



# Research & Development

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**HITACHI TECHNOLOGY  
2008-2009**

## EMIEW2 “Human Symbiotic Robot” Building a New Relationship between Humans and Robots

Hitachi, Ltd. has developed the EMIEW2, a “human symbiotic robot” that operates alongside humans and safely supports their daily activities. This humanoid robot incorporates a leg-wheel locomotion mechanism and other technologies required for its intended application in office buildings and similar, including map-building and localization using a laser range finder, distant talk recognition, and obstacle avoidance. Having established a foothold with the development of the EMIEW2, Hitachi aims to develop futuristic robots that can coexist and cooperate with humans based on its “human symbiosis” vision for robotics R&D.



Junichi Tamamoto (left), Senior Researcher (Unit Leader); Ryosuke Nakamura (right), Urban Development & Robotics Technology Project, Mechanical Engineering Research Laboratory

### R&D Aims for “Human Symbiosis”

While Japan has seen remarkable progress in robotics technology in recent years, Hitachi’s experience in the R&D (research and development) of robots dates back to the 1970s when the field of industrial robotics was still in its infancy, and the company has worked on researching and developing robots for public, medical and welfare, and lifestyle applications. This R&D is now moving past being just an attractive new technology and is entering full-scale practical use, with Hitachi demonstrating the EMIEW (excellent mobility and interactive existence as work-mate) 1 at the 2005 World Exposition, Aichi, Japan. EMIEW1 was the product of R&D into “human symbiotic robots” which support humans in situations where they are in close contact with people. The next robot model was the EMIEW2 in 2007 which was intended for use in office buildings and similar and was developed with the aim of establishing a better understanding of what form such “human symbiotic robots” should take.

### Pursuit of Inherent Safety and Friendliness

The EMIEW2 robot has two major features. One is that, at 800 mm in height and 13 kg in weight, it is significantly smaller and lighter than the EMIEW1. A weight of 13 kg is practical for carrying by an adult woman and this feature is part of the objective of achieving inherent safety in robots that are to operate alongside people.

The other feature is that the robot has practical mobility and

intelligence. Equipped with a leg-wheel locomotion mechanism, the EMIEW2 can travel at the speed of 6 km/h and has a lever on its legs that can be used for bipedal walking when confronted with a difference in floor level. The robot can also reconfigure itself into a stable four-wheel position while it is at rest or performing work. The EMIEW2 has four intelligent processing technologies. The first is map-building and localization using a laser range finder. This allows the robot to travel to a particular destination using a map it creates itself. The second is distant talk recognition that can identify and separate multiple sound sources and recognize human speech clearly. The third technology is high quality speech synthesis that is used to make friendly voices to communicate with people. Finally, the EMIEW2 incorporates obstacle avoidance technology that allows the robot to travel through places where people are moving around. Having been built from these various technologies that were developed at different research laboratories within Hitachi, Ltd., the EMIEW2 robot can be seen as representing a culmination of the R&D capabilities of the Hitachi Group.

Design also played an important role in development. Rather than starting from the hardware design, the design was the result of studies carried out from the perspective of the robot’s affinity with humans, ranging from the body design through to the egg-shaped face and neck movement based on a concept sketch created by the Design Division at Hitachi, Ltd. In keeping with the “human symbiotic robot” concept, the goal was to create a robot with a friendly design that would not give an intimidating impression. For instance, the position of the camera was intentionally set at the upper part of the head rather than at the level of the eyes.

### Toward a Society in which Humans and Robots Coexist

Specific services that could be carried out by the EMIEW2 include guiding visitors around an office as well as patrolling and surveillance. As the robot has already proven its ability to operate as expected in the lab, the next step will be to try its effectiveness in actual office environments. In particular, as the EMIEW2 can perform surveillance as it moves about, it has advantage of providing office security without causing any psychological stress to the people at work.

Efforts are currently underway to establish safety standards for service robots, which are scheduled to be completed in 2011. Once these are in place we can expect service robots to gradually become a part of people’s lives. Eventually, they could become as integral to our lifestyle and society as the personal computer. Hitachi intends to continue undertaking R&D aimed at realizing this vision of people living together with “human symbiotic robots.”

## Successful Development of a Prototype—2-Mbit Non-volatile SPRAM Chip

While there are many types of memories crucial to digital equipment, realization of a “universal memory” that has features of those memories in one has been widely anticipated. Hitachi, Ltd. and Tohoku University are successful in jointly developing a promising candidate: a 2-Mbit-prototype chip of the SPRAM. SPRAM can be a next-generation memory device, with its possibility to achieve high-speed and density comparable to existing types of memories.

### Expected Realization of the Universal Memory

Memories currently used for mobile phones and digital appliances include DRAM (dynamic random access memory) and SRAM (static random access memory), among several others, and are hierarchically combined for use to capitalize on their strengths. However, such combined use results in a complicated equipment structure, and poses problems such as longer startup or operation switching time. In order to solve these problems, next-generation memory is expected to achieve performance as “universal memory,” combining advantages of various memories for general purpose.

The joint development project by Hitachi, Ltd. and Tohoku University on a non-volatile RAM employing the SPRAM (spin transfer torque random access memory) has been pursued as a project for the “Development of High-performance and Super-low-power-consumption Memories” by the Ministry of Education, Culture, Sports, Science and Technology aiming for the development of next-generation memories. This technology is a significant evolution from the MRAM (magnetoresistive random access memory), which has been expected as a major candidate for the next-generation memories, with a new principle, the spin transfer torque scheme.

