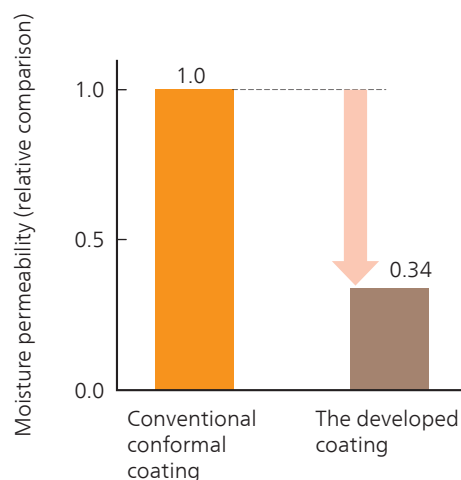
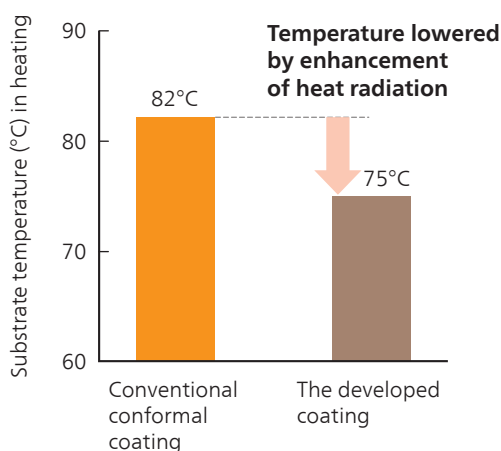
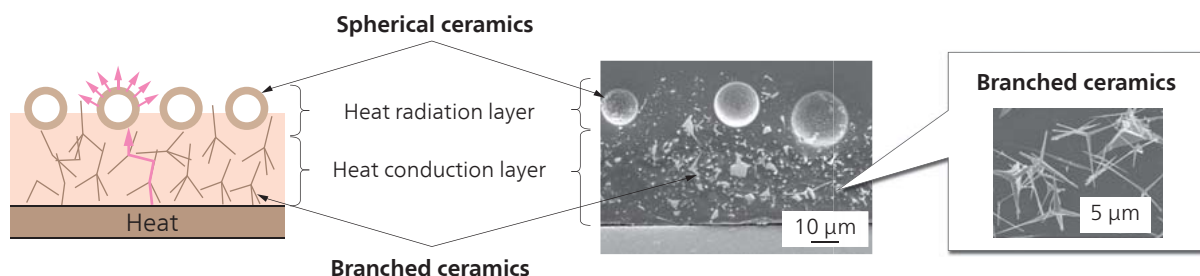


High Functional Materials



1 Cross-sectional view of the newly developed coating (top)
Heat radiation property and moisture permeability of the coating (bottom)

1 Circuit Board Coating with Excellent Heat Radiation and Reliability

Conformal coating is usually applied to the surfaces of circuit boards for home electric appliances, mobile devices and other electronic equipment to prevent short circuits caused by dew condensation on the boards. Meanwhile, circuit boards are required to exhibit a high level of heat dissipation characteristics because heat generation density increases due to downsized circuits and integrated electronic components. Therefore, Hitachi has developed a novel conformal coating with excellent heat radiation.

