



Components & Materials

 Batteries

 Automotive Systems

 Displays

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 Materials

EV-ICT Solution and Connected Navigation System for EVs

The threat of global warming has made CO₂ emissions reduction an issue for the entire world and EVs are recognized as a new technology with the potential to help in this task. Together, the EV-ICT solution developed and marketed by Hitachi Automotive Systems, Ltd. and a communication and navigation system for EVs developed by Clarion Co., Ltd. provide a telematics service platform for EVs which had its first commercial release in December 2010 for use in the Nissan LEAF*.



Shinji Kawamura (left), Engineer, Core Technology Development Management Department, IT Core Development Department, IT/IITS Group, Clarion Co., Ltd.; Takashi Kataoka (middle), Engineer; Shigeru Ota (right), Chief Engineer, Next Generation's Telematics System Department, System Solutions Division, Car Information Systems Division, Hitachi Automotive Systems, Ltd.

Technology to Maximize Attraction of EVs

Zero emissions of CO₂ (carbon dioxide) and other greenhouse gases are a key feature of EVs (electric vehicles), creating high expectations that they will be a standard bearer for the future of motoring. Range anxiety, however, is a major concern with current EVs, as is the problem of how to replenish the vehicle's battery. In response, Hitachi Automotive Systems, Ltd. has used the EV-ICT solution (information and communication technology solution for electric vehicles) to create a global service platform implemented as the global telematics center which makes EVs more convenient and their use more reliable and comfortable. Operating in conjunction with the connected navigation system for EVs developed by Clarion Co., Ltd., this service reassures EV drivers with features that include support for EV location information as well as battery and charging station information. The maximum potential of EVs has been realized by getting the ICT (information and communication technology) services and solutions of Hitachi Automotive Systems to work together with the in-vehicle information units from Clarion in the form of the car information system solution.

Connectivity Technology

"Connectivity" is a key feature of this solution. This means that the center and in-vehicle terminals cooperate via a network. For example, the Internet-based online connectivity between the global

telematics center and EVs allows information such as vehicle location and other data such as remaining battery power and battery status to be checked 24 hours a day. Similarly, information about charging stations can be kept up to date by having the center transmit this data to the EV communication and navigation system. The system features multilingual operation and support for different carriers and communication protocols including those used in Japan, North America, and Europe. Support for other regions will be progressively added. EV Drive Assistance includes a pre-drive route planning function that provides reassurance by determining a route to the desired destination that takes account of the vehicle's current battery level and a route transmission function to send the resulting route information to the car navigation system. The system features a comprehensive range of functions that owners and drivers can use with confidence, including remote operation from a PC (personal computer), smartphone, or other device for tasks such as checking the state of the EV's battery, initiating charging, turning the HVAC (heating, ventilating, and air conditioning) control on or off, and receiving e-mail warnings if the charging unit is not plugged in.

The in-vehicle units that handle communications for this information service for EVs consist of a special-purpose TCU (telematics communication unit) and a new connected navigation system for EVs developed by Clarion. The TCU has a FOMA* mobile phone module embedded so that it can establish a network connection to the center at any time. The TCU is connected to the EV's navigation system and CAN (controller area network) to implement a variety of EV-oriented services including navigation, remote operation via the center, and vehicle management functions. The system also helps make EVs easier to use and more environmentally conscious through functions such as display of power consumption records and details of the available driving range.

Contribution to Social Energy Management

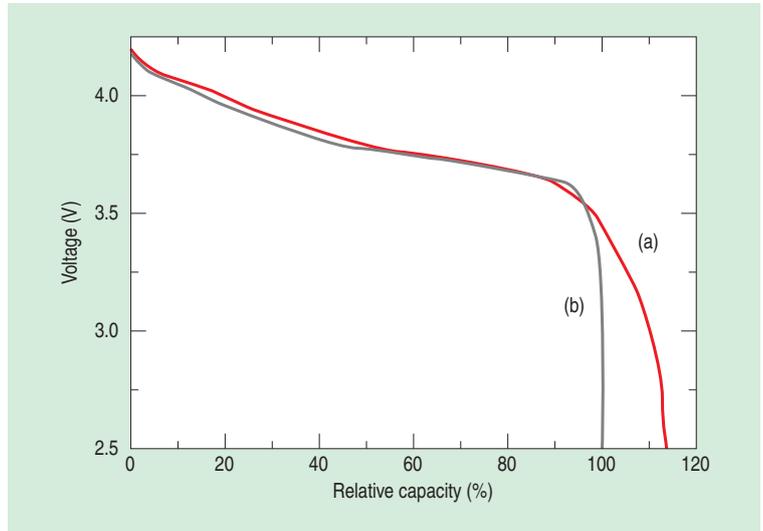
Future applications of ICT solutions for EVs include cooperation with smart houses, commercial vehicle dispatch, and managing EVs in car sharing schemes which offer a new model for vehicle use. These have the potential to make an even broader contribution to social energy management and Hitachi aims to help realize a low-carbon society through the growing market for EVs.