### Progress Made in Practical Application of High-speed, Highly-integrated, Low-power-consumption, Non-volatile RAM

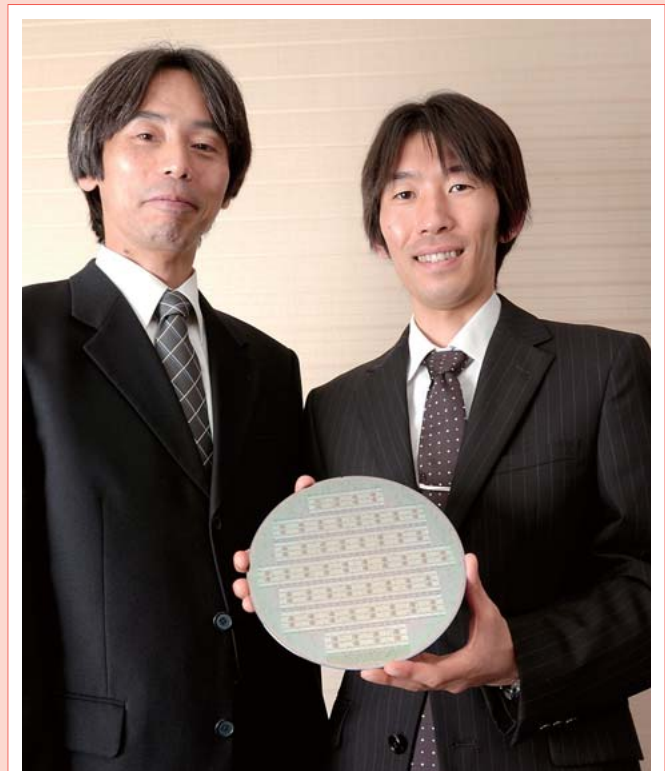
SPRAM records data using the three-tiered TMR (tunneling magnetoresistive) element which the MgO (magnesium oxide) insulation film is sandwiched between the two ferromagnetic films as a memory cell. The key to realize low-power-consumption writing and high-power readout is the MgO insulation film in the TMR element, which has been independently developed as an element technology suitable for the spin transfer torque scheme.

Data readout is achieved by taking information of zero and one through the use of the difference in electrical resistance when the two ferromagnetic films have the same (parallel) magnetization direction or when they have reverse (anti-parallel) directions when the electric current between the two cases is applied perpendicularly. To write the data, electric current is applied perpendicularly to the TMR element. The direction of magnetization in a ferromagnetic film is reversed by the spin effect, which is a magnetic characteristic of electrons. In this technology, unlike the magnetic-field-based reversal method used in normal MRAM technologies, higher integration and lower power consumption are allowed simultaneously in theory because, as smaller the TMR element becomes, less power is needed to write. The technology provides writing/readout performance and rewritability comparable to a DRAM, and has non-volatility to retain the stored information even when there is no power, as with a flash memory. This is indeed perfect to become a universal memory.

### Potential Innovation in Performance of Digital Equipment

SPRAM has the potential to significantly improve the reliability and the performance of digital equipment by replacing conventional memories to simplify the memory structure. We will make steady progress for scheduled realization of 2010 or later, wishing our customers to enjoy more convenient and higher-performance Hitachi products.

Amid the fierce worldwide development race, this joint research project achieved the world-leading outcome, creation of a 2-Mbit chip prototype in about five years from the initiation in 2002, partly because Hitachi and Tohoku University have worked on creation of the prototype in close cooperation, taking advantage of their respective strengths. Through this strong partnership, two organizations will further focus on research of new memory principles with a view to the subsequent generations.



Takayuki Kawahara, Ph. D. (left), Chief Researcher, System LSI Research Department, Central Research Laboratory; Jun Hayakawa, Ph. D. (right), Senior Researcher, Nano System Laboratory, Advanced Research Laboratory



## “Life Microscope” and “Business Microscope”

Innovations with Sensor Network Technologies to Renovate Life and Business

Sensor network technologies to collect sensor-measured data via wireless networks have been in use already. “Life Microscope” and “Business Microscope” are systems to support innovations in lifestyles and working styles by recording and visualizing day-to-day activities as well as daily rhythm and communications at the office.

### Visually Understand the Daily Rhythm

New issues emerging in the era of information explosion are how to utilize smaller and higher-performance computers and increasingly-expanding higher-speed communication networks, and what values could be provided through such utilization. As an answer to these issues, Hitachi has been looking to sensor network technologies, which are designed to automatically collect and utilize data measured through the use of various sensors, wireless communication capability and battery-operated small terminals installed in any given locations. “Life Microscope” and “Business Microscope” are intended to create new values by applying to people the technology, which has already been commercialized in services for properties and buildings, such as temperature control in production facilities.

“Life Microscope” is a system to automatically estimate the amount of physical activities, number of steps, sleeping hours and others, for the day based on data of the acceleration, pulse, and temperature, which are measured 20 times per minute by the wristwatch-type terminal worn on the wrist. Possible applications of the collected data include, among others, watching over the elderly and helping healthcare. For example, “Life Tapestry,” a chart of color-coded daily activities, will visualize daily rhythm that people are usually not very aware of, helping the users review their lifestyle or monitor their health.