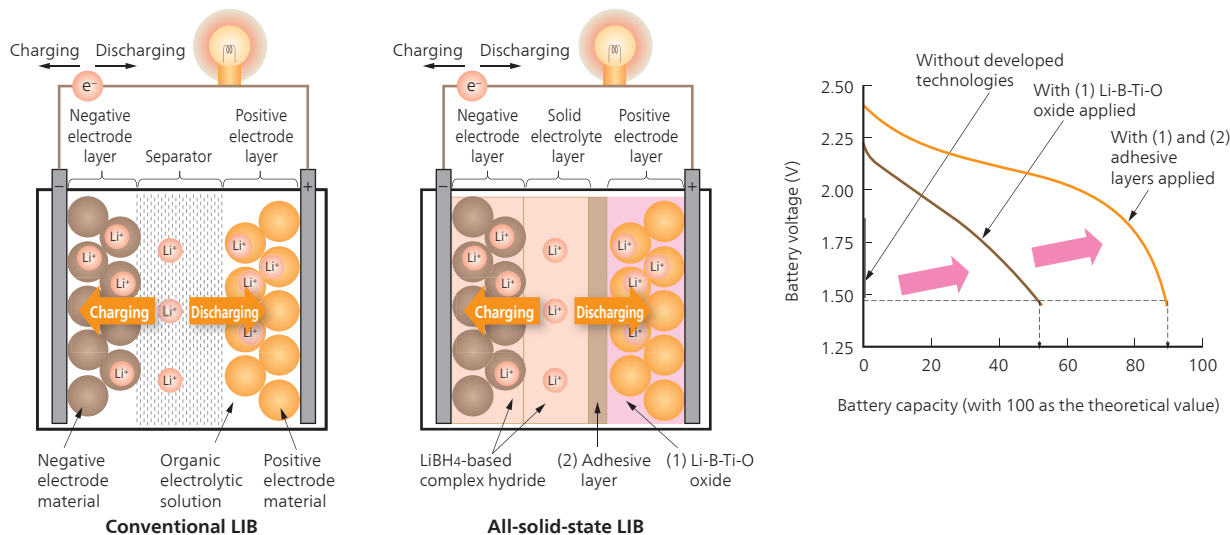
A resin with low moisture permeability is used as a main component to secure greater reliability. Higher heat dissipation is achieved than those of conventional heat radiation materials. Branched ceramics distributed in the heat conduction layer increase heat transfer channels between the particles and achieve high heat conductivity. On the surface, spherical ceramics with a

high radiation rate are exposed to increase the radiation area and improve the heat radiation.

In this coating material applied to a circuit board, spherical ceramics with low specific gravity come to the surface and simultaneously form a two-layer structure. Therefore this new coating allows use of the conventional process of applying coating materials without change. This coating is expected to be applied to devices for which a high level of heat radiation and moisture resistance are required.

2 Thermally Durable All-solid State Lithium Ion Batteries

Hitachi has developed a basic technology for reducing the resistance of all-solid-state lithium-ion batteries (LIB) with the use of an LiBH_4 -based complex hydride and also prototyped a small battery incorporating this technology to attain a capacity of 2 mAh and an energy density of 30 Wh/L. The battery has been demonstrated



Li: lithium, B: boron, H: hydrogen, Ti: titanium, O: oxygen

2 Comparison of battery configuration and discharge curves at 150°C

its operation at 150°C.

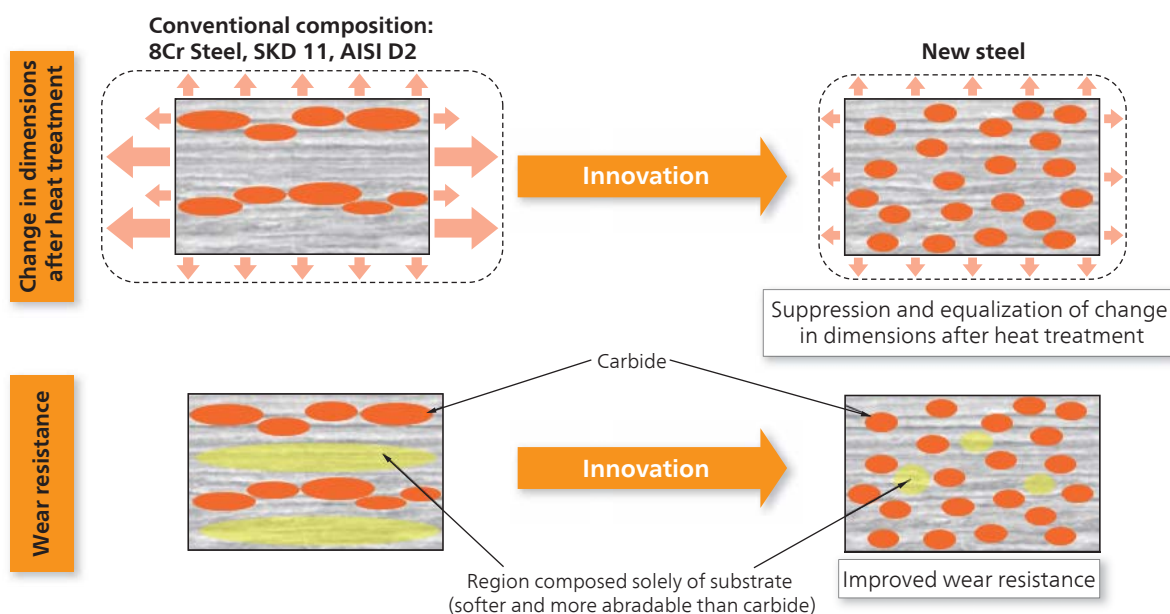
The conventional LIB applying organic electrolyte solution has a withstanding temperature of around 60°C, and its applications are limited. All-solid-state LIB utilizing a non-volatile solid electrolyte in place of organic electrolyte solution is therefore awaited as a thermally durable battery that may be used in high temperature conditions and introduced to electricity storage systems free of cooling. The all-solid-state LIB with a complex hydride has high resistance on the interface between the positive electrode and the electrolyte, and it was a challenge to reduce it. In collaboration with the World Premier International