* See "Trademarks" on page 83.

Prismatic Lithium-ion Rechargeable Battery with New High-capacity Silicon-based Negative Electrode

As the functions of mobile handsets become more advanced, the power consumed by devices running applications such as mobile TV (television) or Internet access is increasing. This creates a strong demand to improve the capacity of the batteries used in these devices. Hitachi Maxell Energy, Ltd. has developed a new negative electrode using a new silicon-based composite material, in which nano-sized silicon particles are dispersed within an ion conductive material. This has allowed a significant improvement in battery capacity and provides enhanced performance at high duty ratios. Initially, Maxell Energy will utilize this new technology in lithium ion rechargeable batteries for smartphones. The new silicon negative electrode is compatible with current Maxell Energy lithium ion batteries in terms of charging voltage and operating voltage. Compared to the current graphite/LiCoO₂ system, the capacity was improved about 10% in the new model which has a SiOC and graphite anode. Thus, longer operating duration and more rapid charging can now be realized without the need for hardware-based charges. The batteries using this new negative electrode can reduce recharging time by up to 30% compared with current Maxell Energy lithium ion batteries.

Maxell Energy will continue to expand its next-generation electrode technology, while securing superior safety and proceeding with the development of high-performance and high-capacity bat-



Discharge curves of the trial prismatic batteries consisting of hybrid of graphite and SiOC (a), and graphite negative electrode and layered positive electrode examined in voltage ranging from 2.5 to 4.2 V at 0.2 C-rate at 23°C (b)

teries. Maxell Energy also intends to expand its battery business into new areas and applications while giving all due consideration to decreasing environmental impacts. (Hitachi Maxell Energy, Ltd.)

Newly Developed Lithium-ion Rechargeable Battery with High Performance for PHEVs and EVs



Photograph (a) and specifications (b) of new prismatic battery for PHEVs

Hitachi has many years of experience in the development of cylindrical batteries for HEVs (hybrid electric vehicles) and has supplied second-generation battery packs since 2005. Third-generation packs are to be integrated into an HEV system by US firm General Motors Company from 2011. Hitachi is now working on the development of fourth-generation prismatic batteries for PHEVs (plug-in hybrid electric vehicles).

PHEVs have drawn much attention for their ability to improve gas mileage and reduce emissions through the combination of EV

(electric vehicle) and HEV operation. Hitachi has developed a promising new type of prismatic battery for PHEVs. The battery combines both high energy (for EV operation) and high output power (for HEV operation) making it suitable for energy management in PHEVs. Although high energy and high output power are conflicting objectives in battery electrode design, Hitachi has overcome this difficulty by using a low-resistance structure for the prismatic battery and by optimizing both the electrode thickness and the composition

of active materials.

The battery has a capacity of 25 Ah, a high energy density of 120 Wh/kg, and a high output power density of 2,400 W/kg. The battery has a larger capacity than the batteries used in HEVs and incorporates a ceramic separator and new electrolyte additives to ensure safety. When connected in parallel, the new prismatic batteries are also suitable for EVs and Hitachi intends to supply them to auto makers for use in both PHEVs and EVs.

(Hitachi Vehicle Energy, Ltd.)

