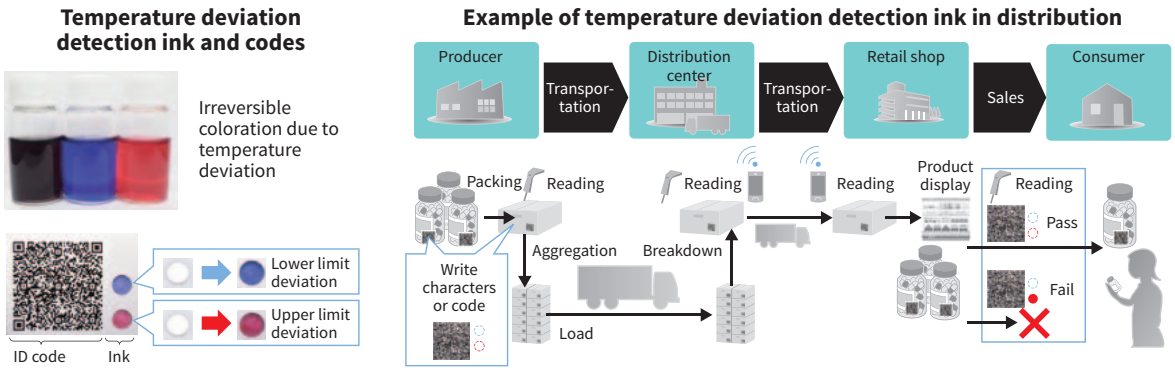
High Functional Material



1 Examples of distribution quality control using temperature deviation detection ink

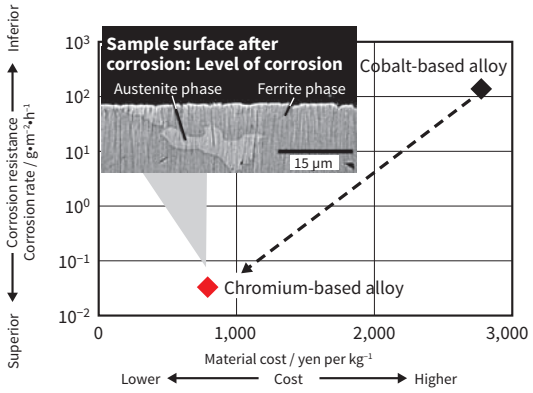
1 Temperature Deviation Detection Ink

Hitachi has developed a new temperature deviation detection ink to enable consistent quality control for each individual product, to provide end users with safer and more reliable food and medical products. The units by which products are transported from producers to consumers are decreasing in quantity from large truck or container loads to boxes or individual products. Currently, product control is limited to large truck and container loads using expensive recording instruments with attached sensors, but a preferable way is to provide an integrated product control service all the way to consumers' doors.

The newly developed temperature deviation detection ink uses irreversible color changes to pinpoint deviations above or below the set temperature ranges for each product. Temperature deviation detection codes combined with individual product ID codes are placed on individual items or cardboard boxes. The codes are read by smartphone at each distribution point (storage warehouse, store, etc.) to acquire information on the status of the product, time, location, and so on. Using the temperature deviation detection codes with the Internet of Things (IoT) can achieve integrated quality control from production line to point of purchase at a low price.

2 High-corrosion, High-wear-resistant Chromium-based Alloy

Due to demands for tougher usage environments and lower costs, the moving parts used in pumps and automobiles need to be highly resistant to corrosion and wear, while containing fewer high-priced metals. In the past, expensive nickel-based or cobalt-based alloys were used, but recent development is aimed at product applications using a chromium-based alloy to



2 Benchmarks for the lower-cost, highly corrosion-resistant chromium-based alloy

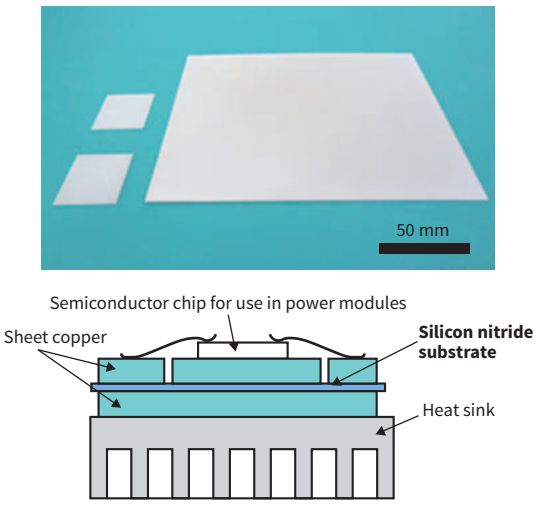
reduce costs. Generally, chromium-based alloys show excellent anti-corrosive properties and strength due to the single-phase ferrite they contain, but are difficult to use in products due to fragility at room temperature.

To overcome this challenge, Hitachi examined the alloy composition focusing on a two-phase alloy that combines both a hard ferrite phase and a soft austenite phase. This successfully resulted in a chromium-based alloy that maintains the desired corrosion resistance, but has better ductility. The alloy was confirmed to have twice the wear-resistance and over a thousand times the corrosion-resistance of cobalt-based alloys, while costing 70% less in raw material.