### Assistance in Personal Transformation of the Working Style

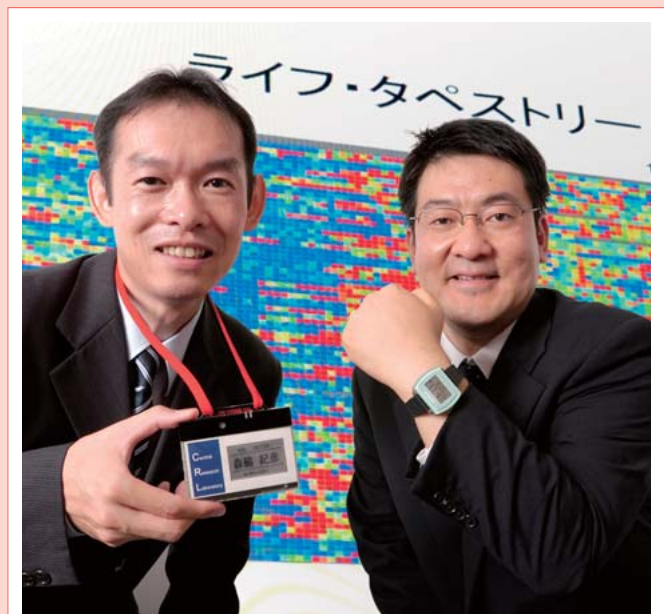
On the other hand, “Business Microscope” aims to enhance the productivity of intellectual workers through the utilization of sensor networks in a business context. A name-tag-shaped terminal equipped with an acceleration sensor, as well as an infrared sensor and an audio sensor, measures data to estimate and display the time used for communication among members of an organization and other activities in a picture similar to a topographical map. For example, it allows quantitative analysis of the organizational dynamics in a successful job so that users can learn from examples of success objectively. Hitachi wishes to eventually materialize a new working style that facilitates personal growth and transformation by giving an opportunity to look back at the personal activities and business approaches as an organization.

Measured data is just a figure or wave pattern in either of these systems. In order to convert such data into information valuable to users through creative ingenuity in analytical processing or display, a vertically-integrated development system is adopted to take advantage of extensive knowledge within the Hitachi Group including information processing and user interfaces.

### Potential Held by “Microscopes” of the 21st Century

Since the invention of the microscope in the late 16th century, biology, medicine, and physics have achieved remarkable development. These two systems may be true “microscopes” to help people view personal and organizational activities, which have not been viewable previously, and have the potential to dramatically change life and business styles in the future. With such expectations, Hitachi has worked on research and development efforts.

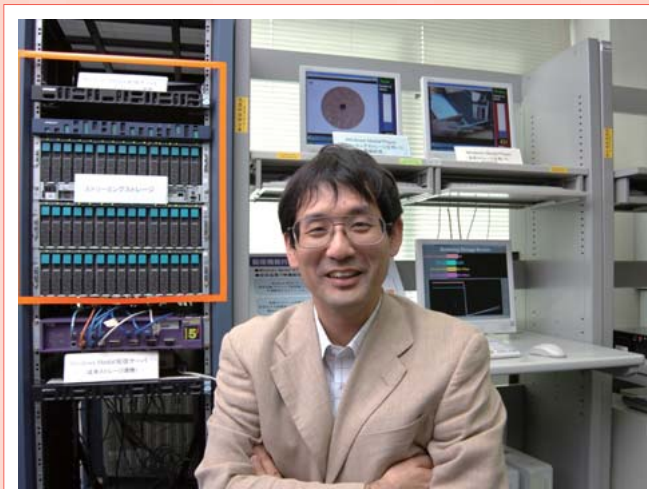
Unlike conventional IT (information technology) devices, which improve the efficiency just by their usage, Hitachi’s “microscopes” support enhancement and reform by the people who are aware of their current problems. Although they are in the course of evolution presently with regard to terminals and applications by experiencing field trials within the Hitachi Group, more people will be involved to use them in the future, allowing the systems to grow together.



Norihiko Moriwaki (left), Senior Researcher, Human Intelligence Laboratory, Advanced Research Laboratory; Shunzo Yamashita (right), Senior Technical Manager, Sensornet Business Department, WirelessInfo Venture Company

## Dedicated Streaming Storage with a Delivery Function over Three-fold Improvement in Concurrent Delivery of Video-on-demand Content

The growth of video delivery services has led to increasing demand for streaming delivery systems that can reliably deliver large volumes of high-quality data to multiple users at the same time. The newly developed “dedicated streaming storage with content delivery function” provides a video delivery service that can handle greater volume and higher quality while reducing equipment and maintenance costs.



Tadashi Takeuchi, Senior Researcher, 3rd Research Department, Systems Development Laboratory

### Proprietary Special-purpose OS and “Zero Copy I/O”

The storage system uses an OS (operating system) that was developed by Hitachi, Ltd. specifically for streaming applications and that incorporates functions for transmitting content over a network very accurately and efficiently. All users need to do is to replace the storage system in their existing servers with this optimized storage. No additional server or software changes are required. Conventional streaming systems typically copy the data to be delivered into the application and then have the OS read and transmit this data. When transmitting content such as high-resolution video with its large data volume, the processing load associated with this copying degrades the performance of the servers. The new storage system solves this problem by sending content files directly from storage, without first copying the data to an application. This eliminates the overhead associated with this data transfer and provides significantly better delivery performance. The mechanism is called the “zero copy I/O (input/output)” high-speed content delivery function. The result is better than three-fold improvement in delivery performance, and because only one third as many servers are required compared to previous systems, this provides significant cost savings.

### High-precision Delivery Timing Control

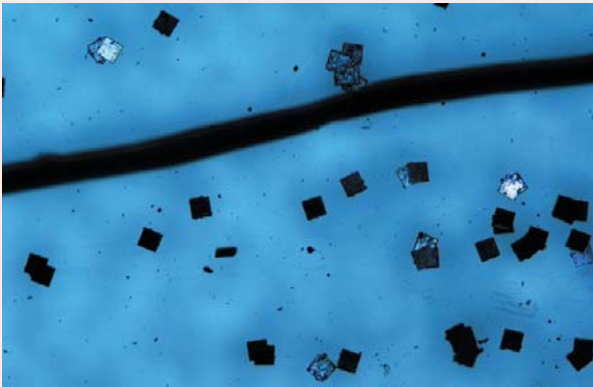
Another technical feature of the system is the high-precision “delivery timing control” technology. Delivery servers usually perform various other tasks in addition to content delivery and this may interfere with the strict timing control required for high-volume content delivery. Hitachi has mitigated the impact of delivery delay due to the CPU (central processing unit) load by scheduling tasks based on a content delivery schedule for each user which is generated by the OS beforehand. Using this timing control function allows delivery of HD (high definition) quality content with assured quality. Conventional servers typically perform task switching every 100 ms which results in coarse transmission control and requires a large volume of data to be sent in each delivery operation. This can lead to data loss and resultant image degradation if the receiving terminal is incapable of handling such a large volume of data. In contrast, the new storage system controls the transmission timing in 1 ms increments which means that data is sent in smaller chunks and can be reproduced with its original HD quality.

