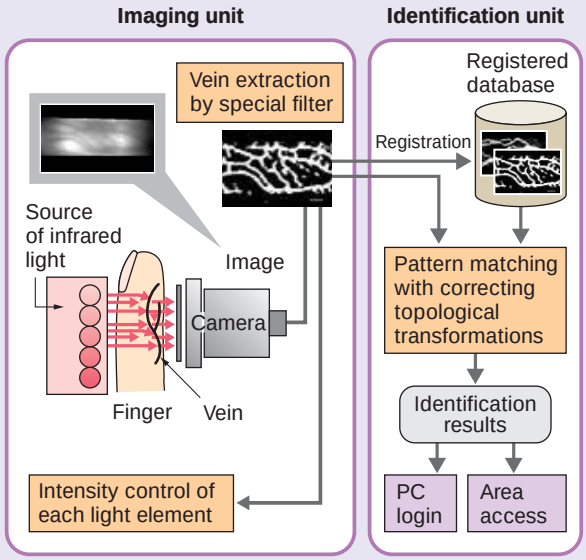
# Research & Development

Research and Development

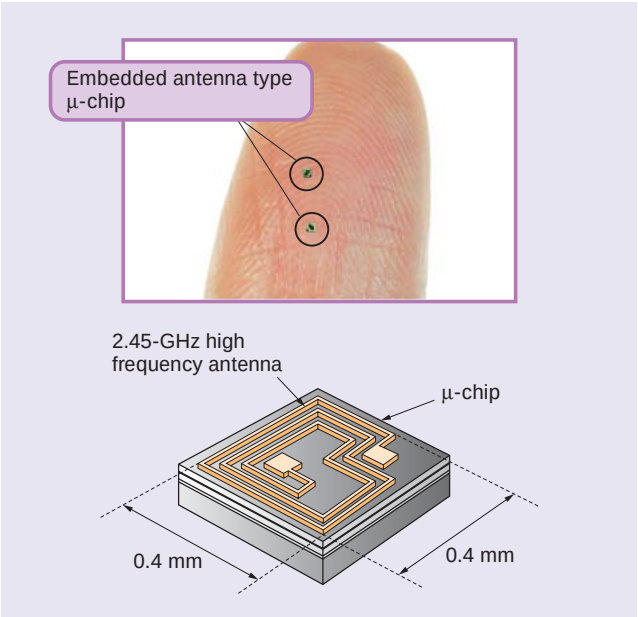
# Small, High-speed and Highly Accurate Personal Identification System Using Finger Vein Patterns

Hitachi has developed an advanced technology for personal identification using finger vein patterns. This system will enable downsizing and improve the speed and accuracy of identification. This new system is 1/3 the size, 10 times faster in identification speed, and ten times more accurate in identification accuracy compared to Hitachi's previous model, reaching the world's highest level in speed and accuracy of personal identification.
Of all the many previously proposed biometrics methods, finger vein pattern identification is the only method that uses the internal characteristics of the human body. This makes impersonation difficult, if not impossible. Finger vein pattern identification has recently attracted considerable attention as a promising biometrics method for the next generation. Owing to this advanced technology, we expect that finger vein pattern identification systems will be widely used in physical and cyber security systems with high security requirements in the near future. Such systems include area access control systems, PC login systems, etc.




Principles of finger vein pattern identification

# Ultra-small Radio-frequency Identification Chip: Embedded Antenna Type μ-chip




Chip photograph (above) and graphical structure of high frequency antenna embedded μ-chip (below)

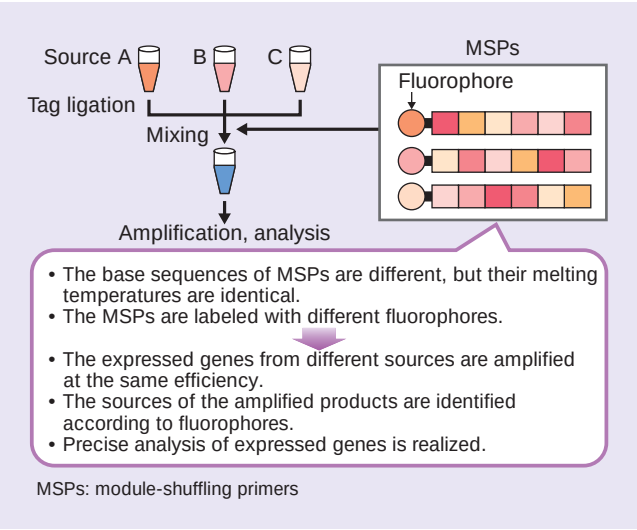
Hitachi has developed a 2.45-GHz, high-frequency, ultra small ($0.4 \times 0.4$ mm$^2$) antenna, embedded in an ultra-small IC chip [μ-chip (mu-chip)], for radio frequency identification. Hitachi's conventional general purpose type μ-chip needs an external antenna to transmit the 128-bit identification number inside the chip. In this new type μ-chip, only a small IC chip is required for battery-less data transmission operations, because the embedded antenna on the chip is able to receive electromagnetic power from the reader. This development enables radio-frequency identification devices to be easily inserted inside a bank note or gift card. Furthermore, this feature also enables the identification devices to be attached to a narrow surface, or inside thin materials. The embedded antenna is formed by using gold plating technology, widely used in the fabrication process of packaging connection terminals on semiconductor wafers. Therefore, the antenna is not only ultra small, but also very easily made on the wafer by the fine and batch antenna forming process. The circuit design and semiconductor process technology are the same as those used for conventional μ-chips.