In the future, Hitachi will look at the applicability of this alloy as a wear-resistant cladding material for selected conditions to match user-specified processes and under actual user environments.

3 High Thermal Conductivity Silicon Nitride Substrate

Power modules are rapidly increasing in popularity for motor control in electric vehicles (EV) and hybrid electric vehicles (HEV). They require a substrate, that not only insulates, but also that can cope with the stresses generated by the temperature cycle. This is leading to the steady adoption of silicon nitride (Si_3N_4) substrates for their excellent mechanical characteristics.



3 The high thermal conductivity silicon nitride substrate (top), and an example configuration of a power module (bottom)

Hitachi Metals, Ltd. already mass produces silicon nitride substrate with thermal conductivity of 90 W/m•K, but the new substrate increases this to 130 W/m•K.

The increasingly high energy density of power modules requires high heat dissipation properties for the insulated substrate. This product achieves higher heat dissipation and higher reliability for the temperature cycle than conventional aluminum nitride substrate or silicon nitride substrate. This contributes to more compact, lower-cost power modules. In the future, this will be applicable to devices operated at higher temperatures, by the use of silicon carbide (SiC) semiconductor chips, which are expected to become more popular, and high voltage applications where aluminum nitride substrates are currently used.
(Hitachi Metals, Ltd.)

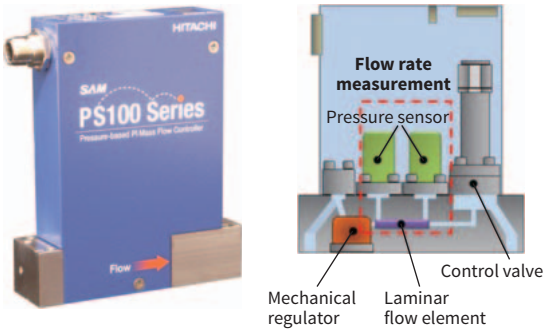
4 PS100 Series Pressure-based Mass Flow Controller

Hitachi Metals developed the PS100 Series pressure-based mass flow controller (MFC) that incorporates a differential pressure detection method that uses pressure sensors to suppress time-dependent variations in flow rate detection and to improve flow rate stability during gas pressure fluctuations.

The main features are as follows.

(1) Measurement architecture using pressure sensors

The PS100 Series, unlike conventional thermal MFCs, uses pressure sensors to measure the flow rate without heating. This limits the



4 PS100 Series Pressure-based MFC (left), and a structural drawing (right)

reactive excrescence of pyrolytic gases on the MFC gas wet path and also reduces time-dependent variations, enabling stable flow rate measurement control over a long period of time.

(2) Improved pressure insensitive function

The MFC has a unique configuration with a mechanical regulator upstream and a control valve downstream for a high level of flow rate stability for inlet/outlet gas pressure fluctuations of the MFC.

(3) EtherCAT Communications Support

This series supports Ethernet for Control Automation Technology (EtherCAT) that enables high-speed communications in addition to supporting DeviceNet* communication and analog input/output signals, too.

(Hitachi Metals, Ltd.)

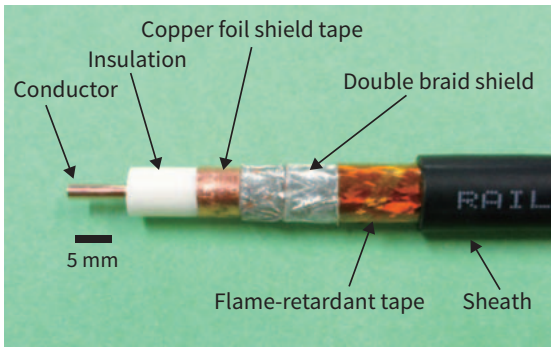
* See "Trademarks" on page 148.

5 Coaxial Cable for Rolling Stock

The expansion of wireless communications devices in rolling stock has led to increased demand for high-frequency coaxial cables to send signals to those devices. Cable installed on rolling stock must meet European Union (EU) Cable Fire Safety Regulations. Hitachi Metals achieved this by blocking insulation from exposure to flames via flame-retardant tape on the braided shield, and the continuous combustion-suppressing effect of the company's own compound of halogen-free flame-retardant material for use on the sheath. Furthermore, aiming to improve the long-distance transmission properties in high-frequency bands (up to 6 GHz), it developed a high-frequency coaxial cable that also satisfies the EU Cable Fire Safety Regulations by using a low-permittivity expanded insulation and longitudinally supporting copper foil shield tape with high conductivity. Total manufacturing of everything from the conductors to the cable enabled the creation of high-frequency coaxial cable with the transmission characteristics and structural dimensions required by the customer.

Hitachi Metals aims to further expand its sales as it fills out this lineup of rolling stock communications cables.

(Hitachi Metals, Ltd.)



