Research & Development

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3-kV-class SiC Diodes and High-speed Drive Technology for Increased Railcar Inverter Efficiency

There are high hopes that reducing the loss of power conversion devices such as inverters will have a major effect on energy conservation in industrial fields. Hitachi has developed a 3-kV-class diode that uses SiC, which has become a focus of attention as a material for next-generation power devices. Hitachi has also created a prototype of a power module that uses this diode. A simulation that includes the module's operating characteristics forecasts that the power conversion loss in the main power converters for alternating current overhead lines will be reduced by about 30%.

Katsumi Ishikawa (left), Unit Leader, Senior Researcher, PS4 Unit, Department of Power Electronics System Research, Information and Control Systems Research Laboratory, Hitachi Research Laboratory; Natsuki Yokoyama (right), Unit Leader, Senior Researcher, Nano-process Research Department, Electronics Research Laboratory, Central Research Laboratory, Hitachi, Ltd.

Expectations for SiC as a Next-generation Power Device Material

Inverters are used in a wide variety of electric devices to convert direct current into alternating current. Currently there is demand for a further improvement in the efficiency of inverters as a means of reducing CO_2 (carbon dioxide) emissions.

An inverter is comprised of power devices such as diodes and transistors. Si (silicon) has long been used as the material for power devices, but a physical limit has been reached in how far their efficiency can be improved. As a result, compounds such as GaN (gallium nitride) and SiC (silicon carbide), which we used in this development project, have received attention as next-generation materials.

Important properties of SiC include its high breakdown field strength that is nearly 10 times higher than that of Si. These properties mean that a chip can be made about 1/10 thinner than an Si device, which reduces resistance loss during conduction by an equivalent amount. As a result, devices can be made smaller, cooling systems can be simplified, and the efficiency can be improved.

Reducing Loss with High Voltage-resistant SiC Diodes and High-speed Drive Technology

In this project, we developed a diode using SiC materials for adoption in a railcar inverter. The "SiC SBD (Schottky barrier diode)" that we developed was designed with a JBS (junction barrier Schottky) structure that combines pn (positive-negative) junctions with Schottky junctions, and makes full use of the SiC properties. Although conventional SBDs that use Schottky junctions only can perform switching faster than with pn junctions, they have a problem in that when an attempt is made to reduce the loss during conduction by decreasing the resistance, a large leakage current occurs when voltage is applied in a direction opposite to the current flow direction. JBS resolves this problem and has a structure that enables both low conduction loss and restriction of the leakage current. This resulted in the achievement of a high reverse voltage resistance of up to 3.3 kV and a low conduction voltage of 2 V.

Although we are making steady progress in improving the quality of SiC single-crystal substrates, unlike Si the substrate still contains numerous defects. There are also many defects in the layer that is formed on the substrate for creating devices. As such, it is important to develop device structures and process technology for restricting the effects of defects.

Further, we have developed high-speed drive technology for exploiting the high-speed switching properties of the SiC-SBD that we developed, and so further reduce power conversion loss. We created a prototype of a power module for railcar inverters in which the conventional silicon diode is replaced with the developed SiC-SBD. By applying this high-speed drive technology, the turn-on loss and recovery loss, which are major causes of power conversion loss, were reduced to 1/6 and 1/10 respectively. This enabled the overall power conversion loss for the main power converters for overhead lines to be reduced by about 30%. And also, because this reduced the heat generated by the inverter, the cooling device could be made lighter and more compact.

Aiming to Expand Commercialization and Fields of Application

The reason that the railroad was targeted in this development is that it will help reduce the CO_2 emissions of society as a whole by further improving the energy conservation of railroads, which is already a transport infrastructure of low environmental burdens. This development has already been noticed by the market and there are high hopes for its commercialization. So first, we will work hard to try to meet these expectations. Also, in the future we would like to use SiC-SBD in a wide range of power devices that have a voltage resistance range of 600 V to 3 kV. We would like SiC-SBD to be used not only for railcars, but in a diverse variety of fields, including industrial devices, power supply devices, elevators equipment, hybrid vehicles and home appliances, as well as in photovoltaic solar power generation and wind power generation. By making improved efficiency a reality, we hope to contribute to the battle against global warming.

Fourth Generation of Vehicular Lithium-ion Batteries with World-class Performance

In recent years, from the perspective of preserving the global environment, and in particular reducing greenhouse gas emissions, there have been growing expectations about the role of HEV and EV, which use electrical energy as a power source. A key technology in making these vehicles of the future a reality is the lithium-ion battery. Using the experience and technical skills that it has cultivated over the years, Hitachi has developed a fourth generation of lithium-ion batteries that achieve a world-class level of performance. In the future, by providing system solutions that include batteries, Hitachi will continue to contribute to the creation of a sustainable society.

Mitsuru Koseki (left), Deputy General Manager, Battery Design & Development Division, Hitachi Vehicle Energy, Ltd.; Hidetoshi Honbou (middle), Senior Researcher, Department of Battery Research, Advanced Battery Research Center, Hitachi Research Laboratory; Toshio Otaguro (right), General Manager, Battery Systems Company, Hitachi, Ltd.

About 20 Years' Experience in the Development and Commercialization of Large Lithium-ion Batteries

Lithium-ion batteries are currently the focus of attention as a power source for vehicles that are more environmentally conscious, such as HEVs (hybrid electric vehicles) and EVs (electric vehicles). These lithium-ion batteries have a volume and weight that is about 1/3 that of lead batteries and 1/2 that of nickel-hydrogen batteries, and have the excellent characteristics of being compact, lightweight and having high output at high energy.

Hitachi was among the first to start the development of large lithium-ion batteries, using the opportunity of its participation in the "New Sunshine Program" of New Energy and Industrial Technology Development Organization (NEDO) in 1992. Achievements in our long history of development include the use of our batteries in Nissan Motor Co., Ltd.'s global-pioneering "Tino Hybrid" HEV and "Hypermini" EV in 2000, adoption for commercial HEV vehicles in 2005, and use in East Japan Railway Company's "Kiha E200 Type" hybrid railcar in 2007, which won the Minister's Prize, the Ministry of Environment in the Eco-Products Category of The 4th Eco-Products Awards.

Increased Battery Output by Reducing Internal Resistance

The results described above were achieved by vehicular lithium-ion batteries up to the second generation, and we have already delivered a total of more than 1 million cells. We have finished the development of our third generation of batteries that have increased output, and are currently completing the preparations for mass production. It has already been decided that this third generation of battery will be used in new HEV from General Motors Company. The vehicular lithium-ion batteries that we have delivered thus far have been highly evaluated for many reasons, including their high quality, performance, safety, and durability. Hitachi develops and manufactures not only battery systems, but also motors, inverters, and other components, giving us the strength to propose optimum hybrid systems.

And now we are developing a fourth generation of lithium-ion battery that increases performance by 150% compared with the third generation, raising output to 4,500 W/kg. To raise the output of batteries, the internal resistance must be reduced. By using a new positive-electrode material made from manganese, making the electrodes slimmer and increasing their surface area, and using square-shaped batteries, we achieved this goal of reducing resistance in the internal current paths. A key problem was the need to evenly manufacture uniform, slim electrodes at high speed. We were able to overcome this issue because of the techniques that Hitachi has cultivated in the manufacture of magnetic tape.

Expanding the Possibilities of Lithium-ion Batteries

Because mobile power sources for automobiles and railcars must be small, light and deliver high output at high energy, the lithium-ion battery is the most suitable technology. Through the development of green mobility technology such as this, not only can we contribute to reducing CO_2 (carbon dioxide) emissions, which is a key global issue, but we can also help construct a low-energy and sustainable society. In the future we believe that demand may increase for technology that uses the characteristics of lithium-ion batteries, not only for vehicular batteries, but also for backup power supplies for high-rise buildings and portable base stations, and for power storage for natural energy such as solar power. We are verifying the long-term reliability and developing manufacturing processes for the fourth generation of batteries with a view to start mass production in 2014, and we are also considering applying the electrode technology in cylindrical batteries that we have already developed. In addition to expanding our lineup to meet the needs of customers, we will also provide society with a wide range of low energy solutions for battery systems that combine products and controls that use our battery technology.

Walkthrough Explosive Detection Technology

Taking countermeasures against terrorism has become an urgent issue to keep society safe and secure. In particular, knowledge about how to make homemade bombs by blending explosives from everyday items has become widely available, so that even in Japan concern has risen about their use in terrorism and crime. Explosive detection equipment that is currently used at airports and other facilities can be broadly divided into two types; bulk detection that identifies the overall shape of the explosive, and trace detection that finds traces of absorbed explosives. With trace explosive detection equipment, the officer must take swabs of the hand luggage or other items, and so from the perspective both of throughput and the number of inspectors that will be required, it is often difficult to increase the number of installations. In response, Hitachi has developed a walkthrough explosive detection system that can detect the vapor of homemade bombs at high speed, without the need for inspectors.