# Method for Precise Comparison of Expressed Genes in Various Tissues

To understand the mechanism of living organs it is essential to measuring the expression levels of the genes in various tissues or cells. We have developed a new method, based on the multiplex PCR (polymerase chain reaction) for the comparative analysis of gene expression levels. This method can be used to analyze plural genes from various sources by using color-selective detection, coupled with size separation. The color-selective detection distinguishes the sources and the gel electrophoresis separates the gene species.

Hitachi performed competitive PCR amplification of the expressed genes from different sources by using three kinds of MSPs (module-shuffling primers) labeled with different fluorophores. The MSPs consist of sequence modules of 3 or 4 nucleotides. These modules are arranged in different orders in each primer. Therefore, the base sequences of the MSPs are different, but their melting temperatures are identical. The genes, expressed in different sources, are ligated with tags complementary to the MSPs. These tag-ligated genes are mixed in one tube and amplified at the same amplification efficiency using the MSPs. The amplified products are detected by multiple-color gel electrophoresis. This method can detect different amounts of each expressed gene, up to a difference of 30%, and its detection limit is $10^{-19}$ mol per assay.

This work was performed as a part of a research and development project of the Industrial Science and Technology Program, supported by NEDO (New Energy and Industrial Technology Development Organization), Japan.



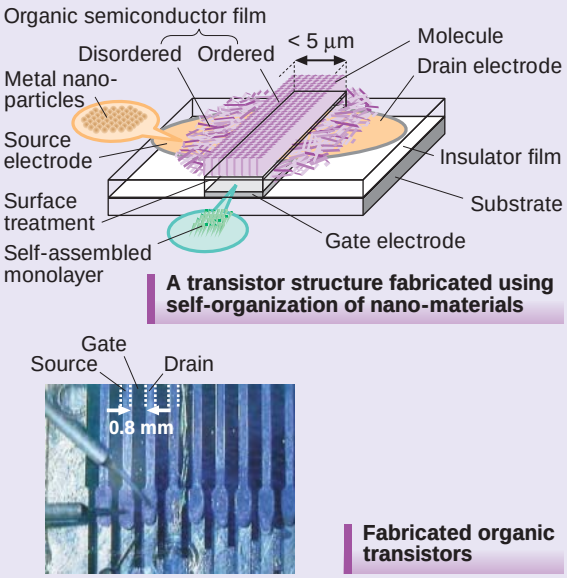

Principle of comparing gene expression levels using module-shuffling primers

# Rice Growth Imaging System

Systematic and comprehensive measurement of whole plant phenotypes is necessary now that rice genome sequencing is nearly complete, because we cannot predict when and where changes in the plant form will emerge in the growth process. To solve this problem, Hitachi developed a new automatic digital imaging system to acquire images of rice seedlings during the growth process. We cultivated 30 plants in test tubes and collected images every five minutes from the germination points. This system captured a series of 2,000 growth image sequences for each plant for about one week. We continuously measured the leaf length from these sequential images. These continuous leaf length measurements made it possible to quantitatively express the precise growth process of rice plants, from the leaf-emergence interval, the duration of leaf elongation, to the growth rate of leaf elongation. Using this method and instruments, the correlation between the growth process of rice plants and specific gene functions will be clearly defined in the future. This systematic phenotypic profiling method may advance our understanding of the biological procedures in plant growth and development, and may contribute to the production of new and better varieties of rice. This work was partly supported by the Rice Genome Project SY-1108.