### Meeting the Need for High-performance Delivery Servers

The spread of broadband networks and advances in digital consumer electronics mean that people can now view the Internet on TV (television). The image quality of video has increased dramatically and the volume of streaming data has grown by an order of magnitude. Accordingly, server capacity has now become a major bottleneck in delivery. Whereas the practice in the past was for content providers to distribute their content on a PPV (pay per view) basis, a recent trend has been for people to watch free content produced by general consumers who have made it available on the Internet. As content providers move to rely more on advertising revenue than PPV, they need to deliver large volumes of content to ensure their profitability. This increases the demand for servers that are capable of high-performance delivery. Although systems that are fully compatible with Windows Media\* server are the current standard, Hitachi plans to add additional functions to support various different formats in the future to meet this growing market demand.

\* See “Trademarks” on page 90.

## Operation of World's Smallest Class Noncontact RFID Powder IC Chip Successfully Tested



Noncontact RFID powder IC chip (upper) and comparison with a strand of hair (lower)

Hitachi has successfully tested the world's smallest- and thinnest-class noncontact RFID (radio-frequency identification) powder IC (integrated circuit) chip which measures 0.05 mm per side and is only 5  $\mu\text{m}$  thick. The aim is to embed the chip in thin paper, a practice that is already in general use.

This small size and thinness are achieved using an SOI (silicon on insulator) semiconductor process with a minimum line width of 90 nm. To improve reliability and provide higher density, electron beam direct lithography technology is used to record the ID (identification) number. The IC chip also has a double-sided electrode structure with electrodes on both the top and bottom of the chip to facilitate connection of the antenna. These technologies are expected to be seen in a wider range of applications.

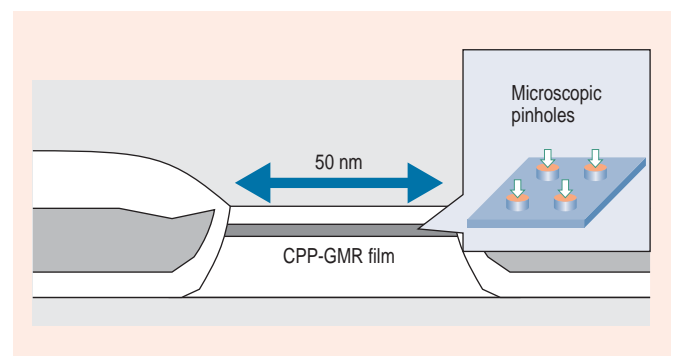
## World's Most Sensitive CPP-GMR Head for HDDs

Hitachi, Ltd. has developed technology for the world's most sensitive\* CPP-GMR (current-perpendicular-to-the-plane giant magnetoresistive) head that can dramatically increase the recording density of HDDs (hard disk drives).

[Main features]

- (1) Process can form 50-nm-wide sensors.
- (2) Artificial lattice film can form nanometer-size pinholes.
- (3) Recording density of 382 Gbit per square inch (about 6.45  $\text{cm}^2$ ) confirmed in prototype testing. This is almost double the capacity of current products.

This technology is expected to allow HDDs to be produced with a recording density of 750 Gbit per square inch, and is now under development in collaboration with Hitachi Global Storage Technologies.



Structure of the media-facing surface in the CPP-GMR head

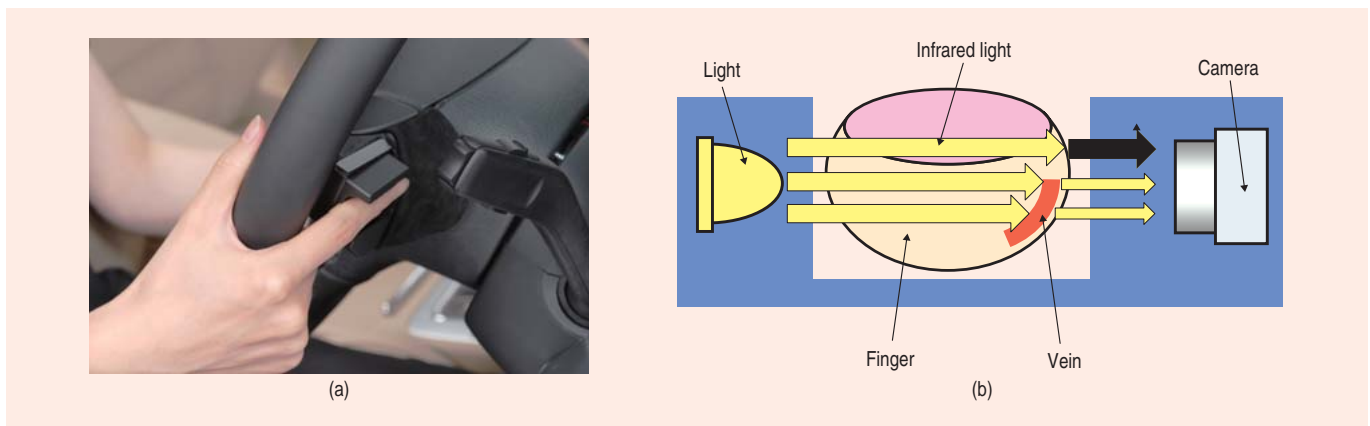
\* As at April 2008.