In the explosive detection system, vapor that is released from traces of explosives that are adhered to the bodies or clothes of people is sent from the air feed area to the air intake area by the airflow, where it is sampled and then introduced to an ion source. In the ion source, the molecules of the explosive are ionized by the corona discharge. The generated ions are sent into a linear ion trap type of mass spectrometer in a vacuum, where mass separation and ion detection are performed (mass separation method). The molecules of explosives have a specific molecular mass and chemical structure, so the presence of explosives can be judged by monitoring for the ion signal strength of mass that is characteristic of explosive molecules. In this system, the presence of explosives can be judged very quickly, within three seconds of someone passing through. Also, Hitachi is improving the performance of this mass separation method to detect more minute traces of explosives by adopting a wire type of linear ion trap, which enables analysis that is 10 times more efficient than conventional methods.

The sampling area of the explosive detection system that is explained above was built into a security gate (automatic gate type). A problem with conventional security gates is that they mistakenly detect substances that are not explosives. With the current ion mobility method that is widely used at airports and other facilities, the incorrect detection rate is as high as 1%. Mass spectrometry is a method that has higher selectivity than the ion mobility method, so a reduction in the incorrect detection rate can be expected. Actual verification tests have been run in public spaces such as Tokyo International Airport (Haneda Airport) and East Japan Railway Company's Akihabara Station (railroad). In the future, Hitachi aims to make the entire structure, including the detection area, more compact, to enable its installation on security gates. Hitachi will strive to commercialize security systems with high throughput, which have good compatibility with current social systems, in order to contribute to the improvement of security in places where many people gather.

Note that part of this research was performed as commissioned by the Project on Science and Technology for a Safe and Secure Society of the Ministry of Education, Culture, Sports, Science and Technology, Japan.

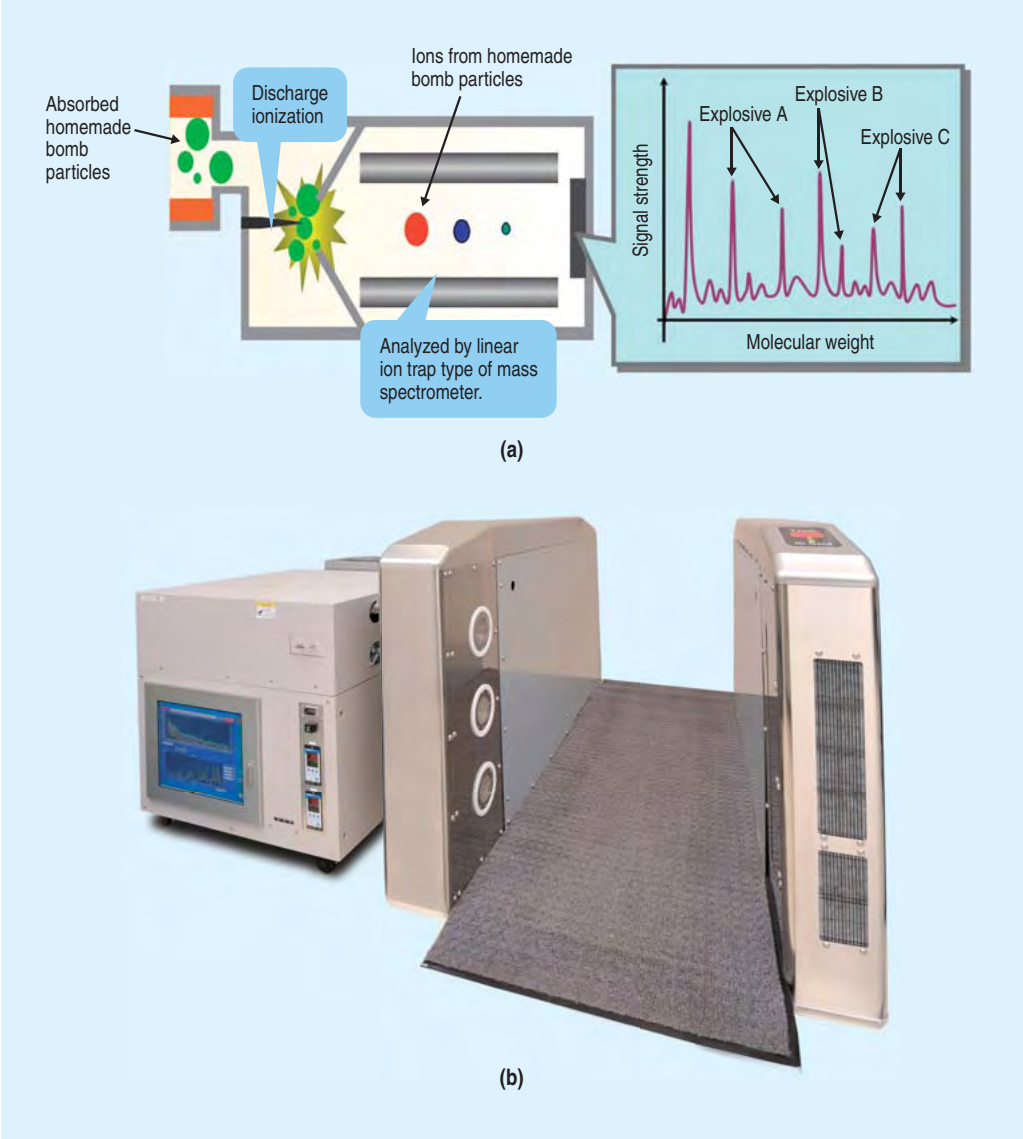
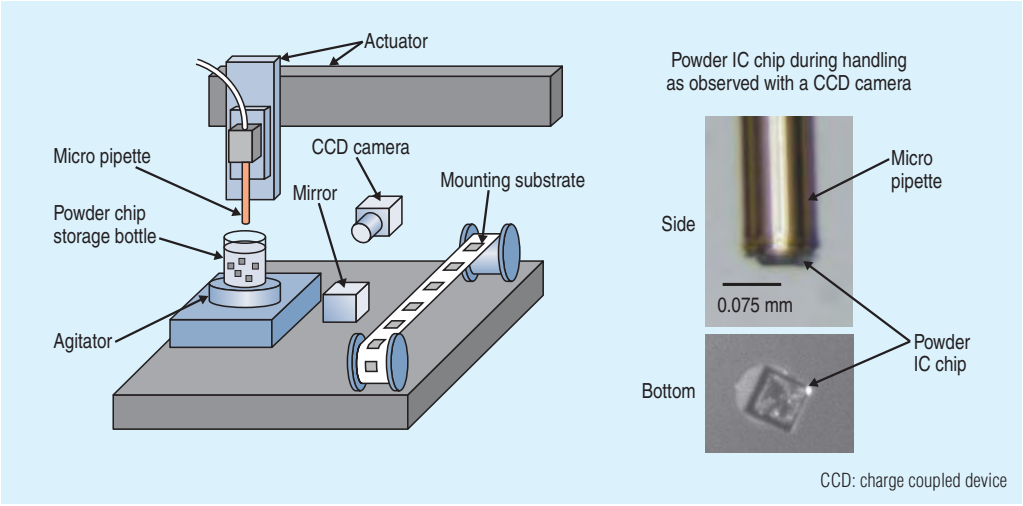


Diagram of explosive detection system (a) and walkthrough explosive detection equipment (b)

Handling Technology for 0.075-square-mm Powder IC Chip



Outline of powder IC chip handling device

Hitachi has developed a handling technology for a powder IC (integrated circuit) chip with a size of 0.075 mm and a thickness of 7.5 µm.

