Mechanical Characterization of Lithium-Ion Battery Micro Components for the Development of Homogenized and Multilayer Material Models

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Recent developments in lithium-ion battery technology are enabling the rapid expansion of the electric car market. Still, barriers remain before electric cars can be brought to mass production. The most important of these obstacles are related to cost, weight, and safety. Most of the current research and developments deal with controlling the environment surrounding the battery, such as voltage discharge and cooling controls, or large metal casings. The research of the Impact and Crashworthiness Laboratory (ICL) at MIT focuses on understanding the battery's mechanical properties so that individual battery cells and battery packs can be characterized during crash events.

The objective of this research is to better understand the battery component (electrode and separator) properties under different loading conditions. Over 200 tests were conducted on battery components. These tests include uniaxial stress, biaxial punch, multilayer, single layer, short-circuit testing, wet vs dry specimen testing, strain rate testing, and more. Additionally, a scanning electron microscope was used to view the battery components and better understand the aforementioned test results.

Of note, it was discovered that many of the electrodes in the Li-ion batteries are damaged during the battery manufacturing process. Also, the two methods of manufacturing battery separator were analyzed and their resulting mechanical properties were characterized.

These results will be used to further refine and validate a high-level, robust, and accurate computational tool to predict strength, energy absorption, and the onset of electric short circuit of batteries under real-world crash loading situations. The cell deformation models will then be applied to the battery stack and beyond, thereby enabling rationalization of greater optimization of the battery pack/vehicle combination with respect to tolerance of battery crush intrusion behavior. Besides improving crash performance, the finite element models contribute substantially to the reduction of the cost of prototyping and shorten the development cycle of new electric vehicles.

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