Overview of Sumitomo Electric Group's Technologies and Products for Electrified Mobility

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With a commitment to environmental sustainability and carbon neutrality, electrification of mobility is progressing significantly. The Sumitomo Electric Group develops and provides a wide range of key technologies and products related to electrification, with "connecting materials/technologies" as our core focus. This paper offers a comprehensive overview of our diverse portfolio, which encompasses four distinct categories: Battery Peripheral, Motor/Inverter Peripheral, High-Voltage Interconnection Wiring/Connectors, and Charging/Infrastructure.

Keywords: electrification, battery peripheral parts, motor/inverter peripheral parts, high-voltage interconnection, charging

1. Introduction

While environmental and global-warming measures toward the reduction of CO_2 emissions are under discussion, Europe (the European Commission has set the goal of banning the sale of new internal combustion engine cars, including HEVs,*1 in 2035) and China (the government has set the goal of making NEVs*2 make up a ratio of 50% or more of new car sales by 2035, with the remaining being HEVs) have played a leading role in the promotion of mobility electrification. According to the world automobile production forecast by S&P Global (as of October 2023), NEV sales will grow from 11.2 million units in 2022 to 26.4 million in 2025, and reach a substantial 50.9 million in 2030. However, BEVs,*3 which account for about 90% of NEVs, are required to achieve improved mileage, reduced charging time, and lower costs, and automobile manufacturers, the Sumitomo Electric Group, and other suppliers have developed technology and products to solve these issues.

2. Main Parts of a BEV (Battery Electric Vehicle)

Figure 1 shows main parts of a BEV, a representative of electrified mobility. They include the fundamental units of (1) battery packs, which store drive energy, and (2) motors/inverters, which generate and control driving force; and connection units of (3) high-voltage interconnection wiring/connectors, which connect fundamental units, and (4) charger connectors/inlets, which connect external infrastructure and internal energy units.

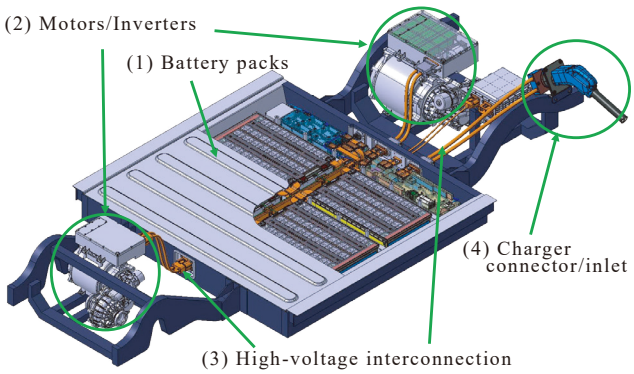

Fig. 1. Main parts of a BEV

3. Electrification Technologies and Products of Sumitomo Electric Group

3-1 Battery peripheral

(1) Battery wiring module

A battery wiring module connects the electrodes of battery cells in series and sends the voltage and temperature information of each battery cell to a monitoring unit. Sumitomo Wiring Systems Ltd. uses FPC*4 for wiring and functional chip-mounting elements, such as thermistors and fuses, to satisfy the needs for reduced height and space saving.

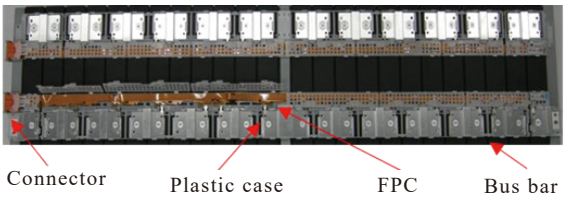

Photo 1. Example of a battery wiring module

(2) High-voltage junction box

A junction box is connected to the input and output terminals of a battery pack to switch the current on and off, trip the circuit breaker when in an abnormal condition, and detect charging/discharging current values. Sumitomo Wiring Systems has incorporated TIM*5 and other structures for efficient heat dissipation and addressed higher

heat generation due to the increase in input and output voltage.