Automatic digital imaging system to acquire images of rice seedlings during the growth process

# New Fabrication Process that Uses Self-assembly of Nano-materials to Construct Organic Transistors

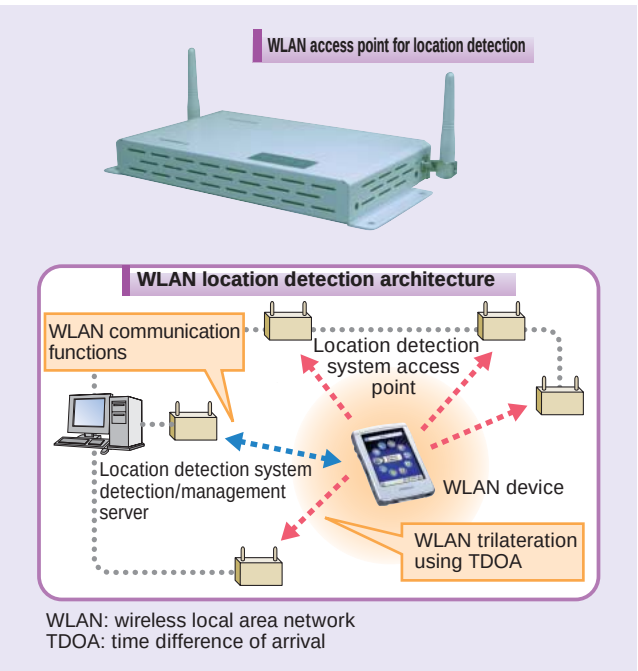



Transistor structure fabricated using self-organization of nano-materials (above) and fabricated organic transistors (below)

Hitachi, Ltd., the National Institute of Advanced Industrial Science and Technology, and the Optoelectronic Industry and Technology Development Association (OITDA), have developed a novel fabrication process for organic transistors, suitable for the mass production of electronic paper, and an indispensible device for ubiquitous mobile communication systems. This process uses a "self-assembly" phenomenon in which nano-materials such as nano-particles and organic molecules are self-assembled into a device structure. Solution-processed source/drain electrodes self-align to form a gate electrode, using a hydrophobic SAM (self-assembled monolayer), optically patterned to the gate structure using a back substrate exposure technique. Organic semiconductor film, deposited on the patterned SAM selectively orders and essentially self-aligns itself to the gate electrodes. This is called the "SALSA (self-aligned self-assembly) process." As a result, high-definition device structures with a minimum pattern size of less than 5 µm can be printed on glass and plastic substrates without using conventional photolithographic processes.

A part of this work belongs to the "Advanced Organic Device Project" under contract to OITDA and the New Energy and Industrial Technology Development Organization (NEDO).

# Wireless LAN Based Location Detection System




Location detection system access point and architecture

"Location" is basic and important information. Wireless LAN plays an important role in the development of mobile navigation systems in today's technocratic society.

Hitachi WirelessInfo Venture Company has developed a new location-sensor system. Hitachi's location detection system has a detection accuracy rate of 1-3 m*, in both indoor and outdoor situations using wireless LAN infrastructures. The location detection system covers many applications in more than 12 industrial market segments, such as the public sector, the retail sector, logistics, security, etc. Hitachi will improve this location detection system to provide seamless services with GPS (global positioning system), hybrid barcode/RFID (radio-frequency identification) reader solutions, and future "sensor networks."

* environmentally-dependant

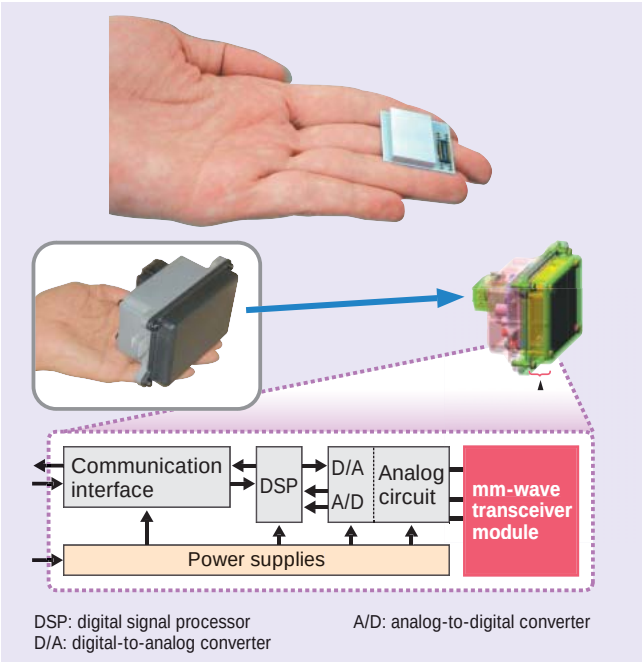
# Transceiver Module Technology for Low-cost Millimeter-wave Automotive Radars

Hitachi has developed technology to realize small-sized, low-cost, millimeter-wave(mm-wave) transceiver modules for automotive radar applications. Mm-wave, forward-looking radars have recently been introduced into the market for adaptive cruise control systems that can automatically adjust the car's speed and distance to that of the preceding cars by measuring their location and relative velocity using of 76-GHz electromagnetic waves.