## Finger Vein Authentication Technology for Steering Wheels

Hitachi has developed a new type of finger vein authentication technology that can verify an authorized driver when they grip the steering wheel. Unlike existing technology, the new technique uses the finger vein pattern from the side of the fingertip. This allows for compact designs in which the finger is sandwiched between a light source and camera with no components below the finger, making the unit small enough to install in something as thin as a steering wheel. As IT (information technology) systems become increasingly integrated into automobiles, this technology is expected to play an important role in preventing unauthorized access to future car information systems. As well as preventing car theft, possible applications include authorizing automatic pay-

ments in drive-through shops or payment for music downloads to car audio systems. The system can also be used as a multi-function switch by assigning different functions to each finger. For example, one finger could be used to set the seat, side mirror position, air-conditioning, and other driving settings for the verified driver, and another finger could be used to operate the car navigation or car audio system. The big advantage of a finger-based interface is that it does not require the driver to look down at the control panel to find a particular button. This makes for safer driving and a natural driving position. Hitachi intends to commercialize the technology in various applications, beginning with automotive products.

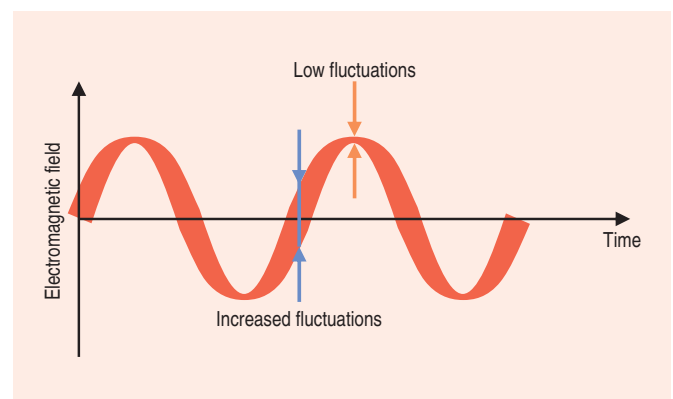


System prototype (a), and finger vein imaging principle (b)

## Secure Optical Communications Using Antisqueezed (Fluctuation-controlled) Light

Cyber security is an increasingly important issue and is likely to remain so in the future. Similarly, secure optical communications will also be in demand in the future. Hitachi is proposing a new technique that uses antisqueezed light to achieve secure optical communications based on considerations of quantum information physics. Antisqueezed light is fluctuation-controlled light that is synchronized with an oscillating electromagnetic field. The light component with large fluctuations makes eavesdropping difficult while the low-fluctuation component allows ordinary communications for a legitimate sender and receiver using a seed key. Antisqueezed light is tolerant of loss and amplification, and systems that use antisqueezed light can potentially be installed on present optical fiber networks. This ability to be used under realistic conditions is a crucial difference between this technique and quantum cryptography. Because Hitachi can generate antisqueezed light using a laser diode, optical fiber, and other standard fiber optic components, the system is capable of being introduced on existing fiber networks. Hitachi has also demonstrated secure optical com-

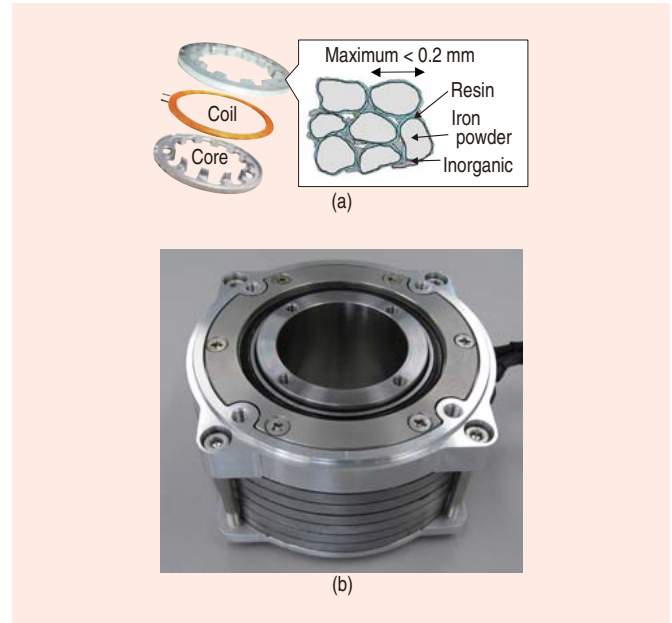
munications over a 100-km fiber channel. This work was partly supported by the Special Coordination Funds for Promoting Science and Technology.



Schematic antisqueezed light

## Permanent Magnet Motor with New Core Design Made Using Powder Iron Composite

Electric motors are widely used in industry due to their high efficiency, and improvements in materials, manufacturing, and design technology have led to motors being made progressively smaller. New materials such as rare-earth magnets have led to significant breakthroughs in motor design, resulting in motors with better performance characteristics. The advantages of powder iron composites include lower eddy-current losses and more flexibility in designing the motor core shape. Hitachi has developed a new permanent magnet motor using a powder iron composite core. Motor cores are typically made of laminated magnetic steel sheets and coils are wound around the laminated core to produce the electromagnetic effect. However, these coil windings may result in less efficient space usage. In response, Hitachi has developed different core and coil shapes that improve this. In the new motor, space is saved by sandwiching a formed coil between two iron cores with claw-shaped parts made of a powder iron composite. This design was selected based on three-dimensional magnetic field analysis. The new motor is significantly smaller than conventional motors and is suitable for use as an embedded motor in electric-powered systems.