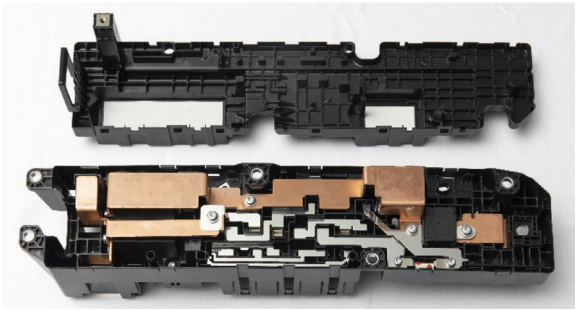

Photo 2. Example of a high-voltage junction box

(3) Tab leads

Tab leads are used for cathodes and anodes of laminated battery cells, such as lithium-ion batteries (Fig. 2). They are required to seal liquid electrolyte and prevent short circuiting with the laminated exterior in view of safety and longevity. Sumitomo Electronic Wire, Inc. ensures stable quality and high reliability through its unique insulation resin technology and heat welding production process, thereby achieving the global top share.

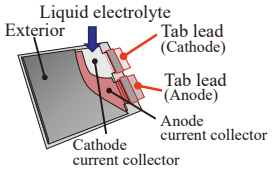

Fig. 2. Laminated battery structure

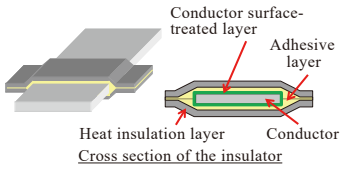

Fig. 3. Structure of a tab lead

(4) Elastic insulator between battery cells

An elastic insulator is a product placed between battery cells in a battery pack to suppress swelling or contraction due to charging/discharging and prevent thermal runaway (Fig. 4). Sumitomo Riko Co., Ltd. has achieved the combination and integration of an elastic body and an insulator, which were separated in a conventional product, using their unique rubber composition design, low thermal conductivity, high flame retardance, and optimal shape design with CAE.

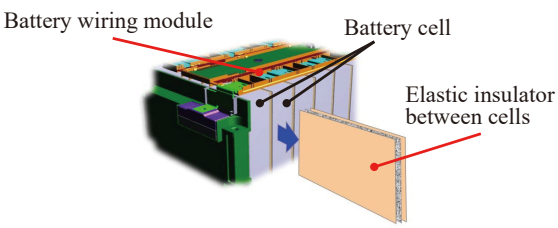

Fig. 4. Arrangement of elastic insulators between battery cells

(5) Battery cooling hoses

Battery cooling hoses pump cooling water to battery packs, PCU,*6 e-Axle,*7 and other units (Fig. 5). Sumitomo Riko uses resin, which is lighter than rubber and metal, and adopts a unique connection structure using laser welding, reducing the number of parts and pressure loss, which leads to lower cooling efficiency.

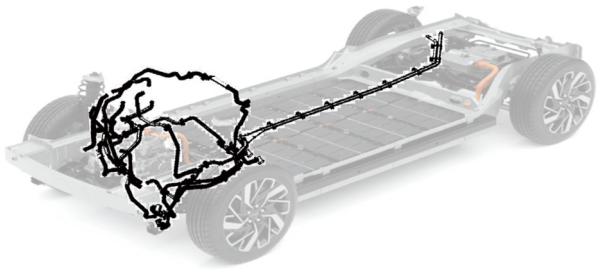

Fig. 5. Location of battery cooling hoses

3-2 Motor/Inverter peripheral

(1) Rectangular magnet wire for motors

Compared to a round wire, a rectangular magnet wire can be wound without gaps in the same space (Fig. 6), helping reduce the size and increase the output of motors.

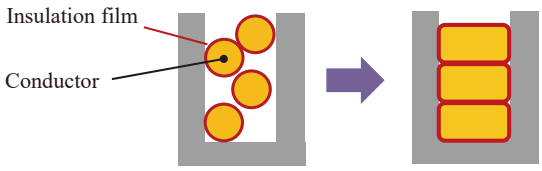

Fig. 6. Improving the space factor with rectangular magnet wire

Sumitomo Electric Wintec, Inc. has achieved a thinner film and higher reliability through the development of material to improve the insulation performance of an insulation film and the development of a process to make the film thickness uniform. In addition, the Sumitomo Electric Group is developing an insulation film made of cross-linked fluororesin or low-dielectric resin to further improve these characteristics.

