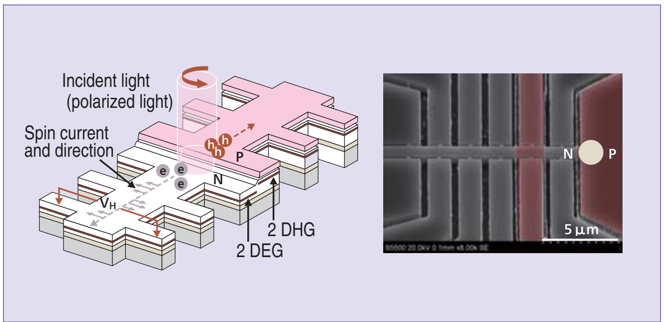
Research & Development

Research & Development

World-first Successful Electrical Control and Observation of Spin Current of Electrons Injected into Semiconductor Material

Spintronics is a new technological field that attempts to utilize both the charge and spin properties of electrons, and is expected to greatly reduce power consumption in electronic devices while at the same time leading to groundbreaking functionality. As research and development have been accelerating, international research teams, starting with Hitachi Cambridge Laboratory, have successfully used semiconductor materials based on gallium arsenide to control and observe the spin current of electrons, just as is possible with current. Researchers working on the front lines provide an overview of this work, in addition to the possibilities it opens up for the future.



Principle of generating spin current in electrons

Spintronics Opens up New Possibilities in Next-generation Electronic Devices

The current generation of semiconductor devices is approaching the limit of what is possible when it comes to scalable miniaturization and integration that can simultaneously achieve both high-speed operations and low-power consumption. Electronic devices must be developed before this limit is reached that are based on new principles or materials that can speed up information processing while reducing power consumption even below that of general-purpose silicon devices. Spintronics is a leading candidate technology for achieving this goal. Unlike electronics, which is based on the use of flowing electronic charges (the electrical property), or "current," the technological field of spintronics uses another property electrons possess in addition to charge, which is referred to as flowing "spin" (the magnetic property). Electron spin can be in one of two states, either up or down, and although these states usually coexist, by introducing spin with a controlled direction, it is possible to cause the spin property to flow from electron to electron, just like what occurs with ordinary current. By running electronic devices based on this spin current instead of ordinary current, it is expected that this will lead to a revolution in devices that will, first and foremostly, greatly reduce power consumption.

World-first Demonstration of Electrical Control of Pure Spin Current

In order to achieve this type of spintronics, Hitachi Cambridge Laboratory worked with an international research team* to develop a component in December 2010 that can use voltage to control the up and down directions of a spin current injected into a gallium arsenide semiconductor, and successfully observed on and off operations. This was the first demonstration in the world of the electrical control of pure spin current (spin current without flowing charge).

This newly developed component combines two spin transistors, and uses an optical technique based on a circularly polarized laser beam as the spin injection method. Conduction electrons with spin are excited by the light. Since the generated electrons are cancelled out by the surrounding electrons as a diffusion current, the current flowing in a specific direction is zero, but the spin rides the diffusive electrons, thereby creating a spin flow. This spin current was directly detected using the Spin Hall Effect.

Towards Achieving an All-electric Control Spin Transistor

As the next step after this accomplishment, testing of technology for opening up the path to achieving an all-electric control spin transistor is currently underway. In addition, as a secondary effect of using optical techniques to generate spin current, it was possible to achieve flat photovoltaic cells with spin receptivity. By combining this with the Spin Hall Effect, it is possible to directly convert circularly polarized optical signals to electrical signals, thereby expanding possibilities for applications in medical and biotech fields, as well as advancements in optical information conversion technology.

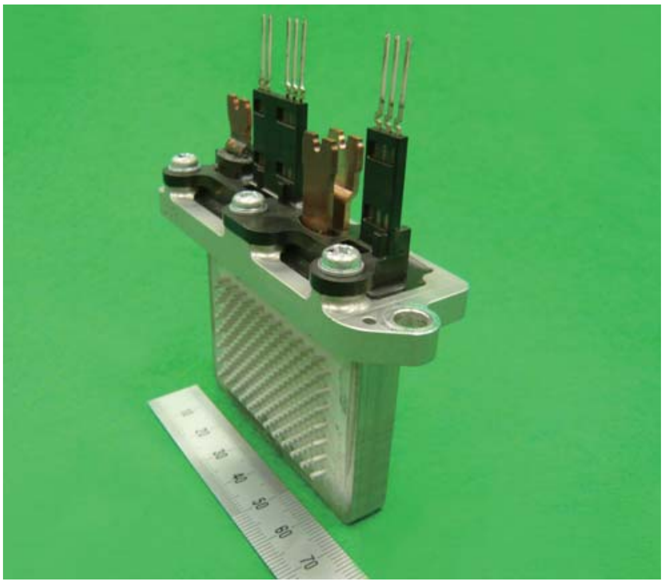
Furthermore, Hitachi is focusing its efforts on new technological concepts based on spintronics aimed at the construction of basic technologies for use in innovative new types of computers, including the utilization of spin orbit interactions, monoelectronic devices, spin torque control, magnetic domain control using electric fields, and new ferromagnetic and antiferromagnetic semiconductor research, and will continue working to achieve new accomplishments in these areas as well.

* Hitachi Cambridge Laboratory, Hitachi Europe Ltd., Academy of Sciences of the Czech Republic, Charles University (Czech Republic), University of Cambridge (the UK), The University of Nottingham (the UK), Texas A&M University (USA)


Byong-Guk Park (left), Researcher; Joerg Wunderlich (right), Senior Researcher, Hitachi Cambridge Laboratory, Hitachi Europe Ltd.

Development of Technologies to Cut in Half Floor Space Required for Power Modules on Inverters for Electric and Hybrid Automobiles

As the development of environmentally responsible automotive technologies continues against a background of global warming, there has been a demand for high reliability as well as further miniaturization and higher efficiency in the inverter, which is one of the core parts of electric and hybrid automobiles. Hitachi has developed technology for efficiently cooling power semiconductors, and has successfully miniaturized the power modules that comprise inverters. The developers were asked about the features and possibilities of the technology used to achieve miniaturization of in-vehicle inverters.



Double-sided Cooling Power Module with Whole-surface Liquid Immersion System

Inverter Miniaturization through Power Module Radiation Performance

Technology for miniaturizing and increasing the efficiency of inverters, motors, and batteries, which are the key components of electric and hybrid automobiles, has been growing even more important. Hitachi has developed technology for achieving the miniaturization of inverters. The key to this miniaturization is the radiation performance of the power module, which is a major component of inverters. Power modules contain a collection of multiple integrated power semiconductors, and by making it easier for the heat they generate to escape to the outside (by reducing thermal resistance), it becomes possible to increase reliability, thereby enabling miniaturization of the power module, which in turn enables miniaturization of the inverter as a whole.

Further Evolution of Direct Water Cooling Technology

Since most automotive inverters are water-cooled, the power module radiates heat into the water. Hitachi has developed direct water cooling technology with radiation performance that is superior to that of conventional products, and has been mass-producing directly water-cooled single-side-cooled power modules for several years. The goal of this effort has been the achievement of double-sided cooling with a further improved, whole-surface liquid immersion system.