5 Structure of the newly developed cable

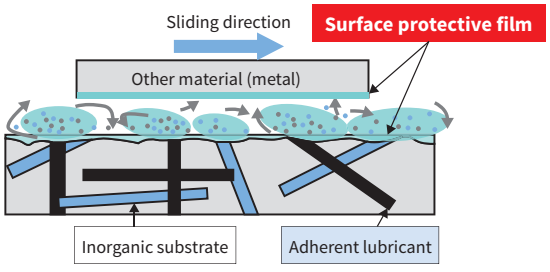
6 Wear-resistant Phenolic Resin Molding Compound

Hitachi Chemical Company, Ltd. has developed a phenolic resin molding compound with excellent wear-resistant properties for metal.

Previous sliding parts made with resin molding compound suffered melted surfaces due to wear heat from sliding and wear was exacerbated by wear debris generated during this process, which acted as an abrading agent. This wear-resistant material is made from thermosetting phenolic resin that does not melt due to slide-induced wear heat, unlike thermoplastic resin. Under certain conditions during the sliding movement, exacerbated wear is reduced by lubricating substances containing wear debris that adhere to the surface of the molded compound and metal to form a protective film that smooths the surfaces.

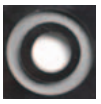
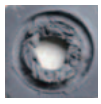
This wear-resistant material is currently used in pulleys with cams for general-purpose engines.

(Hitachi Chemical Company, Ltd.)



6.1 Mechanism whereby the developed material reduces slide-induced wear

Results of slide-induced wear testing (ring on disc)

Item	Themosetting phenolic resin molding compound		Thermoplastic resin molding compound		
	Newly developed material	Conventional materials	PPS/GF40	PPS/CF30	PEEK
Slide-induced wear on test piece after testing					
Depth of wear	0.03 mm	2.10 mm	2.44 mm	2.14 mm	2.16 mm
Testing time	26.5 min	3.7 min	2.4 min	8.4 min	1.3 min
Remarks (Reason why measurement stopped)	Instrument temperature limit (300°C)	Depth of wear limit (2.0 mm)	Depth of wear limit (Melting test piece)	Depth of wear limit (Melting test piece)	Depth of wear limit (Melting test piece)

Test conditions: For SUS304, dry atmosphere, speed of 0.3 m/s (210 min-1), initial load 1,000 N, load increased by 200 N every 5 minutes

6.2 The results of slide-induced wear testing

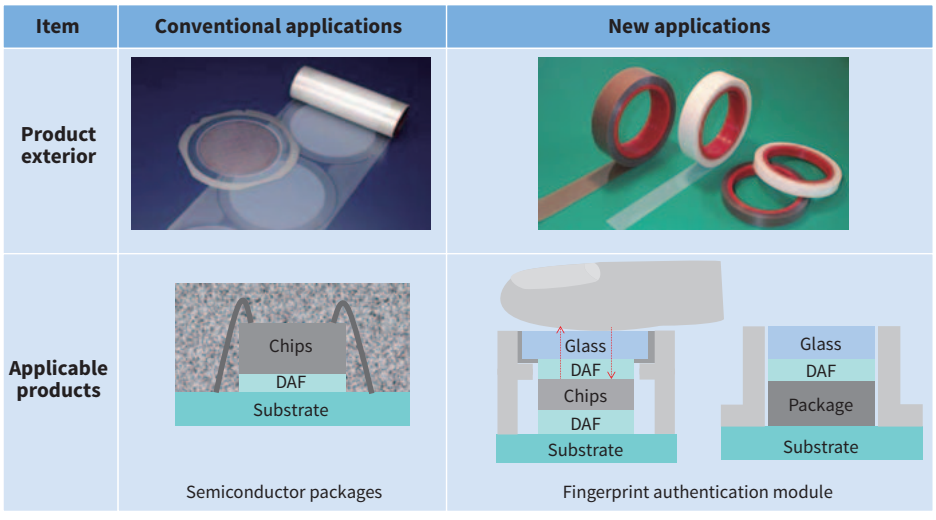
7 Die Attach Film for Fingerprint Authentication Module

In recent years biometric authentication (e.g. facial, iris, or fingerprint identification) is increasingly being applied to mobile devices in order to enhance their security.

Fingerprint authentication sensor modules for smartphones are configured with a sensor chip that is applied to the cover glass, or by incorporating a semiconductor package into the sensor chip and then attaching it to the cover glass. Paste is the standard adhesive used for connecting the cover glass, sensor chip, and semiconductor package, but film is gaining in use to resolve variations in productivity and thickness. After considering the use of die attach film (DAF), used in semiconductor packages to connect the semiconductor chip to the support (the substrate or lead frame), as a film-type adhesive, it was found to have a high level of adhesiveness and reliability.

Hitachi Chemical will continue to expand the use of DAF technology, refined as a semiconductor material, as a film-type adhesive for next-generation fingerprint authentication sensors.

(Hitachi Chemical Company, Ltd.)



7 DAF product and example of use in a fingerprint authentication module