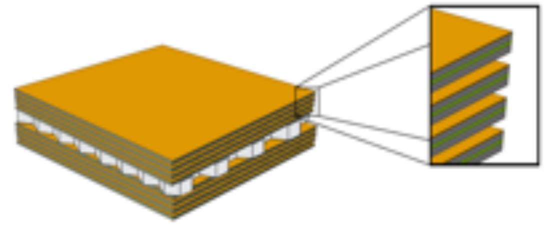
All-solid-state mediator supercapacitors are opening a new direction in the development of multifunctional, structural electrochemical material, thereby driving the high specific power and energy. The combination of the supercapacitor with lithium-ion battery electrodes, along with the potential for greater structural capability, creates a revolutionary electrochemical storage material.



Enabled by the design and implementation of mediators molecules, a structural supercapacitor (or hybrid capacitor/battery) functions similarly to a standard electric battery, except the strong, stiff carbon fibers act as the terminals allowing electron flow and collection. The material performs as a strong, lightweight structural carbon fiber composite and as a reserve electrical energy system.

Structural battery materials are applicable to multiple NASA missions and platforms including Ground Systems Development (GSDO) and Habitat Demonstration Unit (HDU) for off-world exploration missions. A structural battery is readily extensible in commercial applications, as they supply additional power for: drones, electric aircraft, robotic exploration systems, and ruggedized sensors. By creating a commercial market, the cost of the structural battery will be greatly reduced for NASA applications. The proposed technology may replace significant structural elements in satellite and transportation applications. Being lightweight is a critical concern for small spacecraft, the availability of structural energy represents a key enabling technology for the increasingly high demands of electronics and sensor systems, thus utilizing less weight for more energy. Being highly scalable, structural batteries can be used anywhere from communication devices to habitat structure walls.

Tasks will be performed cooperatively by the University of Miami, NASA Kennedy Space Center (KSC), and NASA Glenn Research Center (GRC). The project will be led at the University of Miami by Professor Ryan Karkkainen. Dr. Luke Roberson, NASA KSC, will be a co-investigator and will lead the NASA effort. Using expertise in launch systems and launch materials, NASA KSC will lead the NASA team on the launch criteria to be used within a CubeSat design. KSC will perform together with the University of Miami material synthesis and characterization. GRC will be in charge of electrochemical testing of the optimized components. GRC will assist the University of Miami battery testing, performance, cycle studies, and data analysis to ensure mission success. Prototyping will be performed collaboratively at KSC.



Effective component and material system design enable a composite structural battery

The Lightweight CubeSat with Multi-Functional Structural Battery Systems project is managed and funded by the Small Spacecraft Technology Program (SSTP) within the Space Technology Mission Directorate. The SSTP expands U.S. capability to execute unique missions through rapid development and in space demonstration of capabilities for small spacecraft applicable to exploration, science, and the commercial space sector. The SSTP will enable new mission architectures through the use of small spacecraft with goals to expand their reach to new destinations, and challenging new environments.

For more information about the SSTP, visit:
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For more information on Lightweight CubeSat with Multi-Functional Structural Battery Systems, contact:

Ryan L. Karkkainen
Mechanical and Aerospace Engineering
University of Miami
r.karkkainen@miami.edu

Roger C. Hunter
Small Spacecraft Technology Program Manager
Space Technology Mission Directorate
NASA Ames Research Center
Roger.C.Hunter@nasa.gov

Christopher Baker
Small Spacecraft Technology Program Executive
Space Technology Mission Directorate
NASA Headquarters
Christopher.E.Baker@nasa.gov

National Aeronautics and Space Administration

Ames Research Center
Moffett Field, CA 94035

www.nasa.gov

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