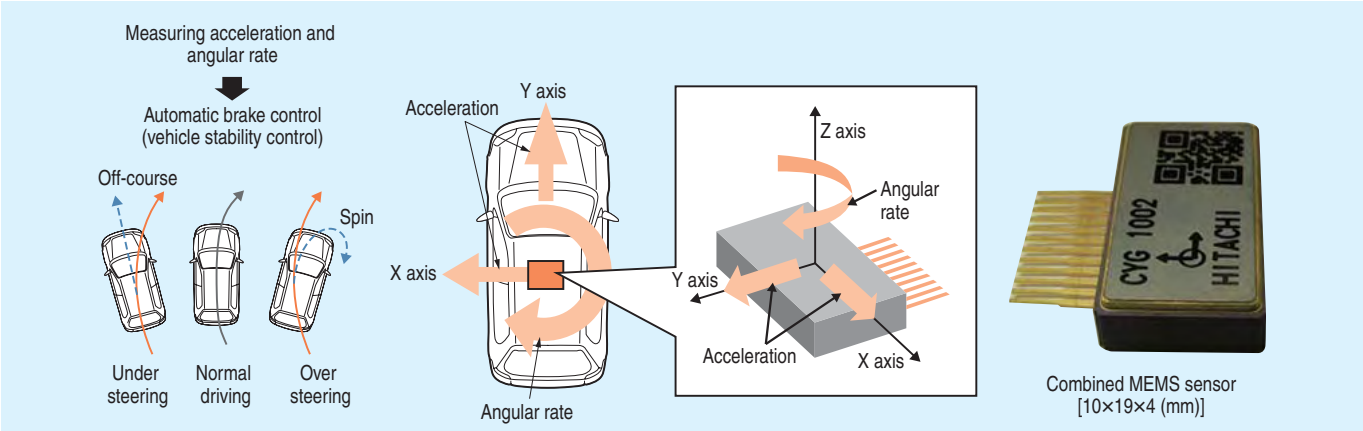
Because the powder IC chips are extremely small and thin, in a dry environment they can be greatly affected by forces such as static electricity and van der Waals force, causing them to stick together or fly apart. For this reason, it was difficult to handle chips one by one using the conventional handling technology for semiconductor mounting. In this development, microparticle and cell capture technology that is used in advanced biomedical fields was applied. The IC chips were inserted into and dispersed in a surfactant solution to enable them to be placed on the substrate without being affected by forces such as static electricity.

There are high expectations that RFID (radio-frequency identification) tags that use powder IC chips will create a new market, developing into a key device for the simple and low-cost management of a large number of objects, identification of paper documents such as stock certificates, and many other uses.

MEMS Combined Sensor for Vehicle Stability Control

An MEMS (microelectromechanical systems) combined sensor that measures two-axis acceleration and the angular rate (rotation) has been developed for VSC (vehicle stability control) systems, which control braking forces for each wheel separately in order to maintain vehicle stability. In the USA, the installation of VSC systems will be mandatory for vehicles up to 4.5 t by the MY (model year) 2012. There is also a movement towards the mandatory installation of VSC systems in Europe and Asia. To apply VSC systems to all vehicle types including small cars, it will be necessary to reduce system costs and simplify installation. In order to meet these demands, a combined sensor with a small package which is embedded on the hydraulic control unit in the engine compartment is indispensable for the VSC system.

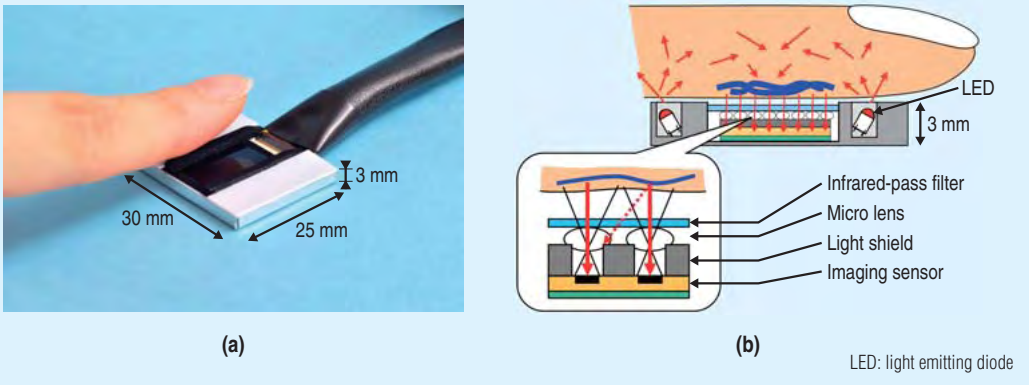
A deformation-resistant MEMS structure has been adopted to achieve stable operation under both high vibration and in a wide temperature range (-40 to 125°C) in the engine compartment. A package as small as 10×19×4 mm is achieved by adopting TSV (through silicon vias) and WLP (wafer-level package) technologies. These sensor technologies can be applied to multi-range detection for other automotive controls such as anti rollover systems.



MEMS combined sensor for vehicle stability control

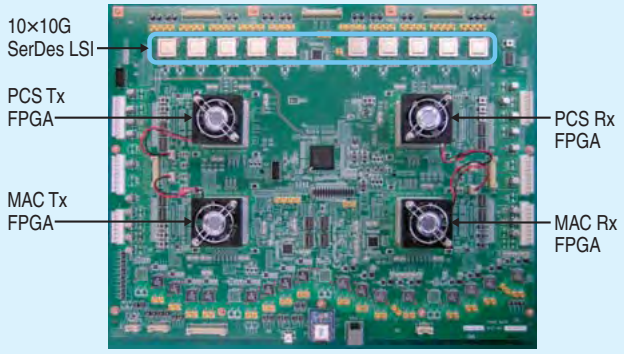
Thin-type Finger Vein Authentication Module

Hitachi has developed a 3-mm-thick thin-type finger vein authentication module which is suitable for mobile use. The significant decrease in the thickness of the finger vein authentication module was achieved through the development of a new contactless flat sensor for capturing the finger vein image. Until now, the image obtained by illumination with infrared light was captured using a single lens camera method. As a result, there was a limit to how thin the module could be made, due to the space required between the finger and the lens, as well as the thickness of the lens itself. In the newly developed thin-type contactless flat sensor, micro lenses with a short focal length are provided for each pixel of the sensor. This enables a focused and clear vein pattern to be captured despite the proximity of the finger to the sensor, thus allowing a thinner finger vein authentication module to be designed. Further, signal processing technology was developed to reduce interference from external light such as sunlight in vein pattern observation to improve practicality. This module makes it possible to expand the application of finger vein authentication technology to a wide range of products such as mobile equipment, motor vehicles and homes, where space is limited or mobile operation is required. Hitachi will continue to use finger vein authentication equipment in a wide range of applications as a security technology that supports innovative businesses in our society.



3-mm-thick finger vein authentication module (prototype unit) (a) and structure of the module (b)

100-Gbit/s Ethernet Prototyping Implementation



Picture of the evaluation board

Hitachi has developed the subsystem of a prototype for 100-Gbit/s Ethernet (100 GbE), a specification that was standardized in June 2010 by the IEEE P802.3ba Task Force. The targets of the 100-GbE prototype are a "MAC/PCS (media access control/physical coding sublayer)" LSI (large scale integration) that supports an MAC sublayer and PCS, and a "gearbox" LSI that provides 10:4 parallel lane-width exchange inside an optical transceiver module.

The MAC/PCS LSI prototype was developed in order to verify the multi-lane transmission method. The result of this prototyping implementation is that the logic scale of the PCS is 135-k LUTs (lookup tables) and 3.1 Mbit RAM (random access memory), and the logic scale of the MAC is 116-k LUTs and 2.6-Mbit RAM. An evaluation board for testing the MAC/PCS function unit was developed. The results indicated that the module functioned as the draft standard specified.

The gearbox LSI was designed using a 65-nm CMOS (complementary metal-oxide semiconductor) process for low overall power consumption. The 10-Gbit/s interfaces reduced power consumption by achieving a transmission performance of 0.98 mW/(Gbit/s). The 25-Gbit/s interfaces were designed to reduce power consumption by using CMOS-type transistors. After implementing the circuit, the gearbox LSI had a 6.1-mm × 3.5-mm die size. The anticipated power consumption will be less than 2.3 W for the whole gearbox LSI.

With this result, the path for achieving low power 100 GbE in the future has been shown.

This research and development was supported by the National Institute of Information and Communications Technology (NICT) and the Ministry of Internal Affairs and Communications, Japan; the MAC/PCS prototyping and the gearbox LSI prototyping are related to the NICT's "Lambda Access technologies" project and the "Universal Link technologies" project, respectively.

Weight Loss Program for Metabolic Syndrome

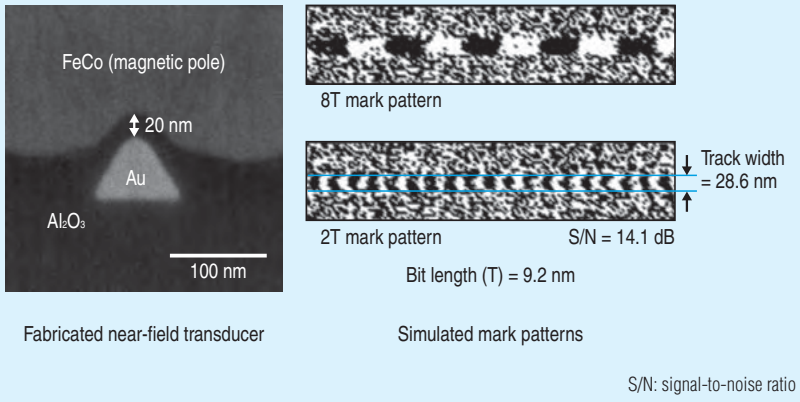
Hitachi has developed a new weight loss program for metabolic syndrome. The participants of the program set behavioral objectives using 100-kcal (≒418,600 J) cards and carried out tasks for achieving their target weight, which is 5% weight loss over 90 days. The 100-kcal cards are illustrated cards that show food that comply with 100-kcal restrictions or exercise that burns 100 kcal. The participants are able to set concrete objectives using these 100-kcal cards. To help them continue their activities, the participants receive e-mail advice from nurses every 10 days.