In order to cool from both sides, it is necessary to achieve a structure that protects the internal power semiconductors from water while also efficiently venting heat. In order to meet these needs, Hitachi developed a structure that increases cooling performance by forming ventilation channels through the insulating layer without the use of grease that forms ventilation channels on both sides of the power semiconductor. When compared to previous directly water-cooled power modules, this structure makes it possible to improve radiation performance by 35% while reducing the required floor space by 50%. Thanks to this cooling performance, a high-performance, highly reliable cooling system can be constructed with miniaturized inverters.

Possibility of Developing a Wide Range of Applications in Support of a Low-carbon Society

The development process took a long time, and involved considering cooler structures that could combine cooling performance with reliability, as well as the selection and evaluation of insulating materials that could provide long-term reliability under harsh usage environments.

There is no doubt that Hitachi was able to conquer these problems thanks to its multidiscipline capabilities, which it applied by implementing development projects across the organization based on a "special research" system. These efforts included the use of semiconductor implementation technologies cultivated during the development of large-scale computers, taking advantage of a wide range of analytical technologies such as thermal fluid, electrical heating, stress, and others, and collaborating with group companies in the development of the new metal and insulating materials that became necessary as a result.

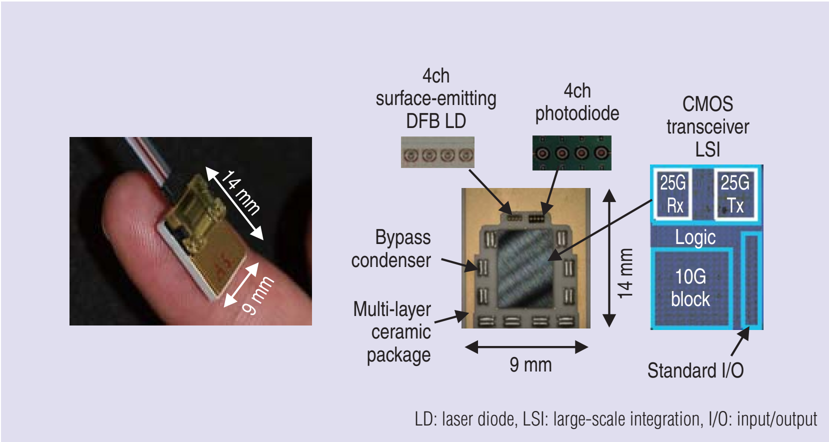
Use of this directly water-cooled power module with double-sided cooling can be expanded beyond automobiles to a wide range of fields where power conversion systems are needed, including motorized construction machinery, the power industry, and others. Related technologies also hold the potential for applications in other areas as well, such as environmental fields. Hitachi will continue working to develop these technologies in order to contribute to the achievement of a low-carbon society.

Kinya Nakatsu (left), Senior Researcher; Takeshi Tokuyama (middle), Researcher, Department of Motor Systems Research, Information and Control Systems Research Center; Toshiaki Ishii (right), Chief Researcher, Department of Organic Materials Research, Materials Research Center, Hitachi Research Laboratory, Research & Development Group, Hitachi, Ltd.

100-Gbit/s Micro-optical Transceiver for Backplane of Next-generation Network Equipment

Optical backplane technology has been developed for application to the next generation of network system equipment, including 10 Tbit/s large-scale edge routers. The main feature is a tiny optical transceiver that converts 10×10 Gbit/s electrical signals to 4×25 Gbit/s optical signals and vice versa with efficient power consumption, consisting of a four-channel 25 Gbit/s surface-emitting distributed feedback (DFB)-laser-diode and photo-diode arrays integrated with a complementary metal-oxide semiconductor (CMOS) transceiver chip on a multilayer ceramic substrate. The power consumption is as low as 2 W when used for full-channel operation.

In addition, the transceiver's footprint size has been reduced to 9×14 mm^2, which is 1/100th the size of the current device. Ample eye opening at a data rate of 25 Gbit/s was confirmed for optical output signals. The optical link was tested by transmitting a digital video signal using the new transceivers. This confirmed continuous error-free operation. In addition to data centers and super computers, the technologies developed could also be applied to medical systems, computer-aided design, film production, and other areas.



Micro-optical transceiver and internal view

This work was performed in part under the management of the Photonics Electronics Technology Research Association (PETRA), with the support of the "Next-generation High-efficiency Network Device Project" of the New Energy and Industrial Technology Development Organization (NEDO).

Location and Guidance Functions for Human Symbiotic Robot

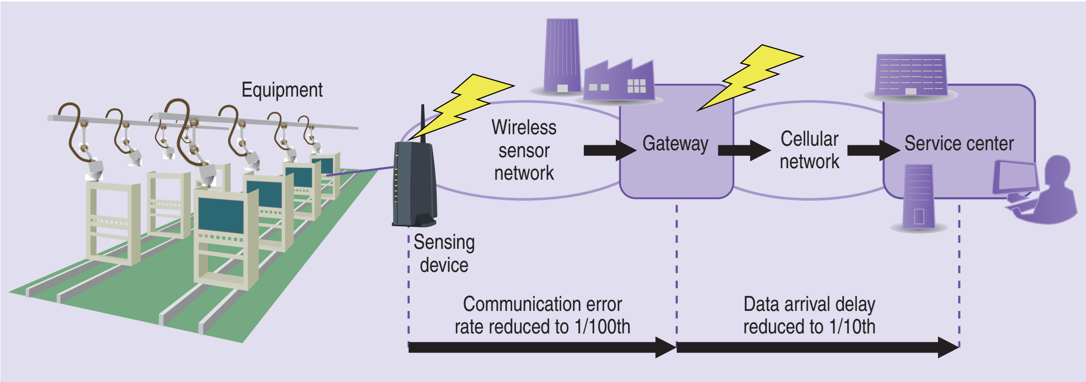

The robot newly equipped with location and guidance functions

This human symbiotic robot, developed by Hitachi in 2007 as a successor to an earlier model that performed on stage at The 2005 World Exposition, Aichi, Japan, is a compact and light-weight robot capable of autonomous movement at a speed of 6 km/h using a two-wheeled mechanism (about the same pace as a human walking briskly). This robot was designed with a view to providing guidance services in offices and public facilities. In 2010, Hitachi announced robust speech recognition technology with 14 microphones on its head, in addition to smooth movement technology to overcome cables and uneven floor heights.

New "location and guidance" functions have also been developed in order to provide even more intelligent services. With these functions, when it is asked to locate an object, it automatically "recognizes" the object using a database created from information on the web, and identifies the location of the object using images captured by the multiple network cameras installed in the facility. Voice recognition for the name of the object is achieved with high accuracy by generating a dictionary from the results of object identification. Hitachi has also developed a "model-predictive posture-control technology" that achieves quick and smooth guidance to locations without the need to reduce speed at corners or in narrow aisles.

* This robot is based on new technologies developed as part of a project commissioned by the New Energy and Industrial Technology Development Organization (NEDO) in 2005.