Research Center Initiative at the Advanced Institute for Materials Research (WPI-AIMR) of Tohoku University, Hitachi succeeded in developing an Li-B-Ti-O oxide and an adhesive layer to reduce the interface resistance of the all-solid-state LIB.

With a view to future commercialization, Hitachi continues to improve performance of LIB in terms of capacity expansion and higher energy density.

3 New-concept Steel for Cold Working Tools

In cold press forming, molds are required to have



Cr: Chromium

3 Schematic of carbide distribution in the new steel

greater precision and wear resistance characteristics for enhanced product precision and strengthened processed material. Hitachi has developed new steel for cold working tools as a material for molds that meets these requirements. Carbides of new steel which give the steel these characteristics, are finely and uniformly distributed as a result of innovation in the manufacturing process, while its composition is within the scope of AISI D2 global standard steel, similar to JIS SKD 11.

The main features are as follows.

- (1) Limited dimensional changes after heat treatment
- (2) Limited dimensional changes due to age deterioration
- (3) Enhanced wear resistance

In addition, new steel features reduced unevenness in characteristics between lots. This has achieved positive effects such as the reduction of galling with the burring punch following the stabilization of the dimensions, the stability of plate precision, and the prolonged service life of molds for forming high-tension steel plates after reducing the abrasion of the cutting edges.

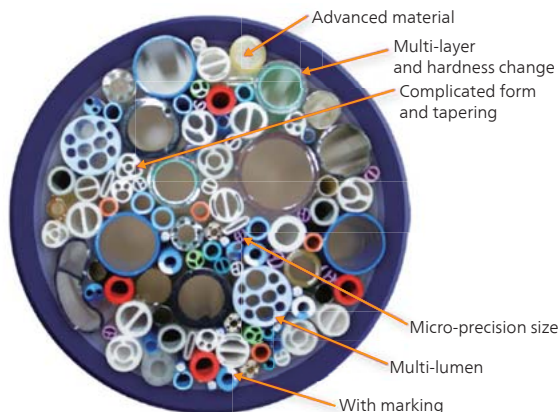
The use of new steel is expected to improve the precision level of press molds, stabilize their quality and strengthen the durability of the molds for forming high-tension steel plates.

(Hitachi Metals, Ltd.)

4 Catheter Tubes

Catheters are used for medical services such as discharge of body fluids, the injection/infusion of medicinal solutions and the examination/treatment of blood vessels and so on. In advanced medical treatment such as for cardiovascular disease, a catheter tube needs sophisticated manufacturing technologies, including small diameters, thin walls, a multi-layer structure, multi-lumen features and more.

In 2016, acquisition of HTP-MEDS, LLC, which



4 Different types of catheter tubes

engages in the catheter tube business in the USA, a wide variety of catheter tubes were added to Hitachi Metals, Ltd's product lineup.