Hitachi has also developed an IT (information technology) system to improve the operational efficiency of the nurses. By using the system, the nurses are able to confirm the weight and objectives of the participants, check off their daily tasks using the to-do list, and send e-mails using the message templates that are automatically generated depending on the condition of the participant.

Weight loss program support system

As a result of the program that uses this system, 421 participants lost 4.7 kg on average and 51.3% of the participants were down to their target weight. The system also reduced the time required for nurses to create e-mails from 20 minutes to 5 minutes. The weight loss program and system are helpful for both the metabolic syndrome participants and the nurses.

Thermally-assisted Magnetic Recording Head Technologies for 2.5-Tbit/in²-class HDD



Fabricated head element with near-field transducer and simulated recording patterns

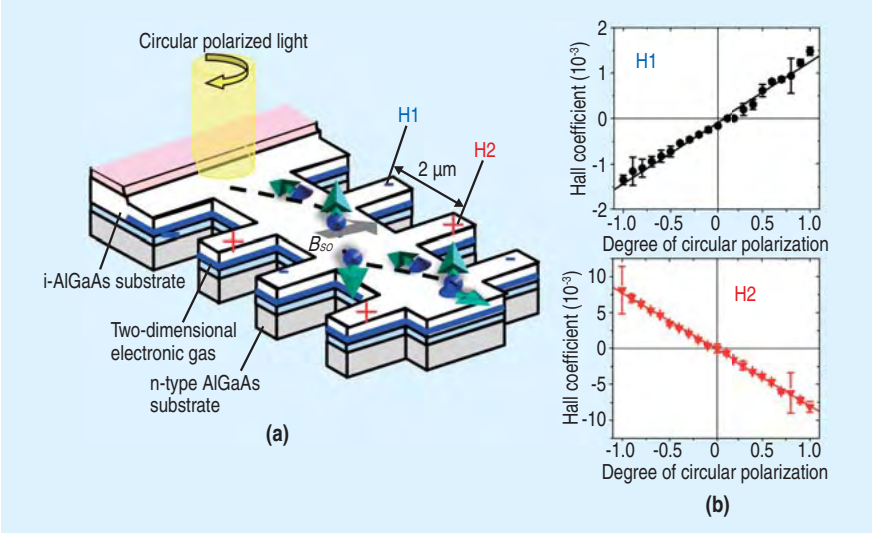
During the past few decades, exploding demand and intense research and development competition in the HDD (hard disk drive) industry have kept the areal density growth rate at over 40% per year. However, a recording density of 1 Tbit/in² is considered by many to be close to the limit of the current recording technology, namely perpendicular magnetic recording on continuous granular media. TAR (thermally assisted magnetic recording) technology is one of the leading candidates for achieving areal density beyond this limit.

In TAR, light irradiation heats a local part of the magnetic media and thus temporarily lowers the magnetic field that is required to switch the magnetization direction. Then, a data bit is magnetically recorded in the easily switchable part of the media, while the remaining part left unchanged. Therefore, the head must be equipped with an optical element to irradiate small optical spots onto the media.

The developed technologies were an optical element that generates a tiny optical spot with a diameter of 20 nm, and an integration technology to simultaneously fabricate an optical element adjacent to the magnetic pole tip. The left figure shows that a near field optical element was successfully fabricated next to the magnetic pole. The performance of the developed elements was verified by a combination of optical, thermal, and magnetic simulations. The right figure shows the magnetic patterns corresponding to 2.5 Tbit/in²-class areal density, which is about five times the current recording density, were successfully recorded.

The development was conducted under "Development of Nanobit Technology for Ultra-high Density Magnetic Recording (Green IT Project)," which was commissioned by the New Energy and Industrial Technology Development Organization (NEDO).

Discovery of Spin-injection Hall Effect



Device structure (a) and measurement results (b)

Hitachi has successfully measured the spin-injection Hall effect for the first time in the world. To observe the spin-injection Hall effect, Hitachi utilized a specially designed p-n junction photodiode. By shining a circularly polarized light on the p-n junction, spin-polarized electrons are excited in the two dimensional electronic layer. The Hall effect signals along the semiconducting micro-channel are used to electrically measure the local spin orientation of injected electrons. The observed transverse electrical signals remain large at high temperatures and are linearly dependent on the degree of circular polarization of the incident light, indicating that electron spins propagate without losing the original information in a range of a few micrometers. This device represents a realization of a non-magnetic spin-photovoltaic polarimeter which directly converts polarization of light into transverse voltage signals. The spin-injection Hall effect demonstrated in the device can have a broad range of applications in non-magnetic semiconductors without disturbing the spin-polarized current and without using magnetic elements. This discovery was achieved by physicists from the Hitachi Cambridge Laboratory, University of Cambridge and The University of Nottingham in the UK, Texas A&M University in the USA, Physikalisch-Technische Bundesanstalt in Germany, and the Institute of Physics of the Academy of Sciences of the Czech Republic.

Technology for Stability Control of Inverted Pendulum Mobile Mechanism for Human Symbiotic Robots

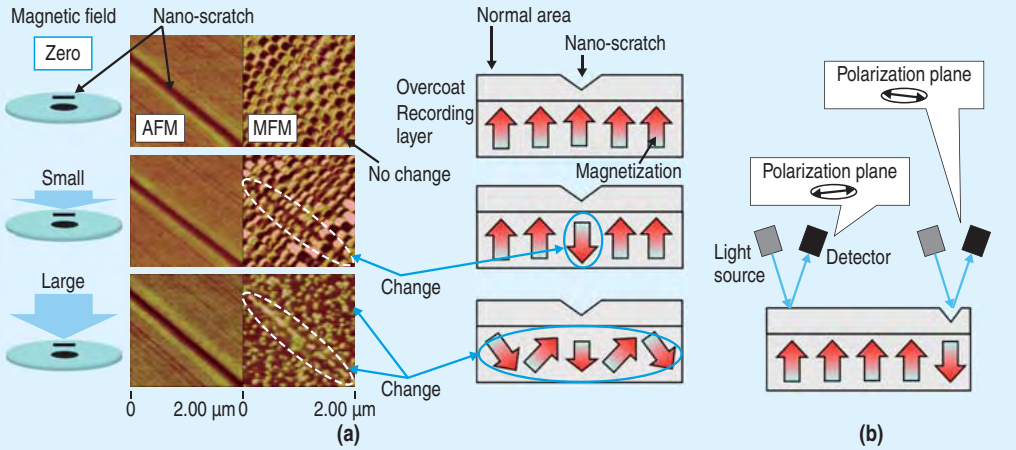
A new control technology for an inverted pendulum mobile mechanism that enables fast and stable mobility on an uneven surface has been developed. It is used in a humanoid robot called EMIEW2 that has a leg-wheel mobility mechanism developed in 2007. EMIEW2 is light (14 kg) to ensure intrinsic safety. However, this makes EMIEW2 unstable when it runs over a bump. This technology enables the robot to run as fast as 6 km/h on a surface with bumps up to a maximum of 15 mm.

A pair of newly developed SHS (serial hybrid suspension) devices is used to stabilize the posture of the robot. The SHS comprises an actuator serially coupled to an orthodox spring-damper shock absorber. The shock absorber alleviates the impact when the wheel hits a bump on the ground. However, conventional suspensions that absorb the impact are too soft and too slow to recover the posture from the fluctuation, thus making the stability low. The actuators of the SHS solve this problem. A gyro sensor mounted on the robot detects the slant, and the actuator lengths are controlled to keep the robot upright.

A new control algorithm is also applied to overcome the instability caused by overspinning. The robot wheels sometimes get out of contact when the robot hits bumps. This causes overspinning and makes the robot unstable. The overspinning is detected by the newly developed algorithm, and the wheel is controlled so that stability is kept after making contact with the ground again.