Highly Reliable Wireless Communication Technology for Remote Monitoring



Remote monitoring system developed using wireless sensor network and cellular network

Hitachi has developed a highly reliable wireless communication technology to enable flexible remote monitoring in factories and buildings. Use of a wireless network lowers set-up costs while making changes to the layout easier to achieve.

Hitachi has developed an interference avoidance technology for wireless sensor networks that monitors the conditions of interference generation and avoids interference by using "good" frequency ranges where communication is smooth. Together with time-division multiplexing, which assigns communication time slots to each sensor terminal, this technology reduces data communication errors without increasing delays in data arrival time.

Hitachi has also developed priority control technology whereby the gateway selectively sends only important alarm signals when a decrease in cellular network communication speed is detected. By applying this technology, it becomes possible to maintain the arrival time delay of alarm signals within a certain threshold.

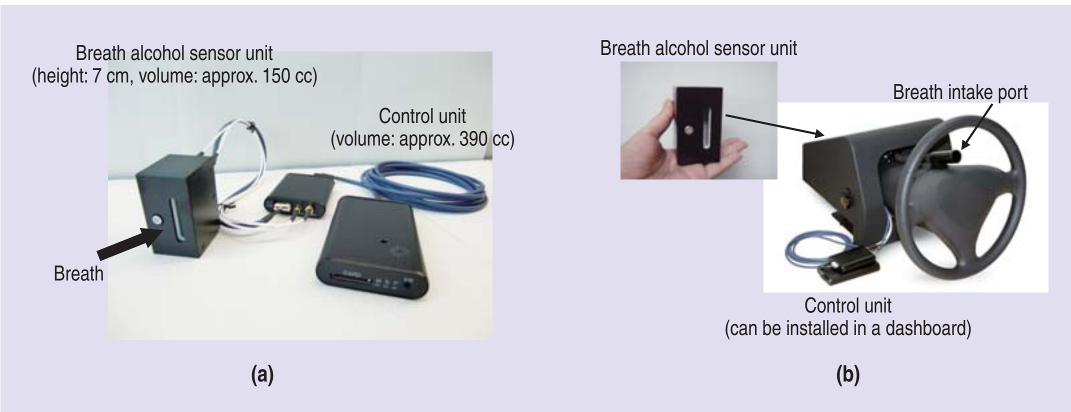
Results of evaluation testing using a prototype system show that the terminal data communication error ratio is reduced to approximately one-hundredth of the previous level, while the alarm signal arrival time delay over a cellular network is reduced to approximately one-tenth.

In the future, these newly developed technologies are expected to be applied not only to remote monitoring, but also to the control and coordination of various social infrastructures in a smart city.

Compact Prototype of Steering-wheel Mounted Breath Alcohol Detection System

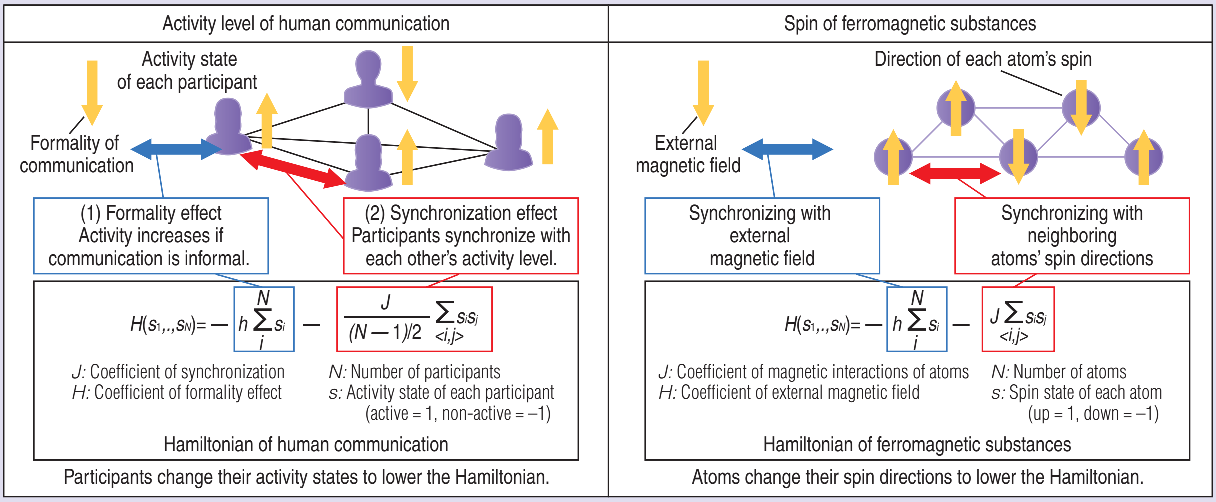
There has been a general need for alcohol detection systems that can measure the breath alcohol level of a driver in the driving position without necessitating any special operation. In order to meet this need, Hitachi has developed a prototype compact breath alcohol detection system by designing a breath alcohol detection unit at a size suited to dashboard installation, along with a breath intake port that can be set up close to the steering wheel. As a result of this design, no special operation is required to accurately measure the breath alcohol level of a driver.

This system features a breath alcohol detection system with a separate breath intake port. It was found that water clusters propagate as a wave through the tube, even though the humidity of exhaled breath disperses during travel from the intake port to the end of the tube. A prototype breath alcohol detection system with a separate breath intake port was developed based on the finding that water clusters propagate to an alcohol sensor through several tens of centimeters of tubing without diffusion. This configuration allows the breath intake port to be set up close to the steering wheel and the breath alcohol sensor unit to be installed in the dashboard. In addition, using microprocessors, the total size of the breath alcohol detector and its controller was reduced to the extent that installation in a car dashboard is possible.



Prototype breath alcohol detection system (a) and steering wheel installation example (b)

Mathematical Model of Conversational Activity in Workplace Using Wearable Sensor Badges

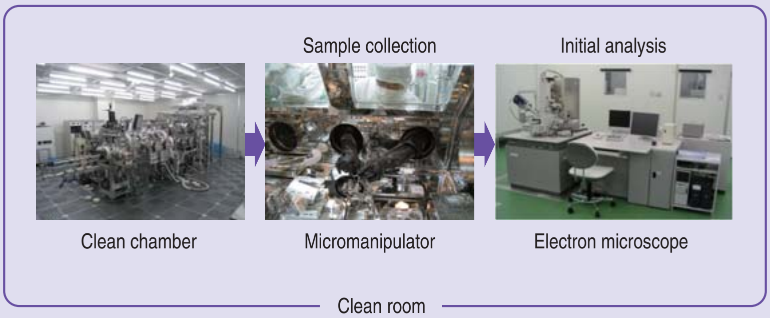


Hamiltonian model of human communication

Hitachi has developed a mathematical model of the level of activity during conversations in a workplace (hereafter referred to as the "activity level") in order to improve organizational communication and meetings. The activity levels during the conversations of 412 employees were measured over three months using wearable sensor badges that record who talks with whom and how often. This model was developed based on the similarity between the activity level of human communication (the activity level of each participant is synchronized with the majority activity level of those present) and the spin of atoms (the spins of atoms in a magnet tend to align in the same direction). Moreover, the simulation results statistically verify the proposed model by reproducing the experimental results.