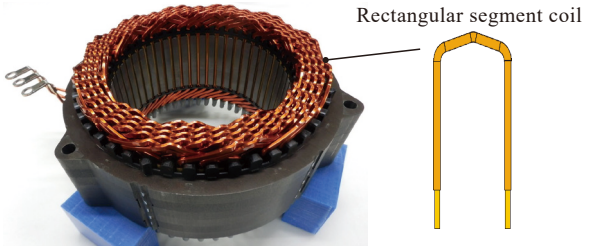

Photo 3. Example of a motor stator using rectangular magnet wire

(2) Planetary carrier for speed reducers

A planetary carrier reduces the rotation speed of a motor. By sintering and joining two or more near-net-shaped parts, Sumitomo Electric Sintered Alloy, Ltd. provides the products shown in Fig. 7 with a precise, complex, and hollow shape, which is a strength of sintered products; they are created without machining, and contribute to the downsizing of the e-Axle.

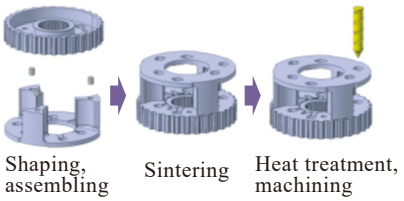

Fig. 7. Production process of sinter-joining parts

Photo 4. Example of a carrier product

(3) Oil pump rotor

An oil pump rotor is a key part of an oil pump for motor cooling (internal gear pump) (Fig. 8), playing a role in sucking in and discharging oil. High-quality and inexpensive gears are commercialized by forming the smooth tooth profile using a sintering process. Using its unique gear design technology, Sumitomo Electric Sintered Alloy provides pump parts that are small, highly efficient, and quiet.

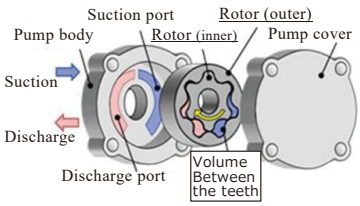

Fig. 8. Structure of an internal gear pump

Photo. 5. Example of a rotor

Sumitomo Electric Group has developed electron beam irradiation cross-linking technology, which enables adhesion to metal and overcomes the drawback of wear resistance of fluororesin, which excels in low friction performance and high heat and chemical resistance. Applying the coating to oil pump rotors helps produce products with low friction sliding and high efficiency.

(4) Motor mount

The motor mount supports driving motors and reduces the vibration and noise of motors and gears. Using its polymer materials technology, Sumitomo Riko has developed products with flexibility, damping, and reliability. Compared to engine mounts, motor mounts should address noise in the high-frequency area, so Sumitomo Riko has taken measures to reduce such noise.

Photo 6. Example of a motor mount

(5) SiC power devices

Silicon carbide (SiC) is a next-generation material for power devices, which are used for inverters. It features higher withstand voltage, efficiency, and operation speed than conventional silicon (Si), and is a promising material that promotes an advanced, energy-saving society. Sumitomo Electric Industries, Ltd. is developing SiC crystals and epitaxial wafers using high-quality, cost-effective growth technology (MPZ*[8]), which has achieved world top-level uniformity and a defect-free area of 99% or more of the wafer surface. It is also developing transistor chips with a unique structure for commercialization, achieving low power loss and high withstand voltage at the same time.

Photo 7. SiC wafer

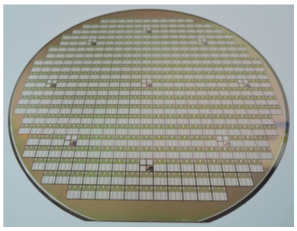

Photo 8. Transistors on an epitaxial wafer

(6) Heat spreaders for power devices

Heat spreaders are indispensable for power modules that use SiC for smaller size and higher output. A.L.M.T. Corp. has developed and provided a Cu-Mo (CPC*[9]) spacer as a heat spreader. It has high thermal conductivity and a thermal expansion coefficient adjusted to that of SiC devices by changing the composition ratio of Cu to prevent solder cracks, contributing to higher reliability and output power of the power modules.

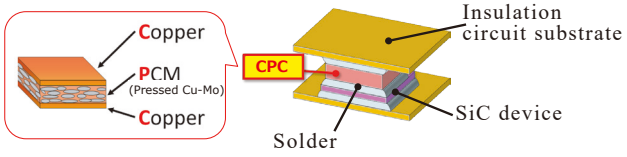

Fig. 9. Application example of CPC to double-sided heat dissipation for a power module

3-3 High-voltage interconnection wiring/connectors

(1) High-voltage wiring harness

High-voltage wiring harnesses connect batteries, inverters, and charging units. Sumitomo Wiring Systems has an assortment of pipe-shielded wiring harnesses for under-floor long wiring, using an aluminum pipe as a sheath, which works as a shield and protector and assists the three-dimensional installation of the harness, to improve mountability in vehicles.