Human symbiotic robot "EMIEW2"

Technology for Investigating the Effect of Nano-scratch on Magnetization in HDD Magnetic Recording Media

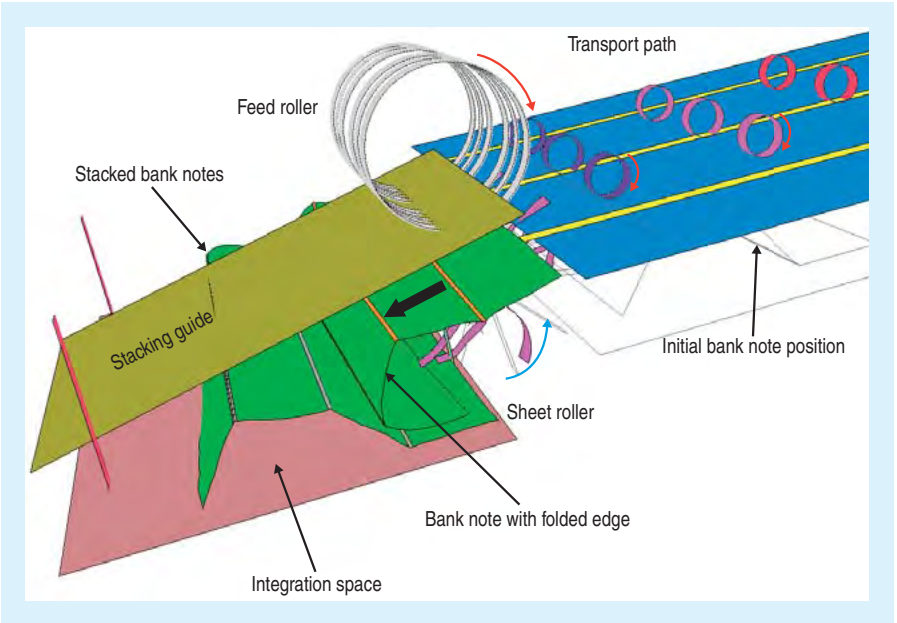


Magnetization changes from the applied magnetic field at the normal and scratch areas (a) and rotation of polarization plane from changes in disk magnetization (b)

Hitachi has developed a new technology to investigate the effect on recording magnetization of nano-scratches with a depth ranging from a sub-nano meter to a few nanometers that occur on the surface of the magnetic recording media of an HDD (hard disk drive). This technology utilizes the fact that magnetization is reversed in a scratch area but not in a normal area when a small external magnetic field is applied to the media. The magnetization direction can be observed through the magneto-optical force effect. Hitachi was the first in the world to quantify the effect of nano-scratches on magnetization. This technology is used for strengthening perpendicular magnetic recording media and improving HDD reliability.

Technology for Three-dimensional Behavior Analysis and Simulation of Multiple Bank Notes in ATM

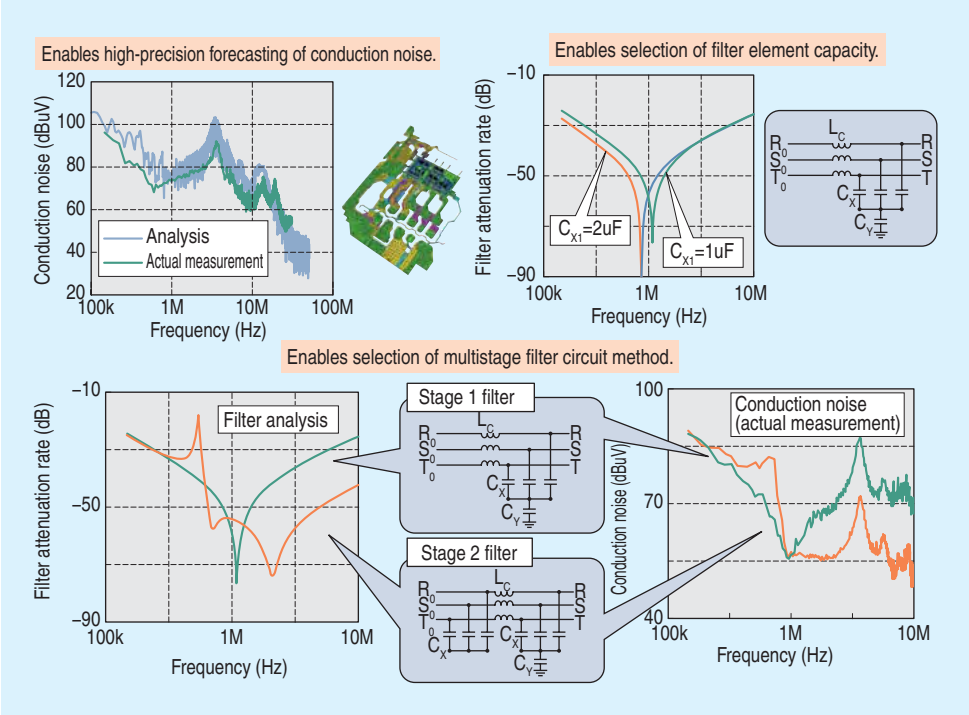
Hitachi has developed a three-dimensional simulation technology for reproducing the bank note and mechanism movements in the bank note feed mechanisms and collection mechanisms that output, input, and store bank notes in ATMs (automated teller machines) when stacked bank notes are separated and fed out one by one, or when bank notes are continuously stacked one by one. With this technology, Hitachi has developed a method where the contact area between bank notes is modeled to a level equivalent to actual conditions, enabling the friction that acts between bank notes to be accurately estimated. A simulation can reproduce the friction condition between bank notes when multiple bank notes are stacked together, and the contact condition between the bank notes and the mechanism parts. As a result, various movements related to bank notes can be reproduced that were difficult to do with previous simulations, such as the simultaneous feed out of multiple bank notes, and collisions between bank notes. This means that the performance of the bank note feed mechanisms and collection mechanisms can be evaluated without using a prototype device or test bank notes. This technology will contribute to shorter development times for ATMs and to developing ATMs with greater reliability.



Example of simulation of abnormal behavior when collecting a bank note that is folded in four

Filter Design Technique for General-purpose Inverters

The operating principles of inverters mean that they generate strong electromagnetic noise. In recent years, Europe in particular has established higher standards for electromagnetic noise. As such, the noise level in inverter products must be restricted to less than the level that is stipulated by the standards. In response, a filter is used to restrict the electromagnetic noise. However, a large filter is required to satisfy the standards, which led to size and cost issues.
To resolve these issues, a filter design technique was developed that uses simulation, enabling a compact and high-performance filter to be developed that is based on noise generation principles. This technique is being used in the development of inverters that are built into filters and are compatible with European standards.



Filter design technique using simulation

Embedded Video Analyzer for Surveillance Camera and Hybrid Recorder

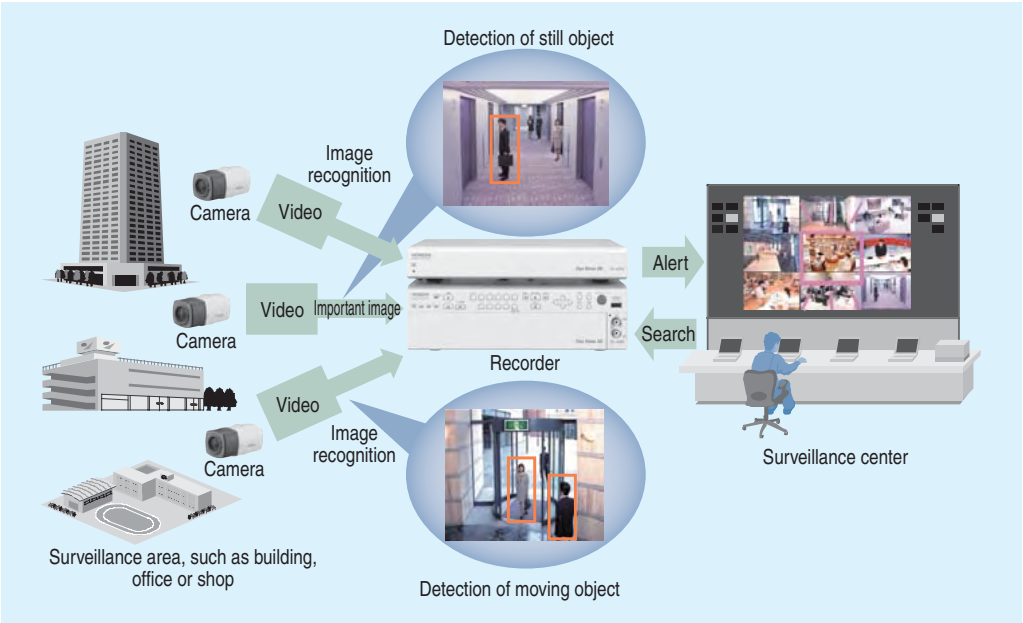
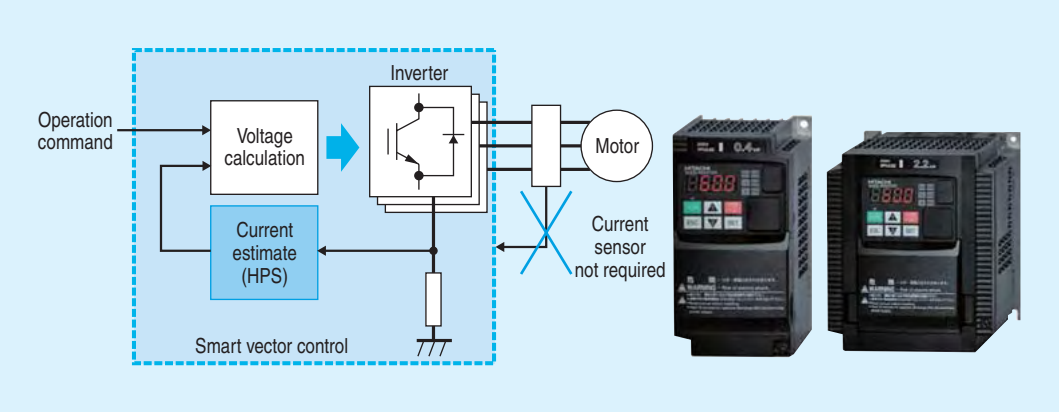