Coil and core configuration (a) and new design motor (b)

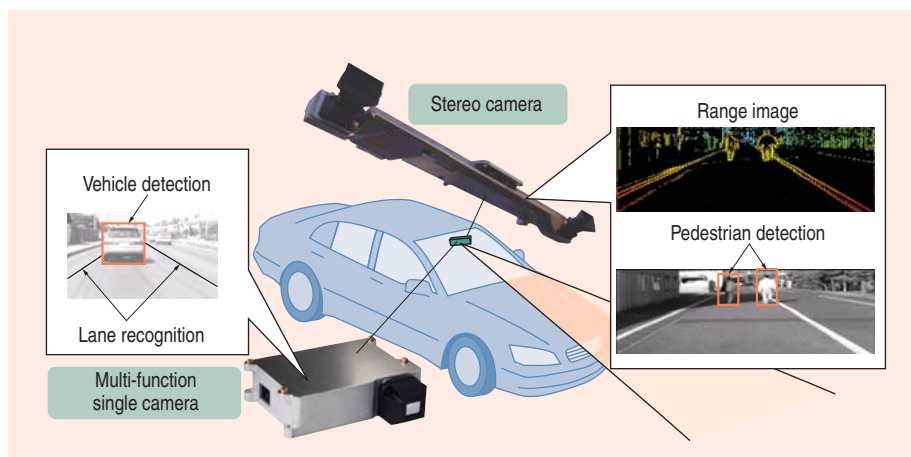
## Image Recognition Technology for Safer Vehicles

New image recognition technology has been developed for detecting potential collisions between vehicles and pedestrians. Two new in-vehicle camera systems have been developed, as follows:

(1) A single low-cost camera system for lane recognition, preced-

ing vehicle detection, and other basic sensing functions

(2) A stereo camera\* system that can obtain distance information by applying stereoscopic techniques to the two camera images and use this to detect pedestrians and avoid obstacles



Single camera and stereo camera for sensing vehicle surroundings

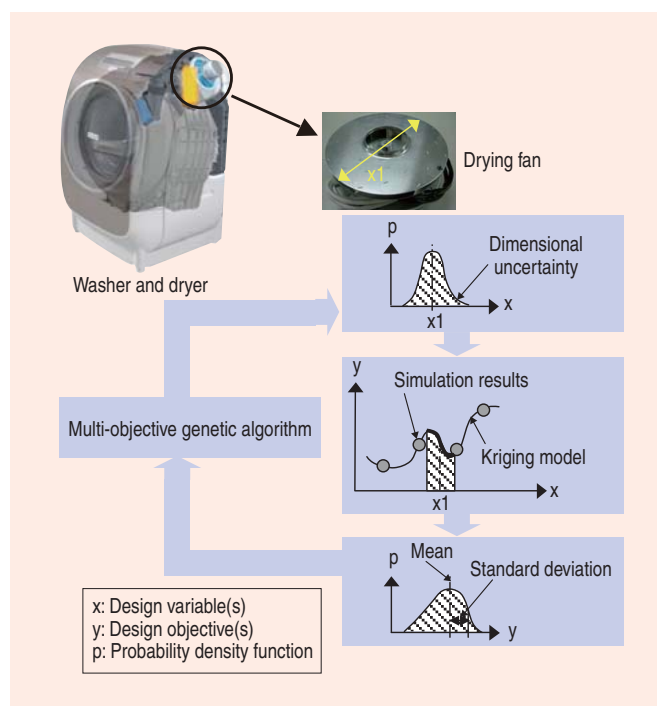
Both camera systems use proprietary image processing hardware with locally parallel processors to perform complex computations in real time. The need to sense the surrounding environment to avoid or reduce collision damage is a common requirement of intelligent drive control systems. Advanced image recognition techniques have a significant role to play in these systems and development of the technology will continue in the future.

\* The stereo camera is being developed jointly with Fuji Heavy Industries Ltd.



## Multi-objective Robust Design Optimization Technology for Turbomachinery

In collaboration with Tohoku University, Hitachi has developed a practical design optimization method able to handle production uncertainties. Optimization problems are often characterized as a hill-climbing problem where the design objectives are related to design variables. While traditional optimization methods only aim to climb the hill to the summit, this new method not only evaluates the heights of the hills, it also evaluates variations in the height of the surrounding area so that the robustness of the design objectives with respect to perturbation of the design variables can be optimized simultaneously. This method is based on a multi-objective genetic algorithm combined with a Kriging surrogate model. The Kriging model uses interpolation of the simulation data to reduce drastically the necessary number of simulations and achieve a practical design turnaround time. Hitachi has applied this method to the design of a fan for a washer-dryer with the aims of improving fan efficiency and reducing noise level. Assuming a certain level of dimensional uncertainty in the mass-produced fan, the method was used to optimize the mean and standard deviation of the design objectives' distribution and obtain hundreds of optimum design candidates. The designer is then able to choose the design candidate that best matches other design requirements such as quality, yield, peak performance or a balanced combination of these objectives.