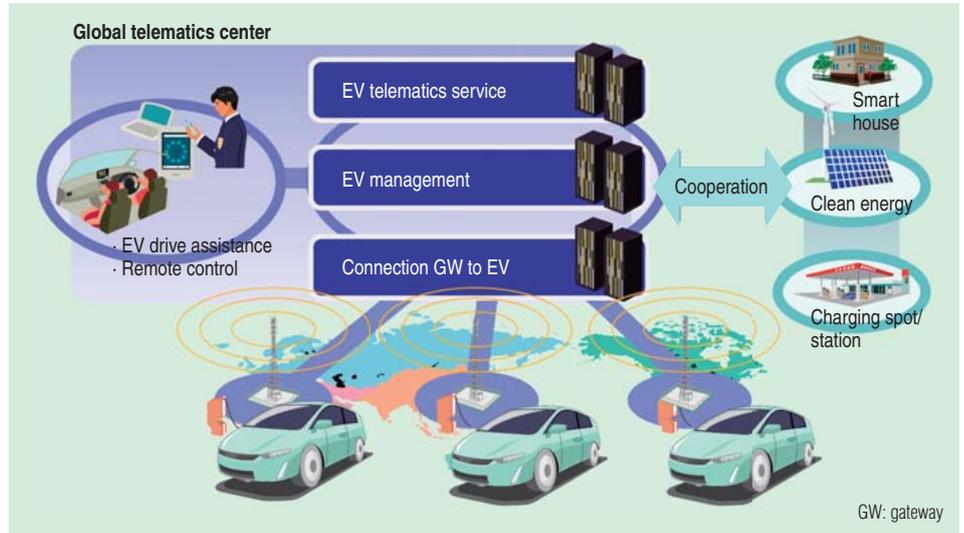
EV-ICT Solution

Hitachi Automotive Systems, Ltd. has developed the EV-ICT solution (information and communication technology solution for electric vehicles) to provide a global connected services platform for EVs (electric vehicles). The solution's first commercial implementation is in the Nissan LEAF.

The EV-ICT solution uses an Internet-based telematics communication feature that can connect to the EV at any time to support functions that reassure EV owners and drivers by making their vehicles easier to use, more comfortable, and more attractive.

[Key features]

- (1) Use of a data center to monitor and collect data on the vehicle location as well as battery charging and usage
- (2) The EV Drive Assistance service with functions that include providing directions to the nearest charging station and a pre-departure route planning function that takes account of remaining battery power and sends the route information to the car navigation system
- (3) Remote operation whereby the driver can use a smartphone and mobile phone to remotely check the battery level, initiate charging, turn the HVAC (heating, ventilating, and air condition-



EV-ICT solution

ing) control on or off, and receive warnings if the charging unit is not plugged in.

The solution is multilingual and is currently available in a number of different regions including North America, Europe, and Japan, with further regions to follow. Hitachi is working with its business partners to promote adoption of EVs throughout the world.

(Commercial availability: January 2011)

(Hitachi Automotive Systems, Ltd.)

Connected Navigation System for EVs



Navigation for EVs

Clarion Co., Ltd. has developed and released a navigation unit and TCU (telematics communication unit) based on IT (information technology) for the Nissan LEAF, an EV (electric vehicle) produced by Nissan Motor Co., Ltd. By utilizing a special-purpose TCU, the newly developed system allows the user to perform operations such as checking the battery level and initiating or scheduling recharging remotely from a smartphone or other mobile phone via the TCU, even when the power in the car is

turned off. The function uses the DoCoMo* network to exchange the required data automatically between a communications center known as a global telematics center implemented by Hitachi Automotive Systems, Ltd. and the connected navigation units fitted with a TCU (which incorporate a DoCoMo FOMA module).

The connected navigation unit also improves convenience for users by periodically uploading vehicle probe information via the TCU to assist with management of battery charging and discharging as well as various other user services.

Also worthy of note is that ICT (information and communication technology) for Nissan LEAF won the Global Mobile Award 2011 prize for the "Best Mobile Innovation for Automotive and Transport" for this system at the Global System for Mobile Communications Association (GSMA) Mobile World Congress. (Clarion Co., Ltd.)

* See "Trademarks" on page 83.