Image surveillance system

Using image recognition technology, Hitachi has developed a network surveillance camera and hybrid recorder (supports both analog and digital) that can detect moving objects such as people or vehicles, as well as people who are standing still.
This function alerts the surveillance staff if an intruder enters the security area, and enables the recorded images to be searched for the important parts only, which increases the efficiency of surveillance work. In this development, to enable the real-time processing of multiple recognition applications, hardware measures were taken for basic computing for image processing, and the recognition algorithm was optimized and installed in mass-produced cameras and recorders.
In the future, Hitachi will continue to develop more intelligent image recognition technology to contribute to video surveillance solutions that achieve better safety and greater peace of mind.

Universal Inverter Drive Control

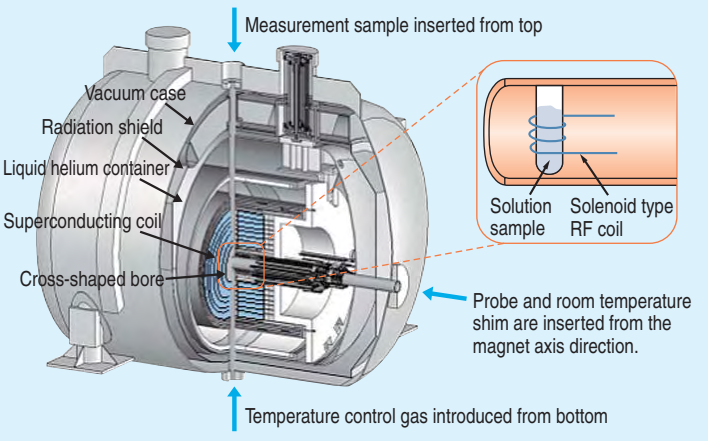
Hitachi has developed sensorless drive technology that is suitable for industrial universal motor control.
For the universal inverter drive technology, Hitachi used smart vector control technology, which has few adjustable elements and high universality, to achieve high starting torque of 200% at an extremely low induction motor speed of 0.5 Hz. Also, to enable use in various operating environments, HPS (half pulse shift) universal current sensorless technology that increases inverter noise resistance was developed, which enables products to be made smaller and at lower cost.



Configuration and outline of developed sensorless drive (left), and the WJ200 compact, high-performance inverter in which the technology is used (right)

Hitachi Industrial Equipment Systems Co., Ltd. used sensorless drive technology in a product in April 2009, and Hitachi is working to further expand the application of this technology.

World's Highest S/N Sensitivity Achieved with Development of New NMR Method

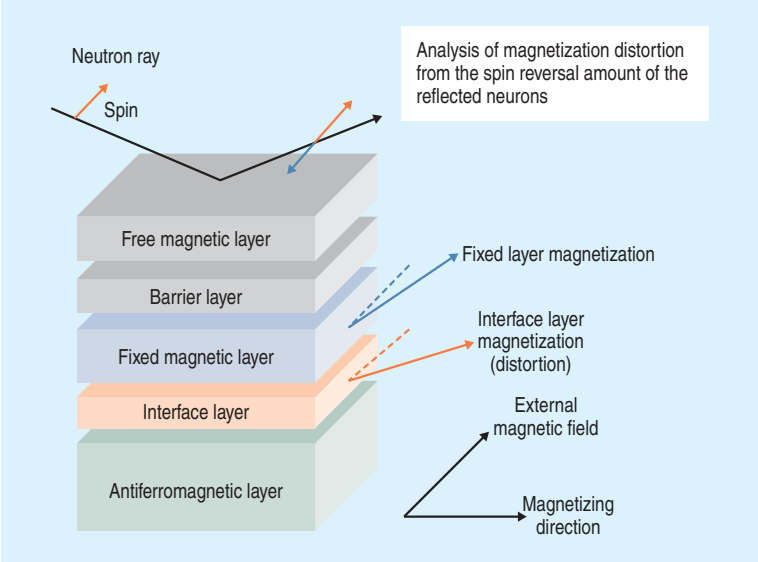


Split superconducting magnet for new NMR method

Hitachi has developed an NMR (nuclear magnetic resonance) device using a new method, which has achieved the world's highest S/N (signal-to-noise) sensitivity.
NMR devices are widely used for chemical analysis, and in recent years there have been high expectations of their use in protein research. There is always a demand for higher sensitivity in NMR measurement, and in the past sensitivity was improved by increasing the magnetic field of the superconducting magnet and by lowering the temperature of the detection antenna.

In this development, a configuration was used that combines a solenoid type antenna, which has excellent detection capabilities, and a split type superconducting magnet. This increased the sensitivity by 1.6 times compared with the previous NMR device of the same class, setting a record for the world's highest sensitivity. In the future, in addition to developing advanced protein measurement technology that utilizes cross-shaped bores, Hitachi plans to expand the superconducting magnet technology, cryogenic technology, and other techniques from this development to uses such as MRI (magnetic resonance imaging) magnets.
Note that this was a joint development with Ibaraki University and used devices that were made in research commissioned by the Ministry of Education, Culture, Sports, Science and Technology, Japan.

Evaluating the Magnetic Structure of Magnetic Head Films Using Neutron Rays



Magnetic structure of magnetic head film as seen through spin reversal neutron reflectance

As the recording density of magnetic disk devices becomes higher, it has become important to develop advanced magnetization control technology for the magnetic layer that makes up the magnetic head film. In response, Hitachi has developed neutron reflectivity technology that uses spin reversal and is capable of evaluating the magnetization amount of each magnetic layer and the distortion in the magnetization.

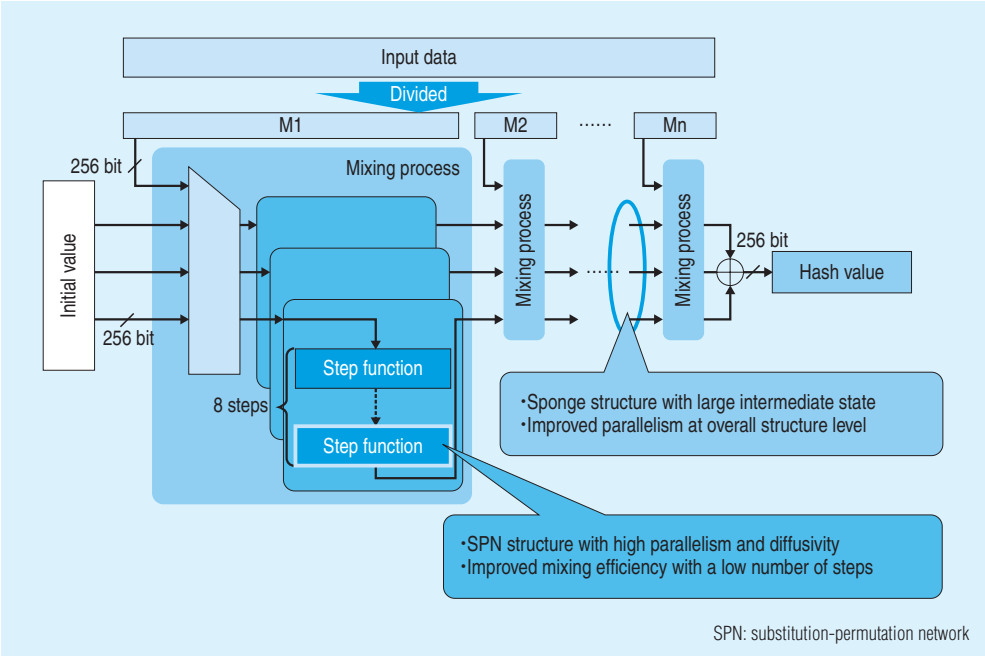
This technology clarifies whether an interface layer that has magnetization-distorting components exists between the antiferromagnetic layer and the fixed magnetic layer, and it has been demonstrated to be an effective method for evaluating the magnetic structure. Hitachi plans to apply this technology in the development of the next generation of magnetic heads.