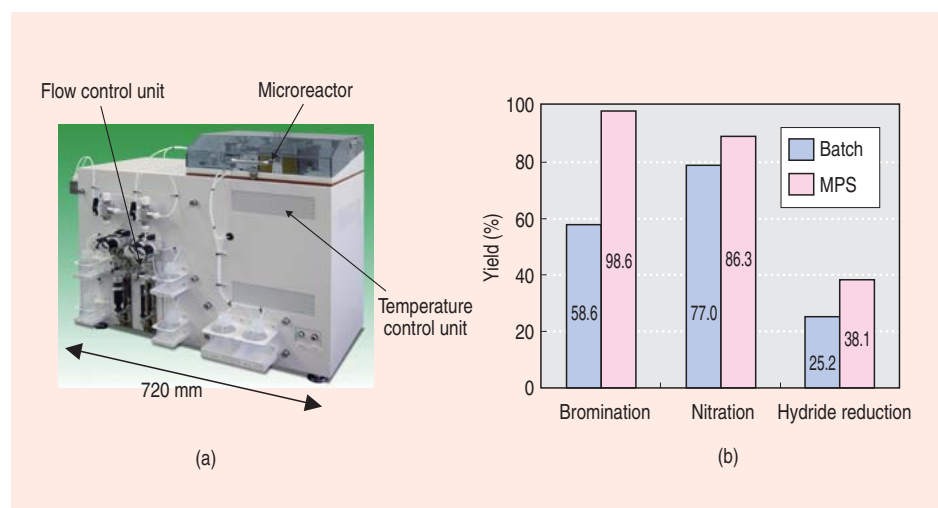


Flowchart of multi-objective robust design optimization

## Chemical Process Innovation Using a Microreactor

A microreactor is a device that enables chemical reactions to be performed on a micro-liter scale. The potential advantages of using a microreactor rather than a conventional reactor (batch process in a stirred vessel) include better control of reaction conditions, improved safety, and improved yield. "Better control of reaction conditions" refers to the ability to control precisely the tem-

perature of the reactor. This is a direct result of the reactor's extremely high surface-to-volume ratio. The improved safety results from the reactor's extremely small size. In cooperation with Hitachi Plant Technologies, Ltd., Hitachi, Ltd. has developed a microreactor system called MPS (micro-process server). The micro-process server is 720 mm wide, 588 mm long, and 459 mm high. It



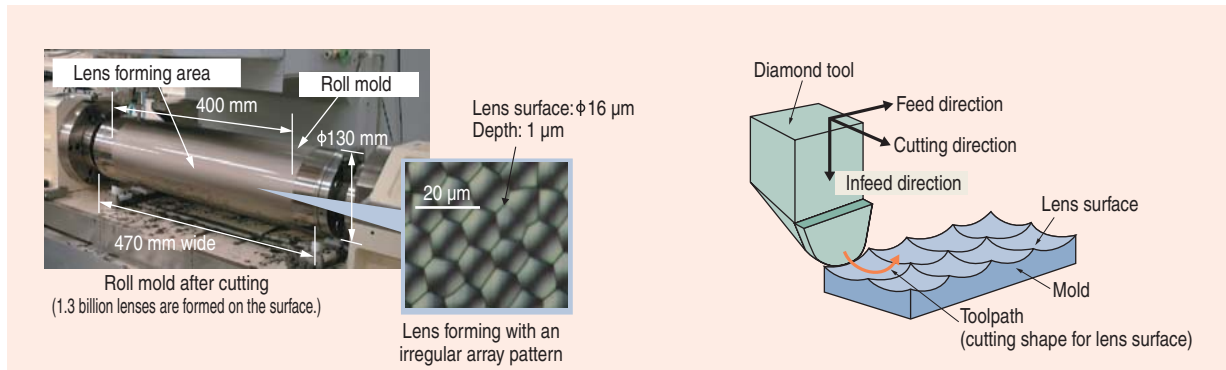
MPS (a) and yield of main product (b)

consists of a microreactor, a flow control unit, and a temperature control unit. The microreactor can be swapped to allow different microreactors to be used for different chemical processes, such as reaction, mixing, and emulsification. Hitachi tested the system on the following three consecutive reactions: bromination of dimethyl phenol with bromine, a nitration reaction of phenol with nitric acid, and a reductive reaction of diisobutylaluminium hydride. The results showed that use of the microreactor improved the yield of the main product by up to 40%.

## High-precision Cutting Technology for Fabricating Roll Molds Used to Produce Optical Film with a Microlens Array

Hitachi has developed technology that uses high-precision cutting with a diamond tool to fabricate roll molds for the production of optical film with a surface covered by a closely packed array of microscopic lenses (microlenses) measuring 10–20 μm in diameter. The technology uses a new roll mold fabrication device with a high-speed/high-precision cutting head that is piezo-actuated. The

device can form approximately 4,000 lenses per second on the surface of the mold and can produce an irregular array pattern on the roll mold surface that consists of about 1.3 billion lenses. This technology is used at Hitachi Chemical Co., Ltd. for the molds used to produce optical films for liquid crystal displays.



Roll mold after cutting and lenses formed on roll (left), and cutting process used to form lens surfaces on mold (right)

## Advanced AFM that Realizes Accurate 3D Shape Measurement of Nano Devices at High-speed

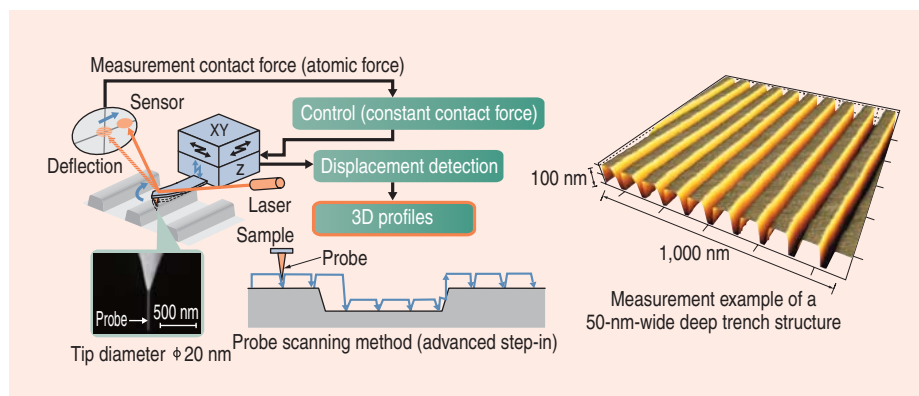
AFMs (atomic force microscopes) measure extremely small 3D (three-dimensional) shape by tracing a sample with a very thin and precisely controlled probe. Despite this capability, their use had traditionally been restricted to experts in laboratories.