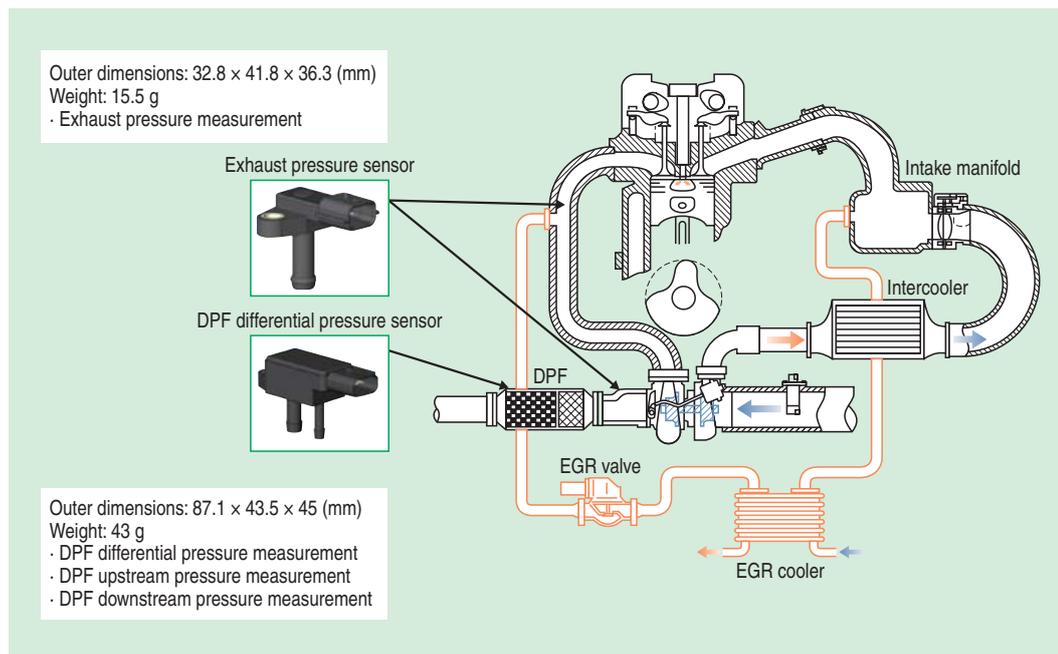
Exhaust System Pressure Sensors

Diesel engines emit less CO₂ (carbon dioxide) than gasoline engines and have a better fuel economy, and so are used widely to power machines such as passenger vehicles and construction machinery. In recent years, to reduce environmental load, strict exhaust gas regulations have been introduced for diesel engines in both passenger vehicles and construction machinery. To comply with these regulations, the demand for exhaust system sensors has risen dramatically. In response, Hitachi is developing an

exhaust pressure sensor for measuring the exhaust pressure, and a DPF (diesel particulate filter) differential pressure sensor for detecting clogging in the DPF.

The exhaust pressure sensor has a larger pressure measurement area than conventional intake system pressure sensors, and by increasing the size of the pressure induction holes, the design reduces the effects of foreign matter and pollutants. The DPF pressure differential sensor uses a two-gage system, enabling the detection not only of the pressure differential, but also the pressure upstream and downstream from the DPF. Further, the sensor chip that detects the pressure has a corrosion resistant design.

In the future, Hitachi plans to further expand the application of these sensors, including using them in EGR (exhaust gas recirculation) systems. (Hitachi Automotive Systems, Ltd.)



Exhaust system pressure sensors

Auxiliary Electric Oil Pump for Transmissions

In recent years, in response to greater environmental awareness, the development and sales of hybrid vehicles and idle-stop vehicles have increased. Hitachi has developed an auxiliary electric oil pump for these vehicles to maintain the operating hydraulic pressure for the transmission while the engine is stopped.

Oil pumps generate an operating noise due to factors such as rotor contact and the pulsation of the discharge pressure. In response to demand for more silent electric oil pump operation while the engine is stopped, Hitachi developed its own silent pump structure that minimizes the contact noise and discharge pressure pulsation. This reduces the operating noise of the electric pump.

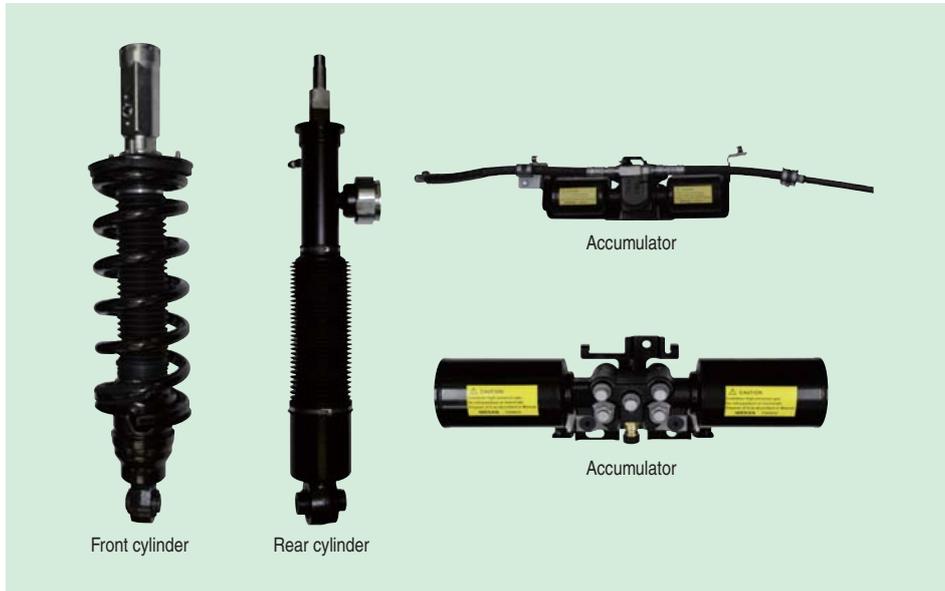
Also, by performing more advanced control of the inverter that controls the motor, and designing a system that discontinues the use of the electric current sensor in the motor, Hitachi succeeded in developing an electric pump that is more compact and lightweight (the motor and inverter are made by Hitachi Car Engineering Co., Ltd.).