Note that this was a joint development with the Japan Atomic Energy Agency.

Development of Next-generation Hash Function

Hash functions are used for checking the integrity of communication data and for authentication of devices and users, and they improve the security of various information systems, such as e-government and online banking. The security of the "SHA-1 (secure hash algorithm 1)" hash function, which is the current worldwide standard, has decreased, leading to concerns about security risks in the near future. In response, the National Institute of Standards and Technology (NIST) in the USA has launched the SHA-3 competition to decide the next generation of standards.

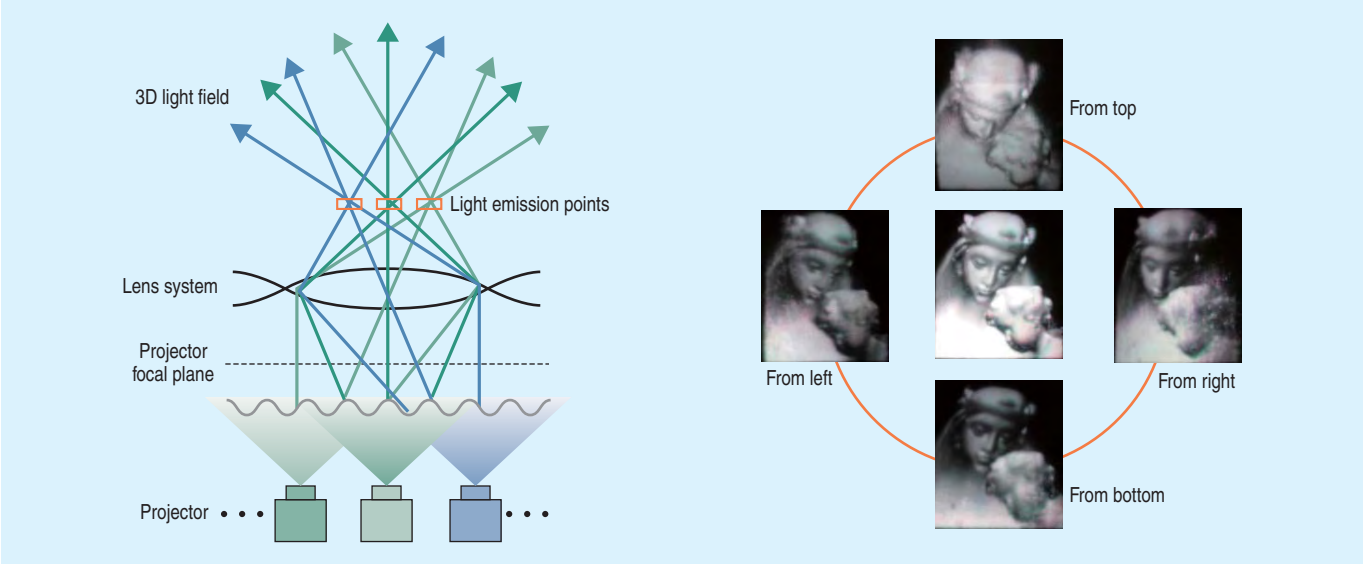
This is the background to Hitachi's joint research and development of a new hash function with Belgium's Katholieke Universiteit Leuven. It was the only proposed hash function from Japan to pass the first round of the competition, where it was selected as one of 14 candidates. A structure that possesses both high security and high speed was achieved by combining a new "sponge type" of hash function structure with the technology of lightweight stream ciphers. This has achieved the highest value in the world for hardware processing speed per unit gate.



Outline of new hash function

In summer 2010, the candidates will be narrowed down to 5 final candidates, and the next-generation standard will be decided around June 2012. Hitachi aims to expand information businesses through the standardization of the hash function, which is the foundation of information security.

Full Parallax Three-dimensional Display



Principles of 3D light field generation and example of full parallax display results

By superimposing multiple projectors, Hitachi has developed a 3D (three-dimensional) display that achieves full parallax with a difference in viewpoint between the top, bottom, left and right, with no need for special glasses.

This method is based on a light reproduction method that can reproduce 3D light fields from real space, resulting in realistic 3D images. Using multiple projectors and performing calibration using actual measurements of the corresponding light directions gives greater flexibility for design conditions such as screen size, view angle, and light density, enabling the construction of the optimum system for the application.

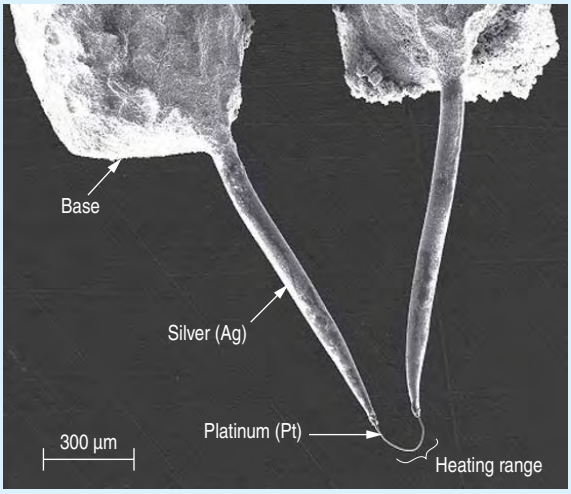
In the future, Hitachi plans to improve picture quality by making the projectors smaller and adding more of them, and expanding its application to fields that make use of full parallax technology.

Ultra-trace Organic Analysis Technology

Using a local heating mechanism that can heat only the minute sample that is subject to the analysis, Hitachi has developed a mass spectrometry method that can identify the chemical structure of trace organics with a diameter of about 3 μm and mass of about 15 pg, which is difficult using conventional analysis methods.

A key feature of this technology is that the heating range is extremely small. In previous heating systems, the heating range was large and adsorptive components other than the sample were also heated, which inhibited the analysis. In the newly developed local heating mechanism, only the tip consists of an extremely fine wire. This tip is heated locally when the electrical power is turned on. With a double-digit reduction in the heating range from the previous method, the occurrence of analysis inhibitors has been restricted, resulting in the highly sensitive analysis of minute samples. Further, high speed heating to more than 1,000℃ can be performed within 0.1 seconds, which enables stable analysis even of refractory substances and macromolecular organic samples.

In the future, this technology will be applied in fields such as environmental surveys and foreign matter inspections in device manufacturing processes.



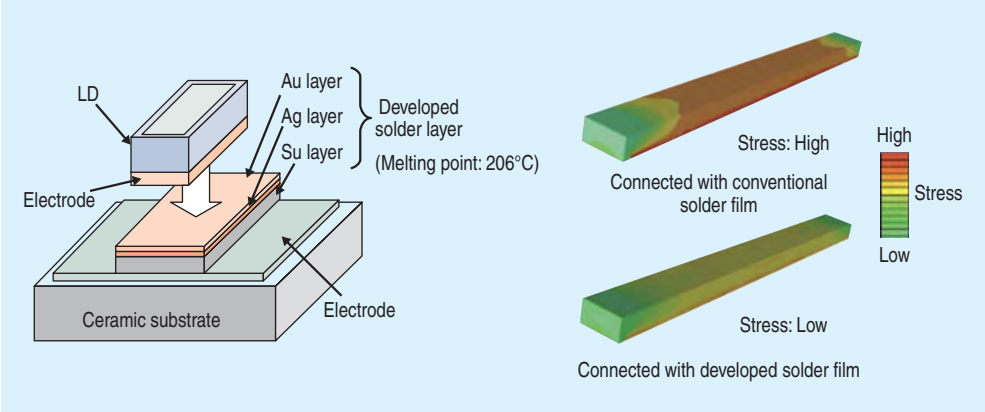
Electron microscope image of local heating mechanism

Solder Film with Low Melting Point for Reducing Stress in Optical Component Connections

At the light source of optical recording drives, the LD (laser diode) and substrate are connected with a solder whose main component is gold (Au). One problem with this structure is that because the melting point of the solder is high (278℃), after the components are connected and cool down, the difference in contraction between the LD and substrate generates a large stress and the LD properties fluctuate.