The model quantifies the characteristics of workplace communication activity, which are currently acknowledged by personal experience. For example, the larger the number of listeners participating in a meeting, the less active that meeting becomes. By applying this model, it becomes possible to make suggestions on ways to improve communication in a meeting or in a workplace, such as by holding a meeting with a large number of people after the activity level has been raised by a small number of people. This model will be applied as a new approach in Hitachi's organizational reform solution service.

Hayabusa Sample Curation Facility



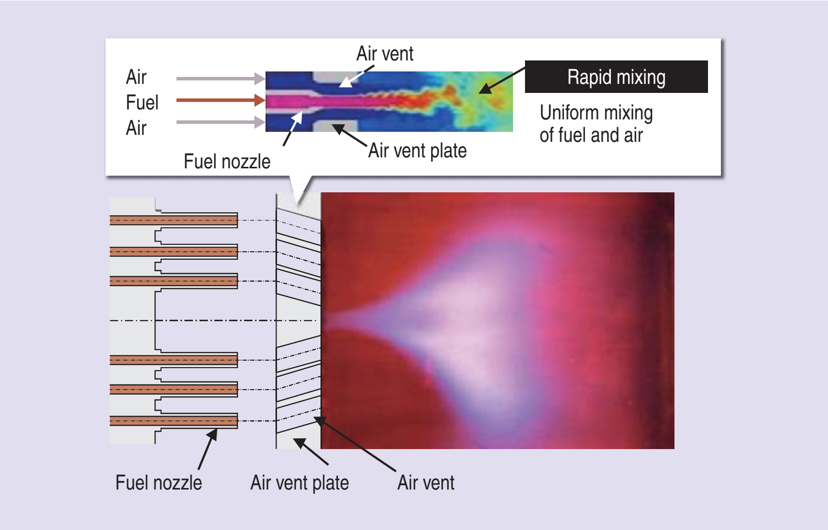
Hayabusa sample curation facility (photograph provided by JAXA)

Hitachi developed a sample curation facility for the asteroid probe vehicle Hayabusa, which was launched by the Japan Aerospace Exploration Agency (JAXA).

This facility was utilized for the collection of particles brought back by Hayabusa from the asteroid Itokawa, as well as initial analysis with an electron microscope, and also contributed to interpretation of the samples. This was possible thanks to Hitachi's achievement of a clean chamber with one of the cleanest environment in the world (nitrogen purity of 99.99999%), in addition to a micromanipulator that can handle samples on the order of micrometers.

Hitachi will be expanding this work into analytical technology fields for the development of new materials.

Gas Turbine Clean Combustion Technology for Next Generation of Coal-fired Power Plants



Example numerical analysis of rapid mixing process and floating flame for coal gasification gas

Hitachi is undertaking research into specific technologies for reducing emissions of nitrogen oxides (NO_x) and achieving stable combustion of fuels with a high concentration of hydrogen during carbon dioxide capture and storage—integrated coal gasification combined cycle (CCS-IGCC) power generation.

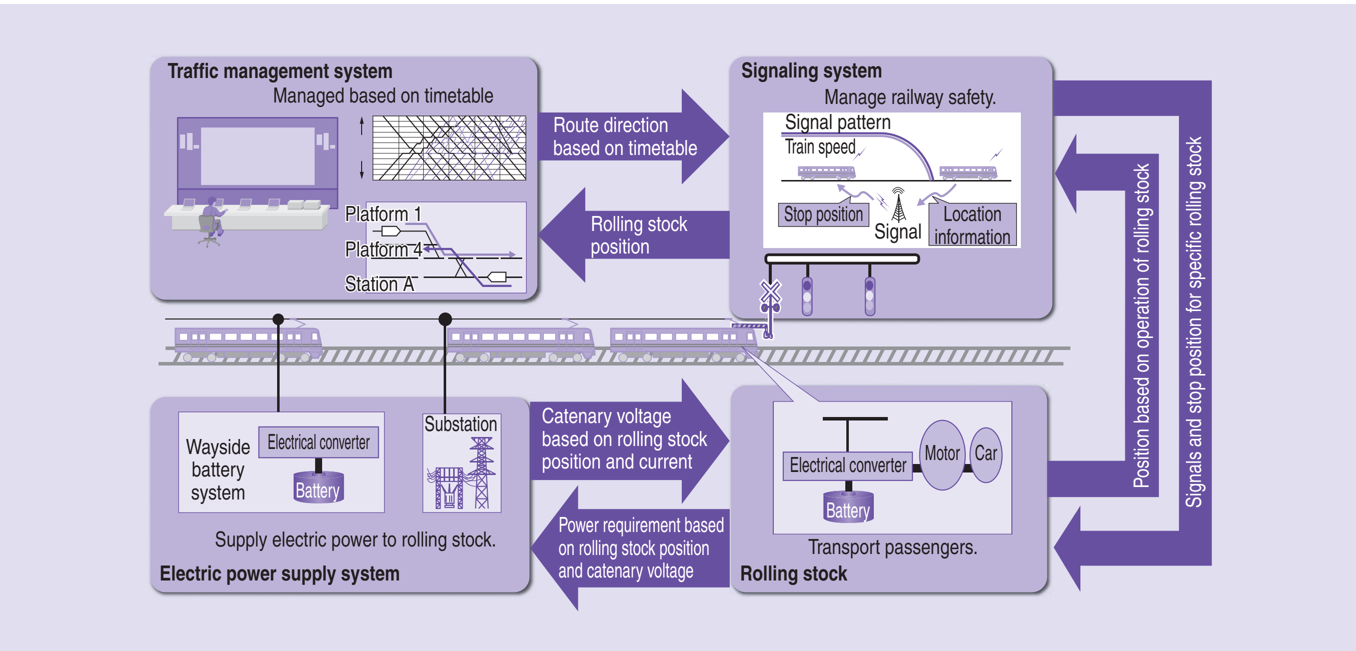
These technologies seek to achieve a floating flame to minimize the production of NO_x and achieve uniformity through the rapid mixing of fuel and air by combining a large number of coaxial-jet burners. In addition to use in CCS-IGCC, future plans include applying these technologies to hydrogen-containing fuels produced as a by-product gas.

This research is conducted as part of the Innovative Zero-emission Coal-fired Power Generation Project of the New Energy and Industrial Technology Development Organization (NEDO).

Integrated Railway Systems Simulator

Hitachi has developed an integrated simulator for railway systems that can perform comprehensive evaluations of an entire railway system, taking into account interactions and coordinated control between multiple railway sub-systems, such as rolling stock, signaling, traffic management system, and power-supply system.

This simulator quantitatively evaluates energy savings achieved through installation of electrical-storage devices in rolling stock or in the power supply system. Consequently, it is possible to propose the most appropriate railway systems that utilize electrical-storage devices. Hitachi also implements solutions that satisfy the global needs of entire railway businesses, including energy costs and the transportation capacity of the railway.