Photo 9. Example of an under-floor wiring harness

(2) High-voltage connectors

High-voltage connectors are used to connect batteries, inverters, chargers, and other units. Sumitomo Wiring Systems has optimized their functions in consideration of the characteristics (temperature, vibration, waterproofing, and noise) of each mounting position, and ensured their connection reliability and safety to allow their use in harsh environments. Products are assorted from Class 20 A to Class 400 A.

Photo 10. Example of a high-voltage connector

3-4 Charger/infrastructure

(1) Charger connector/inlet

(a) For normal charging

Alternating current (AC) charger connectors of Sumitomo Wiring Systems are compliant with international standards (IEC 62196-1, SAE J1772, UL2251).

Photo 11. Normal charger connector/inlet

(b) For quick charging

The high-power charger connectors are rated at up to 200 A and are compliant with Japanese domestic standards (CHAdeMO), European standards (CE), and North American standards (UL). They feature a resin case for weight saving and a rubber cable for easy bending, high durability, and easy handling.

Photo 12. Quick charger connector

(2) V2H (vehicle to home) products

V2H is a system that uses electricity from BEV batteries for household use. The system uses on-vehicle batteries as an electricity storage destination for photovoltaic power generation and cheaper electricity available overnight, and as an emergency electricity source in the case of power outages due to disasters.

(a) Charger/discharger connectors, charger/discharger

These are designed and developed for the domestic and European markets to be more compact and lightweight in consideration of handling for household use. Sumitomo Electric is developing a more compact and efficient V2H charger/discharger to satisfy the expanding market.

Photo 13. Connector for charger/discharger

3-5 Others

(1) Steel cords for BEV tires

Steel cords are used as reinforcing material for the wheel treads and carcasses of tires. While tires for BEV are required to have lower rolling resistance and weight for high electricity efficiency, and higher carrying capacity to address weight increase in batteries, Sumitomo Electric has achieved mono-wired and flattened cords, as shown in Fig. 11, in cooperation with Sumitomo Rubber Industries, Ltd. to address the requirements for EV tires, such as reduction of rubber amount, through downsizing and higher strength of cords.

Fig. 10. Cross section of a tire

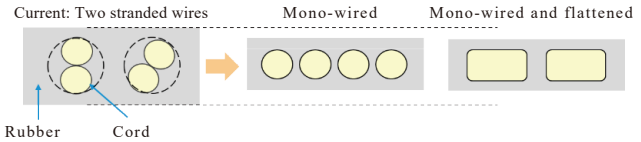

Fig. 11. Schematic drawing of cord downsizing

4. Conclusion

This paper introduced Sumitomo Electric Group's technologies and products for electrified mobility, including their strengths and features. While the electrified mobility market is growing, the technologies and products are in the process of evolution and innovation. Targeting areas that have not yet come to the surface since the evolution and innovation, we will make efforts to create new values with the technologies and products described in this paper, as well as a bird's-eye view of the Group.

Technical Terms

∗1 HEV: Hybrid electric vehicle. A hybrid vehicle powered by a combination of an internal combustion engine and (an) electric motor(s).
∗2 NEV: New energy vehicle. A general term for fuel-cell vehicles, BEVs, and Plug-in hybrid electric vehicles.
∗3 BEV: Battery electric vehicle. An electric vehicle powered solely by on-vehicle batteries.
∗4 FPC: Flexible printed circuit. A type of circuit board made of a flexible substrate.
∗5 TIM: Thermal interface material. A heat-conductive material placed between components to fill a gap.
∗6 PCU: Power control unit. A unit that controls the driving force of an electric vehicle. It includes an inverter that controls the motor and a DC-DC converter that multiplies voltage.
∗7 e-Axle: An electric drive unit that integrates a motor, an inverter, and a speed reducer.
∗8 MPZ: Multi-parameter and zone-controlled SiC crystal growth technology.
∗9 CPC: A heat spreader with a laminated structure of Cu, pressed Cu-Mo, and Cu.

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