(Hitachi Automotive Systems, Ltd.)



Auxiliary electric oil pump for transmissions

Hydraulic Devices for Nissan's HBMC



Hydraulic devices for Nissan's HBMC

To respond to the need for advanced roll rigidity and good performance on poor roads in large SUVs (sport-utility vehicles), Nissan Motor Co., Ltd. adopted HBMC* (Hydraulic Body Motion

(Hitachi Automotive Systems, Ltd.)

* See "Trademarks" on page 83.

Control) in its volume production of the Patrol in April 2010. This is the world's first hydraulic closed circuit system linked to four-wheel drive shock absorbers.

The HBMC system uses hydraulic cylinders and accumulators made by Hitachi. The cylinder is a newly developed coil spring coaxial type of inverted cylinder, with high rigidity, high rust resistance, and low friction. Metal bellows accumulators that are optimally designed for closed circuit systems are used in the roll restrictor valve and temperature compensation valve. This achieves a world-class vehicle performance.

In the future, Hitachi plans to expand these hydraulic devices to other vehicles by achieving more weight reductions and reducing costs.

Booster for Improving Dynamic Responsiveness

Hitachi has developed a vacuum booster with excellent dynamic responsiveness to provide effective braking when a passenger vehicle brakes suddenly (such as when a person or object moves unexpectedly in front of the vehicle).

Normally, boosters change the output relative to the input in accordance with the operation speed, and the faster the operation speed, the more the output drops. Drivers often feel that brake effectiveness decreases during sudden braking, and this performance is called dynamic responsiveness. The dynamic responsiveness can be controlled by the airflow that passes through the opening and closing valve inside the booster.

In the product developed by Hitachi, the valve shape was optimized with CAE (computer-aided engineering) fluid analysis, both increasing the airflow and improving the sealing performance. The dynamic responsiveness was improved in all brake pedal depression speed ranges from slow to sudden, with a particularly high improvement of about 25% during sudden braking.

In the future, Hitachi will apply this technology to boosters of different sizes.

(Hitachi Automotive Systems, Ltd.)



Booster for improving dynamic responsiveness

21.3-inch High-definition (5 Mpixel) Monochrome LCD Module for Medical Uses

With the increased use of IT (information technology) in medical fields, demand has grown for better quality and higher precision medical monitors. Medical monitors are classified according to the amount of information in the diagnosis image, with mammography monitors in particular needing high definition with a resolution of 2,560 × 2,048 (5 Mpixel).

Hitachi has developed a 21.3-inch LCD (liquid crystal display) module with 5 Mpixel by applying its unique monochrome LCD processing technology. This delivers high brightness, high contrast, and wide viewing angles, contributing to better precision in mammography diagnoses.

[Key features]

(1) Maximum brightness of 1,000 cd/m² and contrast of 1,100:1 has been achieved with high-transmission IPS (in-plane-switching mode) technology, reproducing precise medical images.

(2) On monochrome monitors, the black display is also an important part of the image. Hitachi focused on improving the black image quality, and applied the first LCD processing technology in the industry that has minimal color or brightness changes when the screen is viewed from an angle.

(3) Each pixel can depict up to 11.5-bit gradations, enabling a smoother image to be reproduced.

In the future, Hitachi will continue to upgrade its high-quality, high-precision medical monitors, to provide a better diagnosis



21.3-inch high-definition (5 Mpixel) monochrome LCD module for medical uses (example: mammography display)

environment and contribute to the further expansion of IT in medical fields.

(Hitachi Displays, Ltd.)

Vision and Business Strategy for an Expanded HDD Market



The LifeStudio Series, a new concept for external HDDs

Accompanying the spread of computers and information appliances, storage needs have grown for digital content such as pictures, videos, and music. External HDDs (hard disk drives) are easy to connect for extra storage. External HDDs account for about 10% of the global shipment volume of HDDs, and high,

double-digit growth is forecast to continue in this field.

In 2009, Hitachi acquired the US company Fabrik, Inc. that was active in the external HDD business, and made a full-scale entry into this market. Starting in the USA, Hitachi is steadily expanding this business to Europe and the Asia-Pacific region.