The main features of the multi-lumen tubes of HTP-MEDS, LLC are as follows.

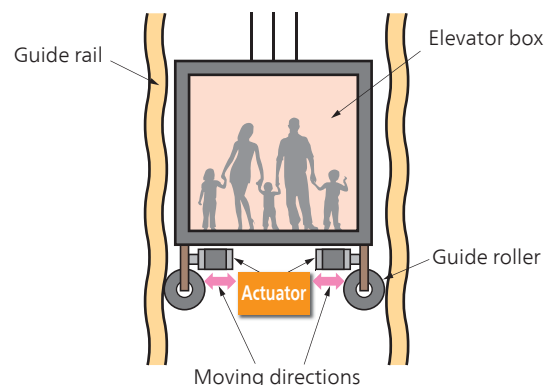
- (1) Available in multi-lumen and atypical lumen configurations.
- (2) Available in small precision sizes.
- (3) A wide variety of materials may be used.

In addition, HTP-MEDS, LLC is capable of producing variable hardness tubes, multi-layer tubes and many other products. A combination of these technologies and ultra-fine wire will lead to the development of tubes with even more advanced functions.

(Hitachi Metals, Ltd.)

5 Short Stroke Actuator

When selecting a short stroke actuator incorporated in a damping system intended for excitation and damping purposes, users traditionally faced the problem of the poor responsiveness of solenoid actuators and the large sizes of voice coil motors (VCMs). In response, MEOMAX ENGINEERING Co., Ltd. has developed the



5 Short stroke actuator and installation example

short stroke actuator as a product with characteristics that lie between those of the two conventional types of actuators mentioned above.

This newly developed product takes advantage of the magnetic field generated by a current-carrying coil and the attraction and repulsion effects of a magnet to move the mover in the axial direction, thereby generating a thrust force. With an original formed core made of silicon steel, its responsiveness is superior to that of solenoid actuators, and it produces a high level of thrust from a smaller amount of magnet than that in the VCM.

The short stroke actuator is delivered chiefly for the purpose of reducing vibrations in elevators. It is designed to suppress the box vibrations caused by the distortion of guide rails when the elevator box moves, thereby improving elevator ride comfort. The short stroke actuator moves the guide roller in a direction that offsets the vibrations. It is expected to be more widely applied in the future.

(NEOMAX ENGINEERING Co., Ltd.)

to be interconnected, and then heated and compressed. It therefore exhibits conductivity between the opposed circuits and insulation between neighboring circuits, and it bonds and fixes the two circuit boards.

Amid recent improvements in the image quality of FPDs for smartphones and other devices, the ACF for the connection of the driver IC chip and a glass board (Chip on Glass) is required to connect finer pitch circuits. Hitachi Chemical Co., Ltd. has developed the particle-aligned ACF by upgrading the resin design technology and the conductive particle dispersion technology, which are the company's fundamental technologies.

After bonding, this ACF efficiently captures particles while maintaining the monodispersed arrangement of the particles prior to bonding with no flux of particles between electrodes. As a result, it achieves a high capture level and a high insulation resistance level while suppressing unevenness in the particle capture level to provide the connection of finer pitch circuits that is difficult with conventional ACFs.

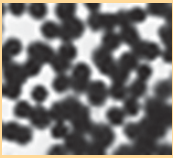
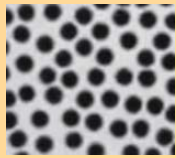

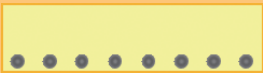




(Hitachi Chemical Co., Ltd.)