Internal structure of simulator for integrated railway systems simulator

Autonomous Driving Technology for Ride-on Mobility Robot

Parameter	Specification
No. of passengers	1 (entry through front)
Weight	200 kg
Size	L: 1,494 × W: 698 × H: 1,627 mm
Ground clearance	150 mm
Tire size	Front wheels D: 254 mm W: 85 mm Rear wheels D: 280 mm W: 75 mm
Top speed	Manual: 9.5 km/h Autonomous: 6 km/h
Brake	Main brake: regenerative braking using motor Parking brake: electromagnetic brake
Driving control device	Joy stick
Battery	Lithium-ion
Motor output	0.5 kW

3D: three dimensional, L: length, W: width, H: height, D: diameter

Ride-on mobility robot undergoing testing at Tsukuba mobility robot special district

To provide safe and comfortable mobility for the elderly and others who find it difficult to use private car and public transportation, Hitachi has developed a ride-on mobility robot with functions that include assisted driving and autonomous operation on sidewalks and zones shared with pedestrians and cyclists. The main features are listed below:

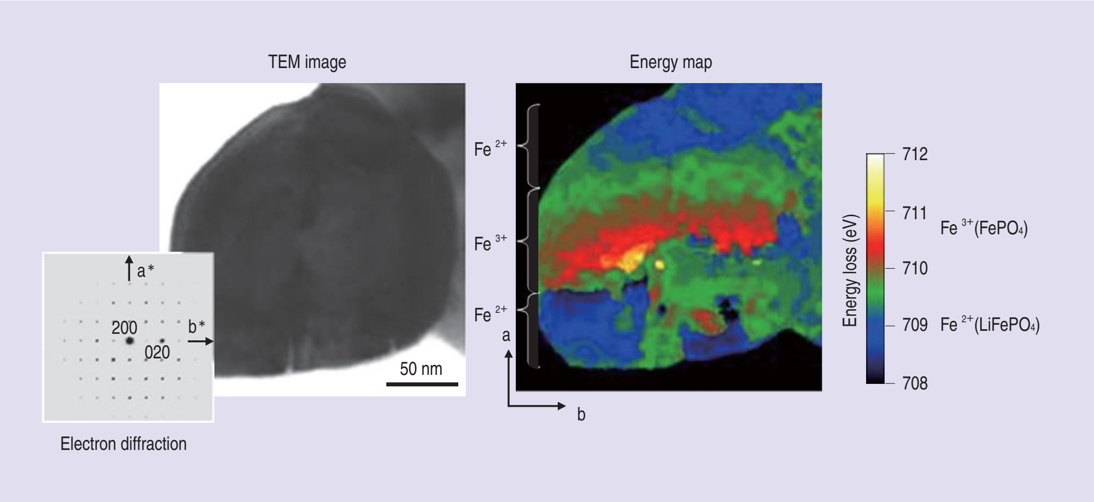
(1) Use of laser distance sensors and stereo cameras to detect obstacles to movement such as pedestrians, bicycles, or steps higher than 50 mm. The robot moves quickly and safely around these obstacles keeping a long distance from them when adequate space is available, or drives safely past at low speed in constricted locations such as between car stop stones.

(2) Even in locations such as near tall trees or buildings where global positioning system (GPS) sensor error becomes large, the robot can confirm its position and reach its destination with a high level of accuracy (0.3 m or less error) by using the three-dimensional shape of trees or buildings as landmarks and combining this information with GPS sensor data.

By using these technologies, the robot was able to record the fastest time twice (in 2009 and 2010) over the course of the Tsukuba Challenge (Real World Robot Challenge) trial for autonomous robots held at Tsukuba in Ibaraki Prefecture, Japan. Building on these results, Hitachi has also been engaged in tests in the real world over a wider area of sidewalk and pedestrian-cyclist road since June 2011 through its involvement with a mobility robot special district, also in Tsukuba.

In the future, Hitachi intends to work towards creating a new generation of safe and comfortable transportation systems by evaluating autonomous functions under a range of different environments and road surface conditions; how compatible they are with passengers, pedestrians, and cyclists; and their social practicality and utility.

Analysis Technique for Lithium Ion Transport Mechanism in Lithium-ion Battery Cathode Material



Two-dimensional energy map of lithium-ion battery cathode material

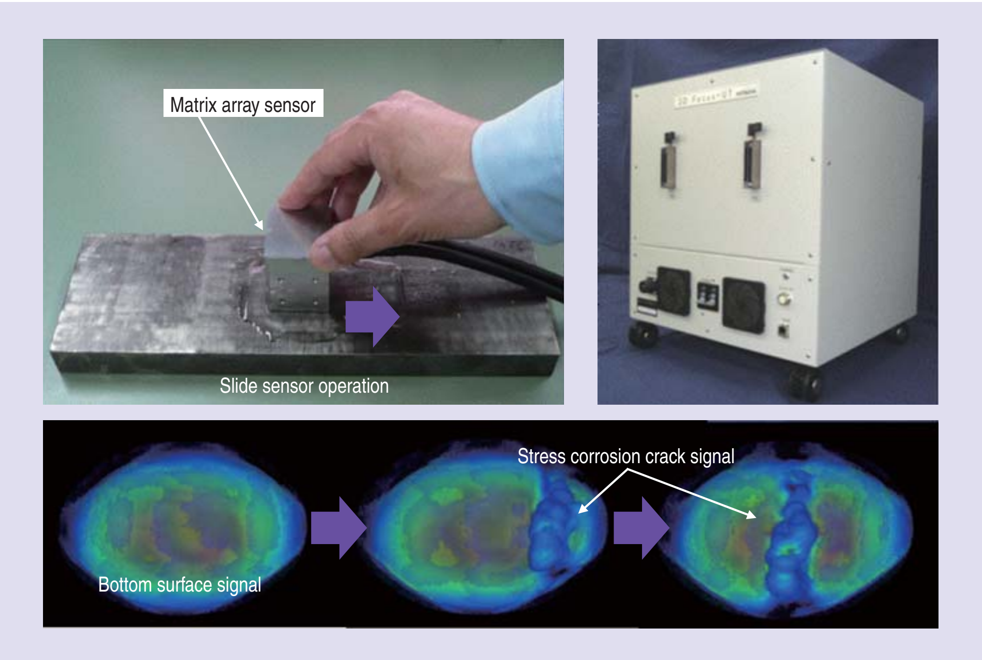
Hitachi has developed a technique for performing two-dimensional measurements of transition metal valence that provides a way to analyze the lithium ion transport mechanism of the cathode material for lithium-ion batteries on the nanometer scale.

A feature of the technique is that it can determine the valence of transition metals whose charge has been compensated by the intercalation and deintercalation of lithium ions. This is realized by using transmission electron microscopy (TEM) and electron energy-loss spectroscopy (EELS) to measure the energy loss by transition metals. Using the technique, the intercalation and deintercalation mechanism for lithium ions in lithium iron phosphate with an olivine crystal structure could be determined from the changes in the valence of iron.

In the future, Hitachi intends to contribute through further work, including using this technique to develop new cathode materials and identify degradation mechanisms.