User surveys show that searching for data from a large volume of digital content takes a lot of effort for users, and maintaining and managing data in a way that is easy to use is very difficult. In response to these issues, Hitachi released the LifeStudio Series in 2010. This is a new concept for external HDDs, which in addition to having functions for simplifying and reducing the work involved in data search, enables the sharing of data across social network services, and provides two data backup functions, local and online.

Based on this convenient and user-friendly product, and functions that bring peace of mind, Hitachi plans on further enhancing its external HDDs with faster interfaces and greater storage capacities.

(Hitachi Global Storage Technologies)

Wide Range of Server HDD Products for Supporting the Cloud Computing

Cloud computing is growing steadily for both business and consumer applications, as a means of optimizing overall IT (information technology) investment and improving competitiveness. In the cloud computing, storage resources are utilized via a network. The volume of digital information handled on the cloud has risen dramatically in recent years, and there are diverse needs,

from applications that require high-speed responses, to large capacity storage.

Hitachi has developed an SSD (solid state drive), which has a higher I/O (input/output) performance than HDDs (hard disk drives), for applications that require the most advanced processing, such as financial transactions and e-commerce. SLC (single level cell) NAND flash memory has been adopted to achieve high reliability and durability, and power consumption is reduced by 50% compared with 3.5-inch HDDs. For data analysis processes that require a good balance between high-speed processing and data volume, Hitachi provides HDDs for servers that operate at

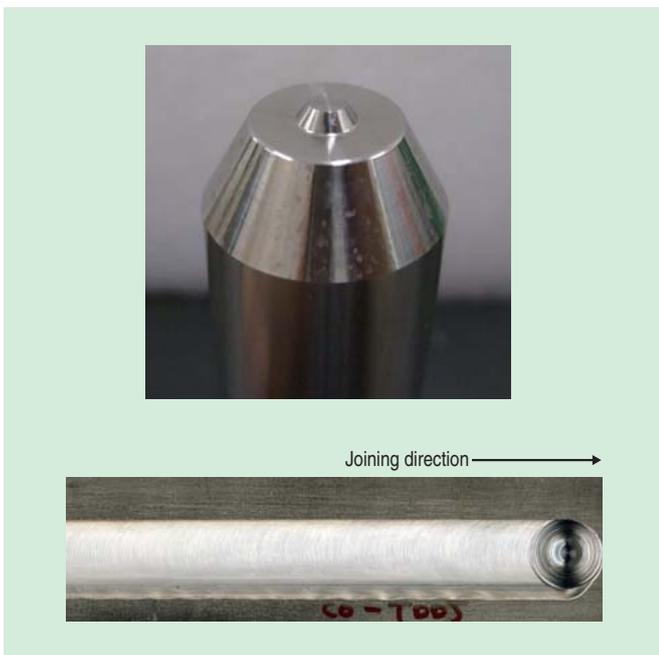


Wide range of HDD and SSD products for business applications

10,000 rpm or 15,000 rpm, have up to 600 Gbyte in storage, and a SAS [serial attached SCSI (small computer system interface)] or FC (fibre channel) interface.

Also, for applications that prioritize storage volume over processing speed, such as e-mail, data archives and nearline storage, Hitachi offers a 3.5-inch HDD in the Tbyte class that has a SATA (serial advanced technology attachment) interface and operates at 7,200 rpm. Hitachi will continue to support the cloud computing by providing storage resources that satisfy a wide variety of needs. (Hitachi Global Storage Technologies)

FSW Tool for Materials with High Melting Points



Tip of the FSW tool for materials with high melting points (top), and the surface of a titanium alloy joined with the developed tool (bottom)

Hitachi has developed an FSW (friction stir welding) tool that enables the joining of materials with high melting points, such as iron, titanium alloys, and zirconium alloys, which are difficult to join using conventional metal tools.

FSW is a joining method where a rotating tool is inserted into the material to be joined and moved along the joining area. Joining is performed by softening the joining material with the friction heat that is generated between the material to be joined and the rotating tool, while at the same time blending the material with the tool rotation. Because the tool temperature also rises to a high level, tool durability is an issue when using FSW for materials with high melting points. Conventionally, expensive ceramic tools have been used.

Hitachi has developed a tool made from a cobalt-based alloy with dispersed intermetallic compounds [Co₃(Al, W)] that maintain their strength even at high temperatures. This achieves durability and wear resistance that are better than conventional ceramic tools.

This success was the result of joint research with Tohoku University.