In defiance of this stereotype, Hitachi has developed a technology that allows high-speed and high-precision automatic measurement of 3D structures with tens-of-nanometer dimensions. The unique probe scanning method (advanced step-in) simultaneously improves speed, accuracy, and usability.

This technology was commercialized in March 2007 in coopera-

tion with Hitachi Kenki FineTech Co., Ltd. The equipment is crucial to the production of nanodevices such as semiconductors.

This article partially belongs to the Terabyte Optical Storage Technology project that the Optoelectronic Industry and Technology Development Association (OITDA) contracted with the Ministry of Economy, Trade and Industry (METI) in 2002 and has contracted with New Energy and Industrial Technology Development Organization (NEDO) since 2003 based on funds provided by the METI.



AFM principle of operation (left) and measurement example (right)

## High-definition Camera Image Processing LSI

As HDTV (high-definition television) becomes more and more popular among consumers, the demand for high-definition camcorders is increasing. In response to this demand, Hitachi released a high-definition BD (Blu-ray Disc) camcorder in August 2007. A key component of this camcorder is a new camera image processing

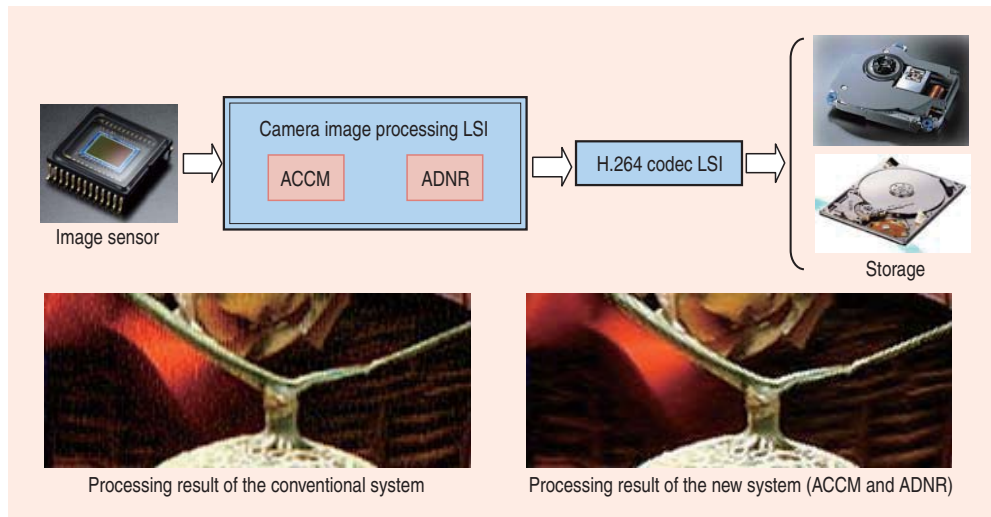
LSI (large-scale integration) developed by Hitachi that can handle full-HD image signals.

Signals from the image sensor are converted into digital image signals by the camera image processing LSI. This LSI includes the following two novel technologies to improve picture quality.

(1) ACCM (advanced correlative coefficient multiple method): An algorithm to reduce color aliasing that occurs on fine textures

(2) ADNR (advanced dynamic noise reducer): An algorithm to reduce random noise without degrading the resolution of the original image

By using these algorithms, Hitachi successfully reduced image noise by half compared to the conventional system.



BD camcorder system (upper) and results of using ACCM and ADNR (lower)

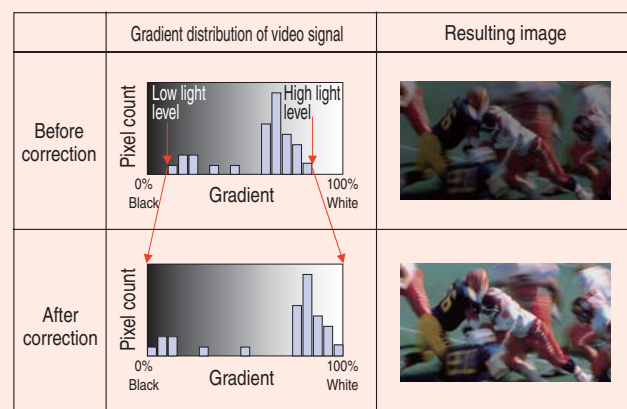
## High-definition Display Technology for Mobile Displays

Hitachi has developed a high-definition display technology for mobile phones that use OLED (organic light-emitting diode) displays. OLED displays feature high contrast and excellent color reproduction characteristics, vivid color reproduction, and can display dark areas of the image with a level of detail and bright areas with a sparkling quality that is not possible with LCDs (liquid crystal displays).

A technique that expands the contrast of video signals scene-by-scene based on the gradient distribution of the input video signal was developed to utilize the high contrast performance of OLED displays.

However, because power consumption is proportional to brightness, the system minimizes any increase in power consumption by estimating the increase in brightness that will result from contrast expansion processing and turning this function off in cases when it will cause significantly higher brightness.

In order to reproduce images with deeper color than LCDs, the system may generate colors that differ from those in the original content. Accordingly, color management is used to achieve high-fidelity color reproduction. Hitachi will proceed with development of high-definition display technologies that can be used with the latest display devices.



Contrast expansion processing



Color management for OLED displays

High-definition display technology for mobile displays