Part 01

Developing Effective Heat Control Measures for Lithium Ion Batteries

Structures for Thermally Insulating and Venting the Battery Module

Lithium ion batteries (Li-ion batteries) are being used to replace other battery types in industry for stationary and portable equipment. Stationary applications require larger capacities and cell formats and are typically provided with modular battery design which contain multiple series- or parallel-connected large format cells. These modules require various forms of heat control for operational stability.
The LIM Series, made available by GS Yuasa for nearly two decades, adheres to Japan's safety requirements[1] and is widely adopted in energy storage systems, automatic guided vehicles, and rail systems (●Fig. 1). This article explores the thermal insulating and venting structures we developed for our LIM Series modules.

1. Thermally Insulating the Cells and Modules

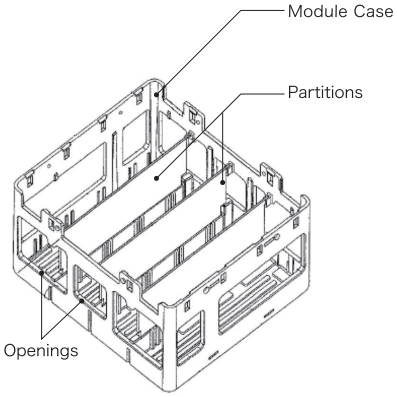
As mentioned above, a module is made up of multiple large-format cells. The cells are arranged adjacent to each other and thus must be thermally insulated to prevent heat from propagating from one cell to another.

The case for a LIM Series module uses partitions to compartmentalize cells (●Fig. 2). Each partition, which is a highly insulating material, faces the long sides of the neighboring prismatic cells. This prevents heat from a cell on one side of the partition from propagating to a cell on the other side of the partition.
The module case includes sidewall openings where partitions are located. A layer of air (i.e., an air gap) exists between the partition and the cell for insulation, and the air within this layer may travel to the opening in the sidewall. This allows for efficient cooling of the cell since air can travel between cells and through the openings in the sidewall.

Just as placing an insulating material between cells thermally insulates the cells, placing an insulating material between modules is also a reliable way to thermally insulate modules. As illustrated here, a plurality of neighboring modules may be installed in a large-scale power storage device (●Fig. 3). The insulating material between adjacent modules prevents heat generated by one module from propagating to another module when a module starts to generate heat.

●Fig. 1 LIM50EN-12 and LIM25H-8[2]

●Fig.2 Insulating between Cells[3]



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2. Structure for Venting Modules

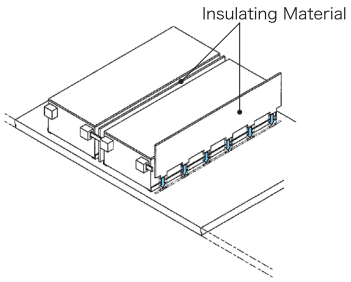
Each prismatic Li-ion cell is provided with a relief valve at the top (●Fig. 4). Cells are covered at the top with an inner lid that is made of a thermoset resin. The inner lid accommodates electronic components such as a circuit board. The pressure inside a cell may increase due to internal or external factors; thus, the relief valve is designed to open and vent the gas inside the cell when the internal pressure reaches a given threshold. It is therefore necessary that the inner lid and the electronic components are not exposed to the gas venting from the cell.

Our solution was to add a structure that thermally insulates the inner lid and creates a venting passage at the underside of the inner lid. This structure protects the inner lid and electronic components while guiding the venting gas across the module. The thermally-insulating material faces the relief valves and prevents the high temperature gas or electrolyte escaping the valves from sputtering onto the inner lid. The relative arrangement of the thermally-insulating material in the lid-protecting structure creates a gap (i.e., a passage) that extends across the module. The passage is essentially created in the space between the positive and negative terminals of the cells to avoid increasing the height of the module.

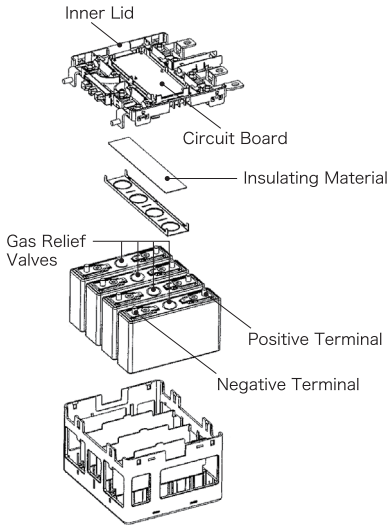
Further, as shown in ●Fig. 5, the inner lid includes a slanted wall near the outlet of the venting passage. The slanted wall increases the size of the venting outlet and includes a rib that prevents accidental insertion of a person's finger, a tool, or the like. The gas flowing across the module along the narrow passage lined with the thermally-insulating material escapes upward along the slanted wall since the venting passage widens upward near the outlet. This controls the venting of the gas and minimizes the impact of the high-temperature gas on the components surrounding the module.

This article explored the structures we use to protect cells and modules: a first structure for thermally insulating a cell or a module; and a second structure for guiding gas across and out of the module. Part Two of this series will introduce the heat control techniques used in the power devices provided with an internal battery monitoring system.

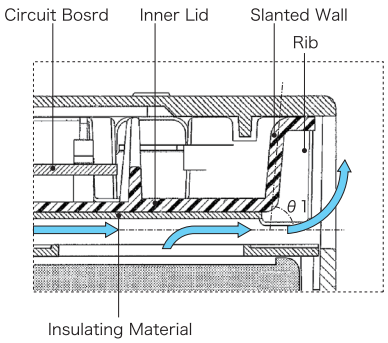
●Fig. 3 Insulating between Modules[4]



●Fig. 4 Module (Exploded View)[5]



●Fig. 5 Structure for Venting Module[6]



1. Japanese Industrial Standard C 8715-2 (Published in 2012)
2. Japanese Registered Design No. 1537163, Japanese Registered Design No. 1537164, US Patent No. D775073, Chinese Design Patent No. ZL 201530001553.4, European Design Patent No. 002608299
3. Japanese Patent No. 6236902, European Patent No. 2816632, US Patent No. 9859533, Australian Patent No. 2014203086 (Filed in 2013)
4. Japanese Patent No. 6252313, European Patent No. 2927990, US Patent Publication No. 2015/0280190 (Filed in 2014)
5. Japanese Patent No. 6295784 (Filed in 2014)
6. Japanese Patent Publication No. 2015-195128, European Patent Publication No. 2927988, US Patent Publication No. 2015/0280190 (Filed in 2014)

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