Environmentally-compatible Low-melting Vanadate Glasses

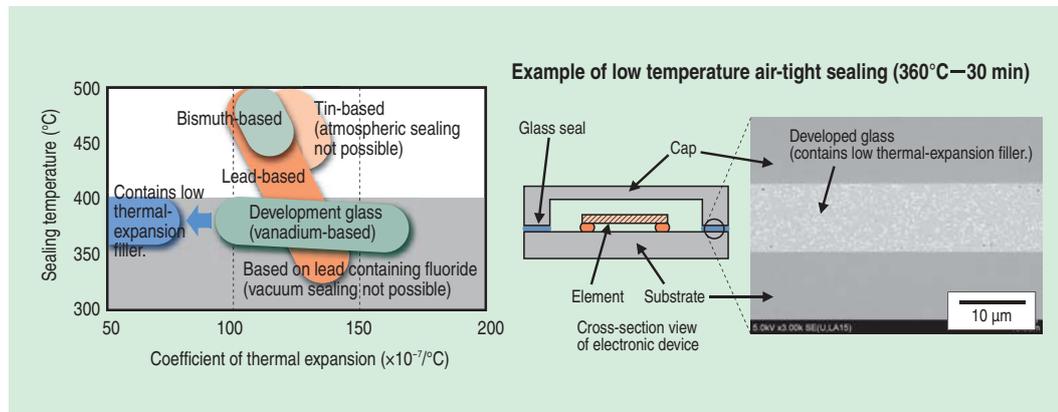
Electronic devices such as an integrated circuit ceramic package, a crystal oscillator, MEMSs (micro electro mechanical systems), and a semiconductor sensor are sealed to be air-tight at a low temperature of 400°C or less using low melting glass that contains a lot of harmful lead, or expensive Au-Sn (gold-tin) solder. There is demand for a new sealing material for these electronic devices that improves the environmental and cost performance, while also maintaining high reliability.

To achieve this, Hitachi, Ltd. and Hitachi Chemical Co., Ltd. jointly developed environmentally-compatible low-melting vana-

date glasses that are unique to Hitachi and contain no regulated substances such as lead. It performs air-tight sealing at a low temperature between 350 and 400°C.

The developed glass is formed with a three-dimensional mesh structure within its layers by using valence control of the vanadium. By inserting elements with large ion radiuses and elements with low melting points into this mesh structure, the sealing temperature is reduced, and reliability such as humidity resistance is improved. The coefficient of thermal expansion can be adjusted across a wide range, making it suitable for glass, ceramics, metal, and a semiconductor.

Low temperature sealing is also possible in atmospheres such as air, inert gases and vacuums. In addition, because electron conductivity can be added, Hitachi expects to expand this technology to materials such as anti-static films. Hitachi Chemical Co., Ltd. provides samples of the developed glass in powder or paste form.



Relationship between the coefficient of thermal expansion and sealing temperature of low melting point glass (left), example of applying the developed glass (right)

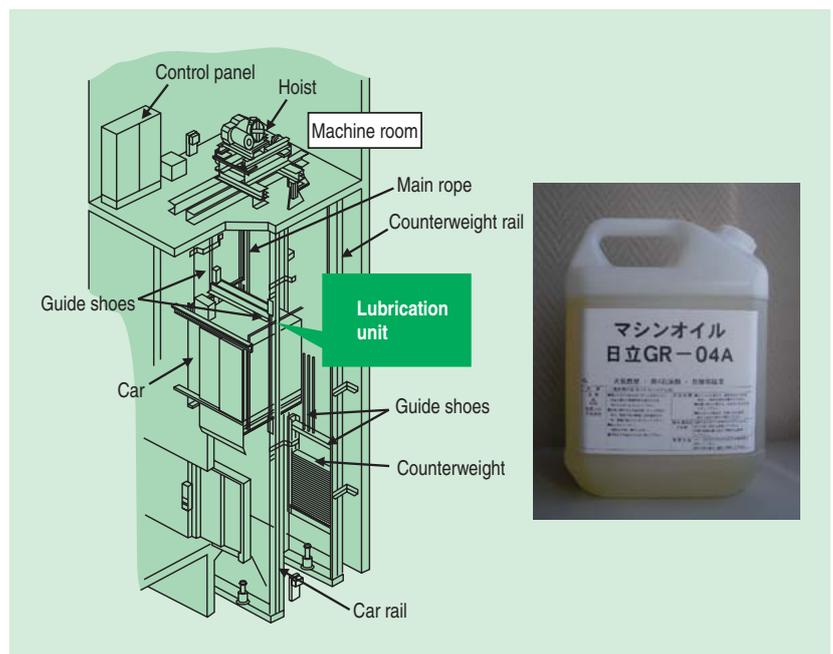
Lubrication Technology for Elevators

Elevators are characterized by numerous sliding parts and variations in the properties of the lubricating oil film between the elevator car or counterweight rails and guide shoes can result in problems with ride quality such as abnormal noises or vibrations that occur when the elevator is in motion.