This work was undertaken in collaboration with the University of Tokyo.

Realtime Three-dimensional Ultrasound Flaw Detection Technology



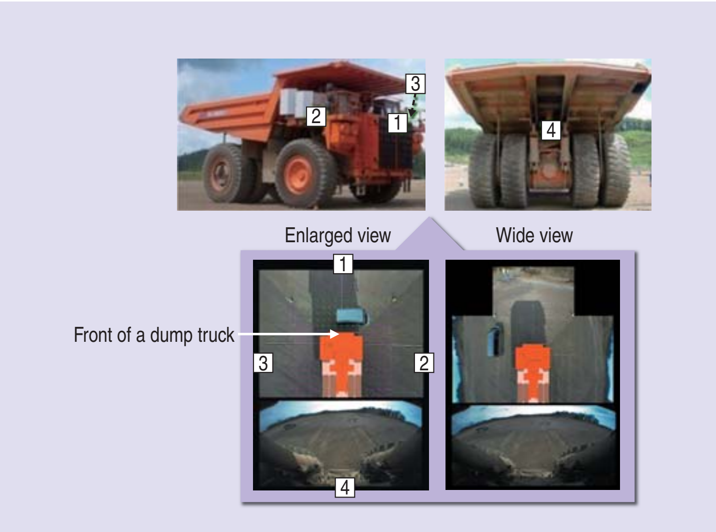
Flaw detection of a metal test piece (23-mm nickel alloy plate) in which stress corrosion cracking has been induced (top left), an ultrasound transducer unit (top right), and the changes in the three-dimensional flaw detection image as the sensor slides over the test piece (bottom)

Hitachi has developed flaw detection technology that uses ultrasound to perform realtime three-dimensional non-destructive imaging of the interior of metal and other industrial components.

The technology uses an intense and focused ultrasound beam generated by a matrix array sensor and can generate and display three-dimensional images from the collected data at the high speed of five frames per second. The resulting improvements include more accurate and efficient inspection compared to the conventional approach of inspecting a cross section image.

Hitachi intends to contribute to safer and more reliable operation of social infrastructure systems by utilizing this new technology in maintenance and inspection of power plants, rolling stock, and other applications.

Overview Monitoring System for Construction Machinery



Overview monitoring system for construction machinery

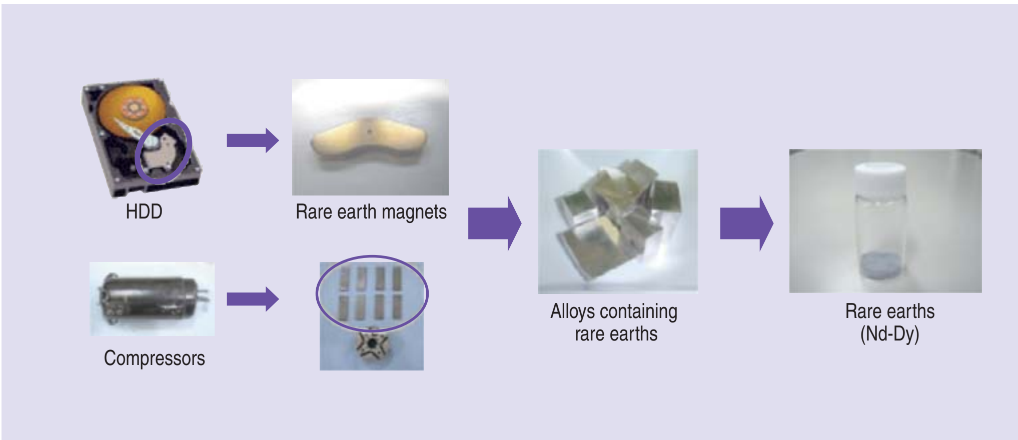
Hitachi has developed an overview monitoring system that helps the operator maintain safety around a construction machine by generating a composite image combining the views from a number of cameras mounted on the machine and displaying it on a monitor in the cab. The main features of this system, which will be marketed by Hitachi Construction Machinery Co., Ltd., are as follows:

(1) The monitor in the cab displays a bird's eye overview centered on the construction machine that has been converted and synthesized from images taken from cameras mounted around its edges.

(2) In addition to showing the immediate vicinity of the machine, the display can also be zoomed or switched to a wide view by the operator in cases when the machine needs a wider field of view.

In the future, Hitachi intends to continue working on improvements in operational safety in workplaces where construction machinery operates.

Recycling Rare Earths from Used Products



Rare earth magnets separated and recovered from HDDs and compressors and rare earths extracted from magnets

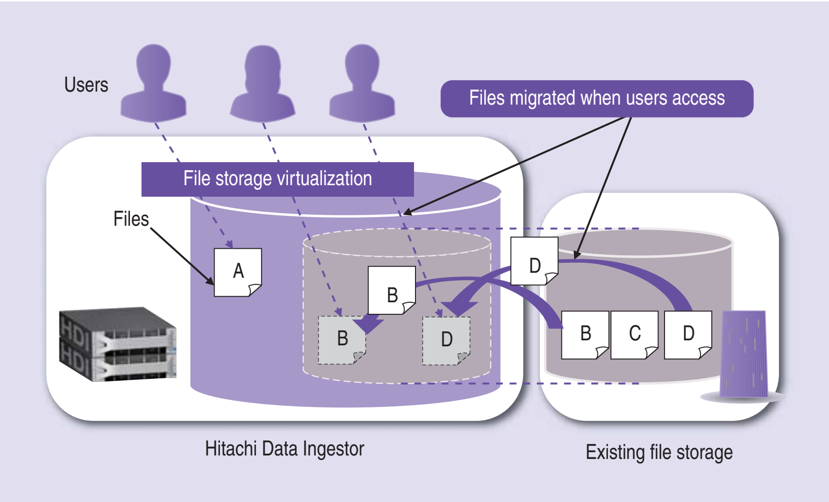
Although rare earth magnets are indispensable to the manufacture of high-efficiency motors and energy-saving products, in recent years the cost of rare earths has been skyrocketing, and the procurement of these materials has become an urgent issue.

It is against this background that Hitachi has succeeded in developing devices to separate and recover rare earth magnets from used products such as the motors of hard disk drives (HDDs) and the compressors of air conditioners, while also extracting rare earths from rare earth magnets in experiments based on a dry system technique. HDDs are disassembled into their component parts by continuously applying vibrations and impacts to the main unit in order to loosen screws. For compressors, Hitachi is developing various devices in order to break casings, pull out rotors, degauss, and remove magnets. In addition, in order to extract rare earths, Hitachi and Professor Toru Okabe of the Institute of Industrial Science, the University of Tokyo, have conducted a joint research project in which neodymium (Nd) and dysprosium (Dy) alloys were extracted from rare earth magnets in experiments using a new dry technique that does not require acids or other chemical agents.

Hitachi is planning to start full-scale recycling of rare earths by 2013.

This development project was conducted as part of the Ministry of Economy, Trade and Industry's "Development of Technology for Recycling Rare Earths from High-efficiency Magnetic Motors and Other Products" subsidiary enterprise program.

