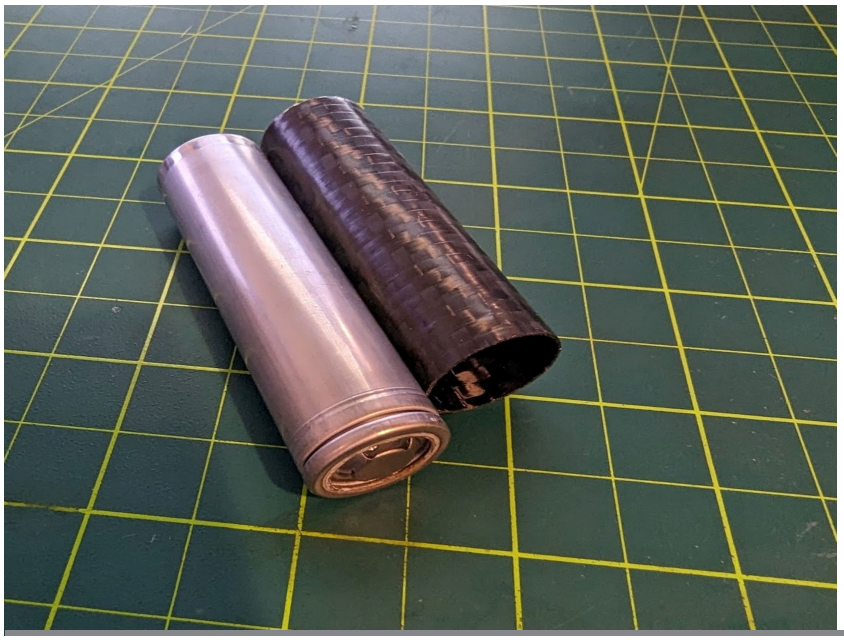


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Power Generation and Storage

Carbon Fiber Sleeve Tempers Battery Thermal Runaway

Prevents fire hazard in small cylindrical Li-ion battery cells via propagation resistant technology

Innovators at NASA Johnson Space Center have developed a carbon fiber reinforced polymer (CFRP) sleeve, that, when fitted over a cylindrical lithium-ion battery cell, can prevent cell-to-cell propagation by containing a thermal runaway (TR) event to the originating cell. TR is caused by a battery cell short-circuiting and its inability to contain the resulting increase in pressure and temperature, which may lead to a sidewall rupture (SWR).

Space flight and other industrial batteries frequently utilize multiple cells, such as the 18650, that are assembled into modules or battery packs and provide power to a variety of applications. A TR event can propagate to all the cells in a battery pack, escalating into a fire that can be catastrophic.

Use of CFRP sleeves for Li-ion cells provides multiple advantages over previous containment designs: increased hazard safety, lower mass, reduced cost, lack of conductivity, and manufacture with readily available materials. Hundreds of billions of 18650 battery cells are made globally and are the most common single cell format. They are used in commercially available products such as power tools, laptops, cameras, e-bikes, and electric cars.

BENEFITS

- Prevents cylindrical Li-ion battery cell sidewall ruptures
- Tempers fire hazard
- Low-mass alternative to aluminum and steel
- Not electrically conductive
- Constructed from easily sourced materials
- Concept adaptable to other battery models

THE TECHNOLOGY

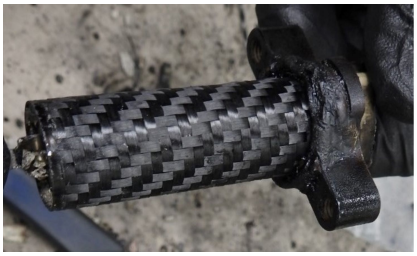
The CFRP sleeve was originally intended for crewed space flight lithium-ion 18650 battery packs rated over 80 Watt-hours (Wh), which are required to be passively propagation-resistant for increased safety. Previous battery designs have addressed SWR propagation by using aluminum or steel interstitial materials to prevent SWRs from directly impacting neighboring cells, but these materials were underperforming.

During testing of 18650 battery cells, it was discovered that cells over 2.6Ah in capacity can have an undesirable failure mode in which the cell wall will rupture or breach during a thermal runaway (TR) event sending heat and ejecta into an undesirable direction. TR is typically triggered when heat produced by the battery cell's exothermic reaction leads to increased and escalating internal cell temperature, pressure, and boiling of the electrolytes. When internal cell pressure exceeds the cell's safety relief mechanism, rupture or bursting can occur, initiating a cell-to-cell propagation that in turn results in a battery pack fire.

By adding a carbon fiber reinforced polymer (CFRP) sleeve to cylindrical battery cells, a sidewall rupture (SWR) can be prevented from occurring or propagating. In initial testing, there were no SWRs of a battery cell using a CFRP sleeve. This result is believed to be due in part to a unique characteristic of CFRP sleeves compared to other materials. Carbon fiber material has a negative coefficient of expansion and accordingly shrinks when heated, while steel and aluminum expand. The shrinking of the CFRP sleeve when heated compresses the cell located within it, significantly aiding in the prevention of SWR.

This technology can be implemented into other multi-physics battery safety models to guide the design of the next generation of battery cells and battery packs.

This thermal runaway propagation resistant technology has a technology readiness level (TRL) of 6 (System/sub-system model or prototype demonstration in an operational environment) and is now available for patent licensing. Please note that NASA does not manufacture products itself for commercial sale.



Shown: An engineer holds a spent test fixture attached to an 18650 lithium-ion battery cell with an external carbon fiber reinforced polymer sleeve. Notice the sleeve intact, even after a thermal runaway event was induced in the battery cell.

APPLICATIONS

The technology has several potential applications:

- Spaceflight
- Aviation
- Electric bikes
- Electric cars
- Laptops
- Power tools
- Cameras

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More Information

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