Working with suppliers, Hitachi has developed GR-04A, a lubricating oil intended specifically for elevators which features a lower coefficient of friction and easier application to the elevator car and counterweight rails. The new oil is already being used on elevators in Japan.

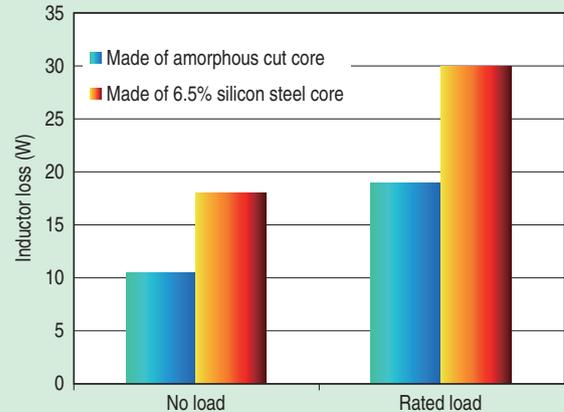
The lubricating oil not only improves elevator ride quality, it also provides a significant reduction in abnormal noises which are more common in winter.

Lubrication is a fundamental technology that has a direct impact on products' reliability, energy efficiency, and environmental performance. Hitachi intends to continue developing technology to help improve elevator customer satisfaction. (Hitachi Building Systems Co., Ltd.)



Simplified diagram of elevator mechanism (left) and GR-04A elevator lubricating oil (right)

Amorphous Cut Core for the Power Conditioner of Photovoltaic Generation Systems



Appearance of amorphous cut cores (left) and inductor loss comparison (right)

Due to global environmental issues, the use of renewable energy attracts a lot of attention around the world. In particular, photovoltaic generation systems have spread rapidly in recent years due to promotion by governments. The power conditioner is a power converter that converts the DC (direct current) energy generated by the solar panel into grid-connected power, and it must be highly efficient in order to use its electricity effectively. To satisfy this requirement, Hitachi Metals, Ltd. has developed an original processing technology for the cut core, which is made of an amorphous alloy called Metglas* with high saturation magnetic flux density and low hysteresis loss. Even when applied with high-frequency

power, the amorphous cut core, which is wound from a thin metallic film (25 μm), can reduce core loss to almost half compared with a 6.5% silicon steel core, due to the suppression of the eddy current loss. Hitachi will contribute to improving the power conditioner efficiency by applying the amorphous cut core to the inductor of the boost circuit and AC (alternating current) filter circuit in the converter.

(Hitachi Metals, Ltd.)

* See "Trademarks" on page 83.

World's First Lead-free Piezoelectric Film

Piezoelectric films are thin films composed of piezoelectric materials that generate a voltage when subjected to mechanical strain. Also, conversely, the application of a voltage to these materials will generate mechanical strain. One of the most commonly used materials for piezoelectric films is PZT [lead (Pb) zirconate titanate]. This material is used in camera shake sensors in digital cameras, vehicle roll-over sensors, and printer heads in piezoelectric inkjet printers.

While growing environmental awareness has forced the use of lead-free materials, creating piezoelectric films based on lead-free materials capable of achieving a piezoelectric constant adequate for practical use has posed a significant challenge. The properties of the materials actually used require significant improvement.

Hitachi Cable, Ltd.'s lead-free film used KNN (potassium sodium niobate) as its piezoelectric material. Among lead-free piezoelectric materials, KNN in bulk ceramic form is known to have a high Curie temperature and ideal piezoelectric properties. However, forming very fine KNN films with c-axis orientation adequate to produce the desirable piezoelectric properties is difficult.

To address these issues, Hitachi Cable developed technologies for forming KNN into a very fine film with high c-axis orientation by optimizing film deposition conditions. Ultimately, Hitachi Cable



Lead-free piezoelectric film

achieved a piezoelectric constant exceeding 100 pm/V , a figure comparable to existing PZT piezoelectric films, for the world's first lead-free piezoelectric film suitable for practical applications. Hitachi Cable plans to pursue research and development to establish technologies for the mass-production of 4-inch films. (Hitachi Cable, Ltd.)