6 Particle-aligned Anisotropic Conductive Film

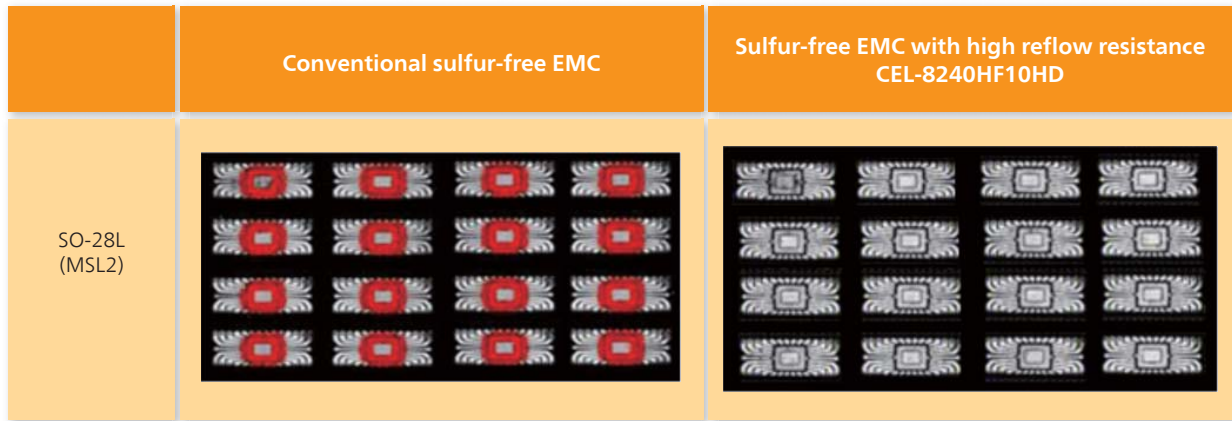
Anisotropic conductive film (ACF) is a circuit connection material for driver integrated circuit (IC) chips introduced to flat panel displays (FPD) and other applications. It is a bonding film with conductive particles dispersed within the thermosetting resin adhesive agent. The ACF is inserted between the circuits

7 Sulfur-free Epoxy Molding Compound with High Reflow Resistance

The recent trend toward the introduction of electronic technologies into automobiles has led to a steady increase in the number of automotive semiconductors. Meanwhile, conventional gold wire is increasingly being

| Item | Conventional ACF | Newly developed ACF |
|---|---|---|
| Conductive particle arrangement |  |  |
| Product structure (cross-sectional schematic diagram) |  |  |
| Bonded area (connection area: 1,200 μm ²) (1) Differential interference microscope image (2) Optical microscope image |   <p>(1) Variability among the number of particles captured</p> <p>(2) Particles between electrodes clump</p> |   <p>(1) Extremely low variability among the number of particles</p> <p>(2) Particles between electrodes are dispersed and unlikely to clump together.</p> |

6 ACF characteristics



MSL2 conditions: 85°C, 60%RH, 168 hours
 Reflow conditions: 260°C × 10 seconds × 3 times
 Pre-baking conditions: 125°C × 24 hours
 SO-28L (copper alloy) die pad: silver plating, 4.1 mm × 5.2 mm, Die size: 2.2 mm × 3.2 mm

7 Constant-depth mode scanning acoustic microscopy (CSAM) image after reflow

replaced with lower-cost copper wire to slash semiconductor package costs. However, copper wire has a drawback in that it is easily corroded by an additive containing sulfur atoms that is used for improving the adhesion with the lead frame. To satisfy the strict conditions in the test of the reliability of automotive conductors specified in the Automotive Electronics Council-Q006 (AEC-Q006), it is necessary to prevent delamination between the epoxy molding compound (EMC) and the lead frame in the reflow process.

As a measure against delamination in the reflow process, Hitachi Chemical Co., Ltd. has modified the epoxy resin to achieve a reduction in the water absorption rate and the modulus of elasticity at

temperatures of around 260°C, and has modified the adhesion additive to make it free of sulfur atoms and improve adhesiveness. By combining these measures, the company has developed a sulfur-free EMC that is capable of preventing delamination in the reflow process at Joint Electron Device Engineering Council (JEDEC) Moisture Sensitivity Level (MSL) 2, and which has excellent preservability at high temperatures.

In the future, the company will promote it in Japan and overseas and continue its development efforts with a view toward achieving JEDEC MSL 1 and zero delamination.

(Hitachi Chemical Co., Ltd.)