File Storage Virtualization Technology



File storage virtualization technology

As data quantities have been sharply increasing in recent years, it has become a problem that a long time is required to migrate a large number of files when a storage system is replaced.

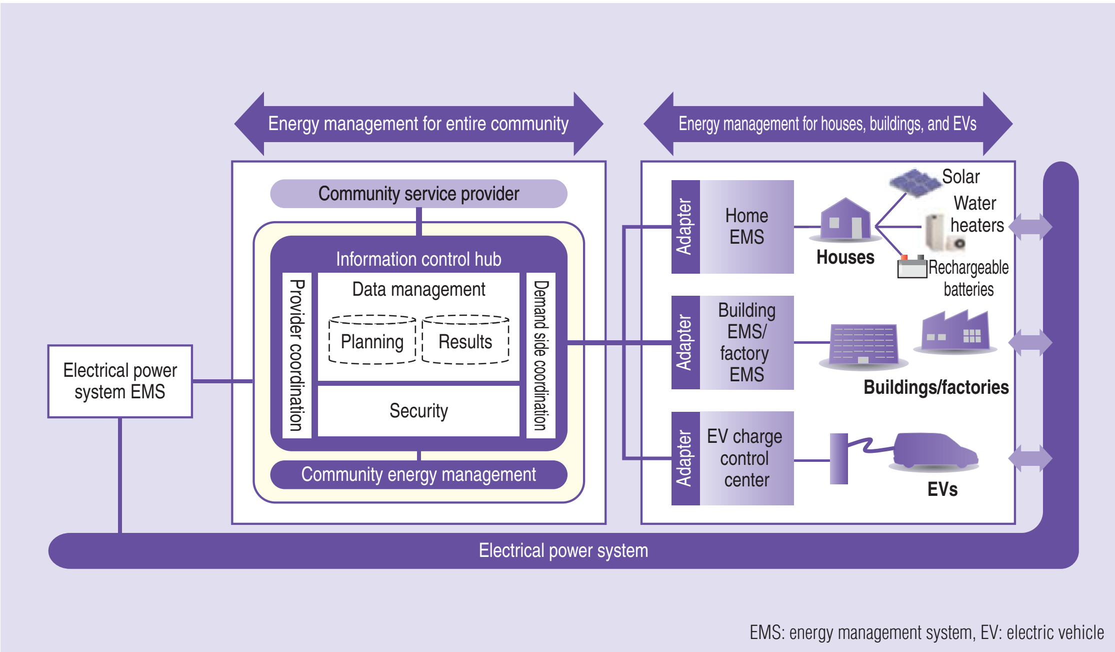
Hitachi has developed technology in which a storage system virtualizes other storage systems and migrates files in response to file access requests.

This system makes it possible to migrate files in parallel with file service under ordinary operations, thereby holding migration costs to a minimum.

In December 2011, Hitachi released Hitachi Data Ingestor, a product based on this technology.

Hitachi continues developing file storage virtualization technologies that improve the operational efficiency of administrators.

Community Energy Management System and Home Energy Management System



Community energy management system

Community energy management systems are one of the smartest ways to improve energy management efficiency in a community, and are currently undergoing demonstrations worldwide. Community energy management at the center includes planning the adjustment of supply and demand within the community, and the information and control hub collects and stores information about various devices on the demand side while distributing information regarding supply and demand adjustments to the demand side. Research and development efforts are not only focused on increasing the sophistication of the supply and demand adjustment functions, but also on developing security technology for safely managing the demand side's information, as well as scalable data management functions for controlling the information of a wide range of different devices.

Hitachi is also conducting trials and research on a home energy management system that can provide optimal control of in-home power generation, electrical storage, and heat storage based on factors such as directives from the community energy management system and the level of power supply.

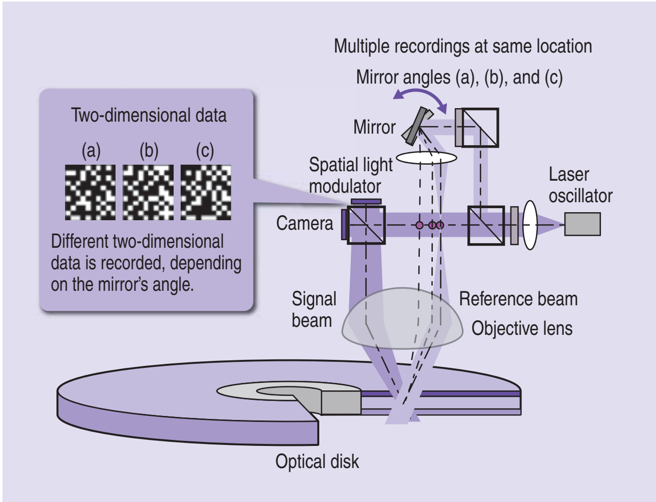
Hitachi will continue developing these technologies and contributing to the provision of energy management systems as part of a social infrastructure that connects the community to the home.

Terabyte Optical Disk Recording Technology

In response to the increasing amount of digital data that is being generated, Hitachi is developing an angular multiplexed holographic memory system as a next-generation optical disk system that can rapidly record large amounts of data. This system uses volumetric recording to record the interference fringe pattern (hologram) that occurs when a reference beam is combined with a signal beam containing two-dimensional information to a recording medium.

In order to miniaturize and increase density, Hitachi has developed a monocular optical system that takes the multiple objective lenses that are required by traditional systems and combines them into a single lens. An evaluation device using the developed optical system achieves the recording density of 1 Tbit per square inch (about 6.45 cm^2), which is necessary for a 1-Tbyte optical disk.

Hitachi will continue working to apply this technology to commercial systems based on this research.