In a joint development between Hitachi Kyowa Engineering Co., Ltd. and the Production Engineering Research Laboratory, Hitachi, Ltd., a solder film was constructed with 3 layers, tin (Sn), silver (Ag), and Au, and the thickness of each layer was adjusted to make a film with a melting point that is lower (206℃) than the Sn base material. Usually, the connection performance of Sn deteriorates because it oxidizes easily. However, the Ag and Au layers in the developed solder film restrict the oxidization of the Sn surface to maintain a good connection performance. This structure reduces the stress by about 30% and improves the LD property fluctuation.

This technology can be applied to components such as LED (light emitting diode) packages, and its applications will be expanded in the future.



Outline of developed solder film and LD connection (left), and stress measurement results (LD only) (right)

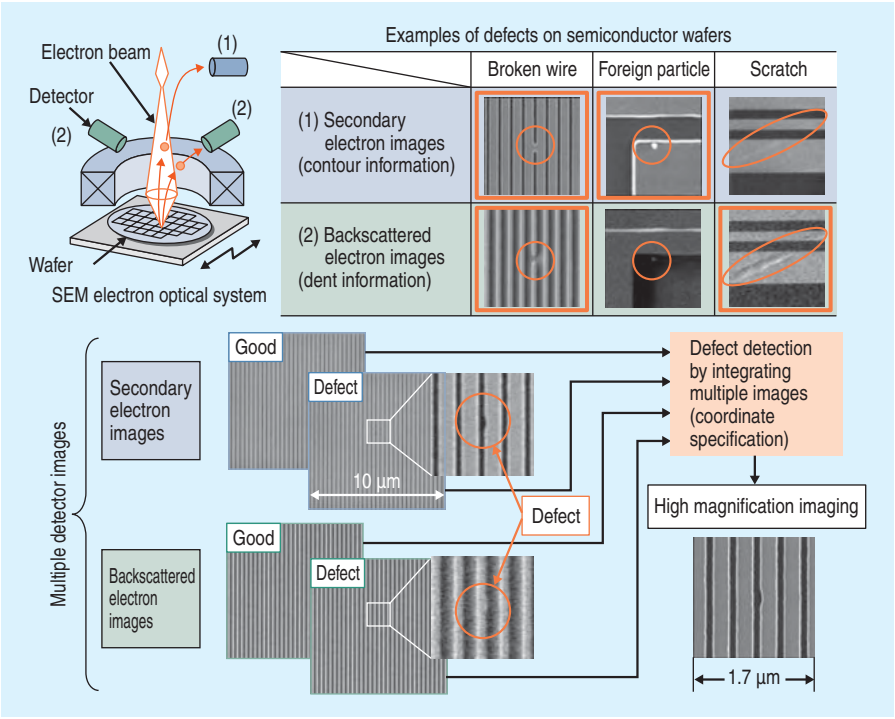
Image-processing Algorithm for High-sensitivity Detection of Minute Defects at the Nanoscale

In the manufacture of semiconductor devices, it is important to detect the various defects that occur in the manufacturing process at an early stage, and then to take appropriate measures. In response to these needs, Hitachi has developed image processing technology for the high-sensitivity detection of minute defects from scanning electron microscope images that are taken of semiconductor wafers.

A feature of this technology is the detection of defects through the integrated use of secondary electron images in which contours can be reviewed and backscattered electron images in which dents and bumps can be reviewed. This enables the stable detection of various defects (such as broken wires and foreign particle) on a scale of tens of nanometers.

This technology was adopted in a defect review electron microscope [review SEM (scanning electron microscope)] of Hitachi High-Technologies Corporation, and is currently being used for the stable mass production of semiconductor devices.

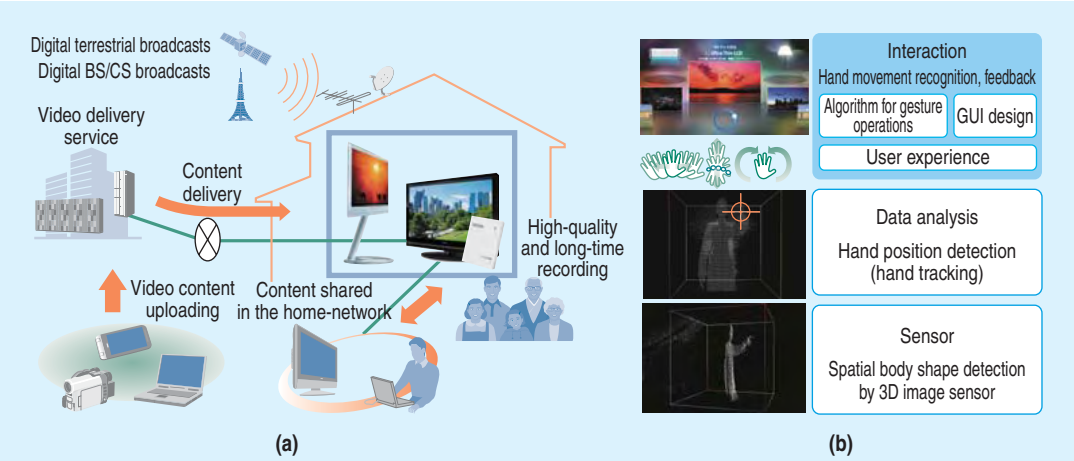
In the future, Hitachi will continue to develop high-sensitivity inspection technology to satisfy the inspection needs of ever-more complex semiconductor manufacturing processes.



Defect detection technology using multiple scanning electron microscope images

Broadcasting, Recording, and Network Integration Technology and User Interface Technology for Digital Television

Hitachi has developed a platform for digital television whose optimized parallel and distributed processing of the dual SoC (system-on-a-chip) system can perform the simultaneous high-speed processing of multiple streams of transcoding/copyright protection system conversion, which enables 8X long-time recording of high definition video onto a HDD (hard disk drive) and the use of video download services via networks and content sharing in the home-network. This brings a new TV (television)-viewing style where broadcasting, recording, and networks are integrated to enable viewers to watch the programs that they want at the time that they want.

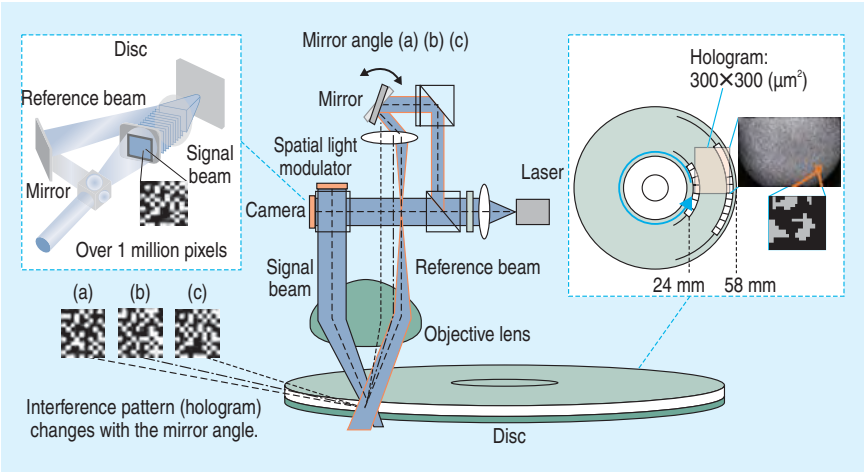


Technology for integrating broadcasting, recording, and networks for digital television (a) and structure of gesture user interface technology (b)

Hitachi has also developed a prototype of a user interface where the basic functions of a television can be controlled with gestures, to create a technology that is more user-friendly than a remote control. In addition to developing an algorithm that recognizes hand movements, Hitachi has devised a GUI (graphical user interface) design that gives easy-to-understand feedback for the operation methods and television status. This was accomplished by repeatedly identifying and improving operations that were difficult for users, resulting in the best possible gesture operations for television watching.

In the future, Hitachi aims to commercialize the technology by increasing the accuracy of hand recognition and further improving the operability to make it compatible with other functions, and to expand its application to fields such as digital signage.

High-density Holographic Recording Technology



High-density holographic recording technology

Hitachi has developed high-density holographic recording technology as optical data storage for digital data that is continuously growing in size.

A feature of this technology is three-dimensional recording. A signal beam which has two-dimensional information and a reference beam create an interference pattern (hologram) in a disc. The interference pattern is recorded in the thickness direction of the disc. The high-density recording was achieved with angle-multiplexing that changes the incident angle of the reference beam and records multiple data items at the same position in a disc. Furthermore, monocular architecture has been developed to reduce costs and size. Monocular architecture requires only a single objective lens, compared with multiple lenses in conventional holographic memory systems. This technology has achieved recording density of 712 Gbit per square inch (about 2.54 cm^2).

Hitachi is aiming to develop optical disc drives with high-density recording and a fast transfer rate in the near future that can store over 1 Tbyte on a single disc.