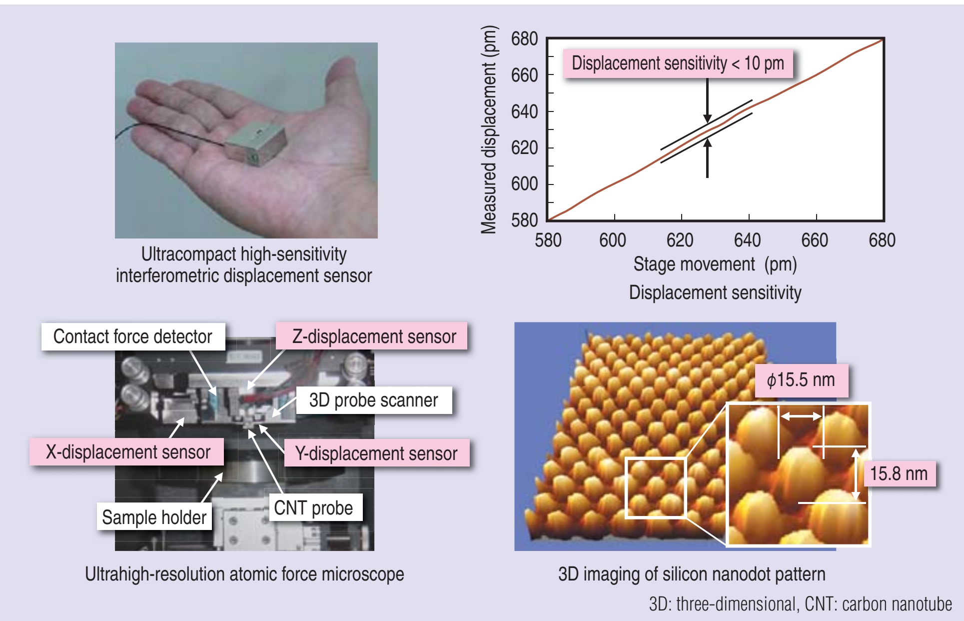
Holographic memory system

Ultrahigh-resolution Atomic Force Microscope

The need to quantitatively measure the three-dimensional nanostructures at a subnanometer-order precision is increasing in the development and manufacturing of nanometer-scale large-scale integration (LSI) devices, magnetic head devices of terabit-class hard disk drives (HDDs), and other products. One well-known method for observing nanostructures at a high resolution is an atomic force microscope (AFM) that measures the three-dimensional profile of a sample, by scanning the surface of the sample with a several-nanometer probe tip while maintaining a contact force between the sample surface and the probe tip at a set level, and detecting the probe position at each scanning position. Since the resolution of the displacement sensor used to detect probe positions is insufficient in a traditional AFM, it has been difficult to achieve subnanometer-order precision measurement.

By using photonic crystals, Hitachi has developed a one-inch (2.54-cm), 10-pm-sensitivity interferometric displacement sensor that has the smallest size and highest sensitivity of any such device in the world (based on Hitachi's research as of December 2011). By incorporating this sensor into three axes in a three-dimensional probe scanner, Hitachi has realized an AFM with a probe position resolution of 15 pm, one order of magnitude smaller than atomic scale. This ultrahigh-resolution AFM has been highly praised for its originality, practicality, and potential for the future, and was selected as one of the "2011 R&D 100 Awards" in the USA.

Hitachi plans to utilize this AFM in a wide range of fields, as basic technology that is indispensable for the research, development, and manufacturing of next-generation nanostructure devices and materials.



Ultracompact high-sensitivity interferometric displacement sensor

Displacement sensitivity

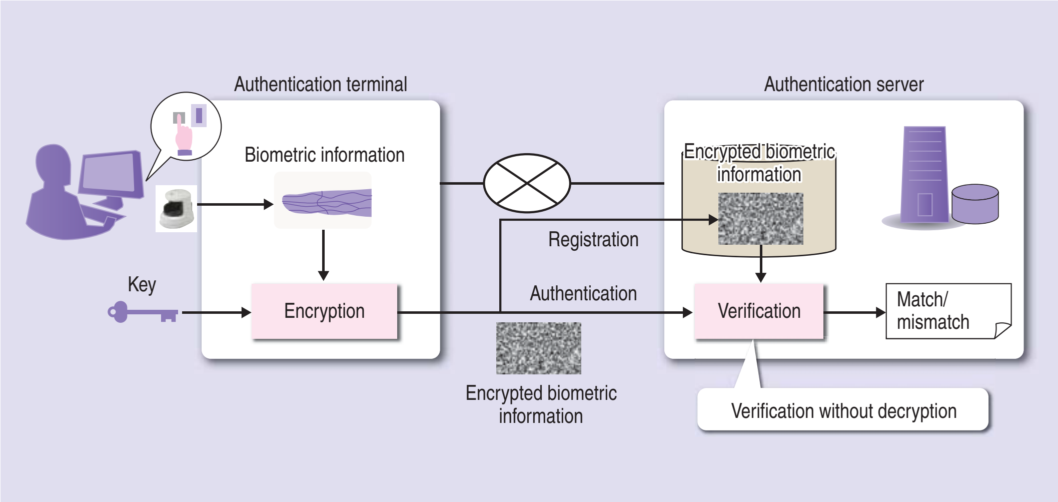
Ultrahigh-resolution atomic force microscope

3D imaging of silicon nanodot pattern

3D: three-dimensional, CNT: carbon nanotube

Ultrahigh-resolution atomic force microscope incorporating ultracompact high-sensitivity interferometric displacement sensor

Cancelable Finger Vein Authentication



Cancelable finger vein authentication

Hitachi achieved the first practical commercialization of cancelable biometric authentication technology in the world in 2010.

This technology makes it possible to send encrypted biometric information to a server where encrypted biometric information has been previously registered, and to verify this information without decryption process in the server. It is also possible to discard and update (cancelable) encrypted registration biometric information without decrypting it first. These capabilities make it possible to use this technology to securely run and administer biometric authentication via a server.

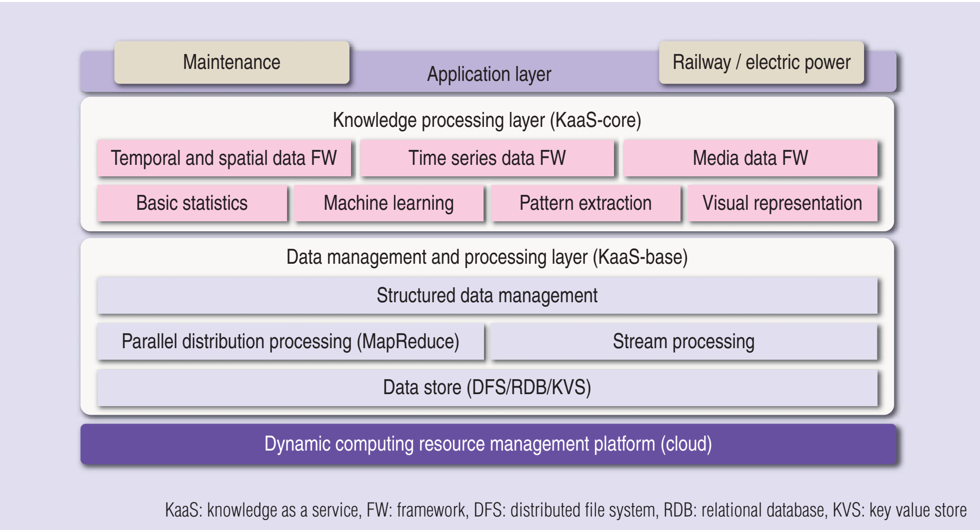
Hitachi has offered this cancelable biometric authentication technology as a "finger vein authentication service" applying finger vein authentication technology since June 2010 as part of its cloud computing solution lineup.

Distributed Processing of Big Data Technology

In recent years, there has been an increasing need for the extraction of valuable information from the large amounts of data stored during corporate activities, and for the utilization of this information in the improvement of operations, products, and services, as well as in the creation of new services.

In order to meet these needs, Hitachi has implemented advanced analytical processes including machine learning and frequent pattern extraction under the Hadoop open source parallel distributed processing platform, and is using data segmentation and reconfiguration technology suited to the data access patterns of these analytical processes in order to develop a platform technology that achieves high-speed analysis of large amounts of data.

In the future, Hitachi plans to apply this technology to a variety of fields including maintenance, railway, and telecommunications, thereby expanding analytical functions and improving platform functions.



Big Data analytical platform system