In order to gain broader market acceptance of these radars that enhance driving safety, however, it is required to improve the cost/performance of mm-wave transceivers .

This new technology will provide the means to house all mm-wave transceiver components, including MMICs (monolithic microwave ICs) and antennas in a multi-layer ceramic substrate, reducing the volume of the transceiver module by a factor of 5. It will also reduce the number of parts and allow for easy assembly without compromising radar performance, when compared to conventional metal housing technologies. The module incorporates several key features such as low-loss, wideband interconnects, planar antennas, a filtering lid to keep signal interference at a –100-dB level between the transmitting and receiving ports, and to offer flexibility to radar unit configurations.

This technology can easily be applied to lower frequencies.




Newly developed transceiver module (above) and current radar unit in production with its configuration (below)

# World's Smallest Single-chip, 40-Gbit/s Optical Transmitter

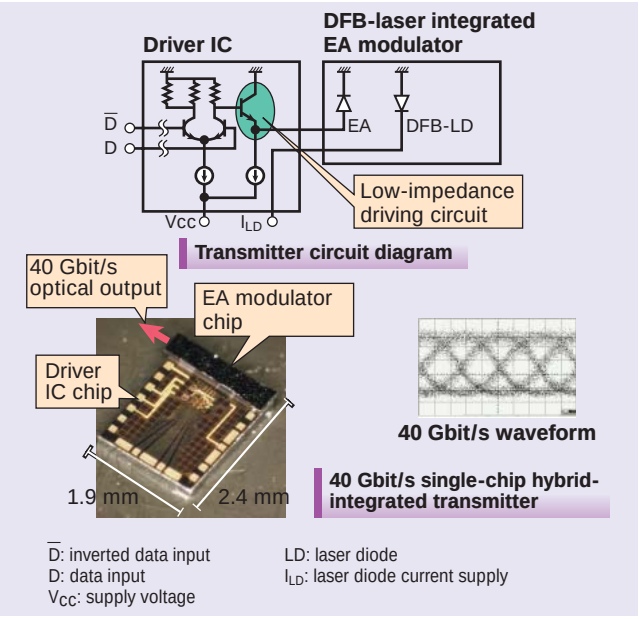
The world's smallest 40-Gbit/s optical transmitter has been developed for use in the ever-growing metropolitan optical networks, where reduction of size and power consumption of the optical transmitter are urgently needed to support the explosive growth in communication traffic.

The chip size of the prototype 40-Gbit/s hybrid-integrated transmitter is only 2.4 × 1.9 mm, and the drive voltage for the semiconductor EA (electro-absorption) optical modulator in the transmitter is 0.7 V, which is one-third of the previously reported drive voltage. Both size and voltage are world records for 40-Gbit/s-class optical transmitters, and are made possible by Hitachi's unique breakthrough technology.

(1) Hybrid integration technique: The optical modulator chip, monolithically integrated with a DFB (distributed feedback) laser source, is mounted directly on the driver IC chip in order to reduce the transmitter size, and eliminate the need for impedance matching between the two chips.

(2) Low-impedance drive technique: Since impedance matching is no longer needed, a very low-impedance modulator drive circuit is used to break the RC (resistance-capacitance)-limit barrier. A low-voltage optical modulator with larger capacitance can now be used to significantly reduce power consumption.

This work was supported by the Telecommunications Advancement Organization (TAO, currently NICT: National Institute of Information and Communications Technology) of Japan.




Transmitter circuit diagram (above) and 40-Gbit/s single-chip hybrid-integrated transmitter (below)

# Mobile and Space-saving High-temperature Superconducting Magnetocardiograph System for Heart Disease Screening Tests

Hitachi has developed an HTS (high-temperature superconducting) MCG (magnetocardiograph) system, composed of 16-channel HTS-SQUID (superconducting quantum interference device) magnetometers, and a vertical, magnetically shielded cylinder. This MCG system is designed to save space and provide mobility for the whole system. Currently, the system's footprint is 1 square meter, including the magnetically shielded cylinder.

The MCG system is superior to other heart checkup methods because it can detect electrophysiological activity to measure the magnetic signal from the heart without using invasive procedures or contact measurements. Moreover, MCG will be able to detect ischemic heart disease in the early stages because it can measure the spatial signals from the heart.

The key components of this space-saving system are its highly sensitive HTS-SQUID and open type, vertical magnetically shielded cylinder with sliding doors using FINEMET. MCG systems should soon be widely used for heart diagnostic procedures because they can be installed in small and medium-sized hospitals.

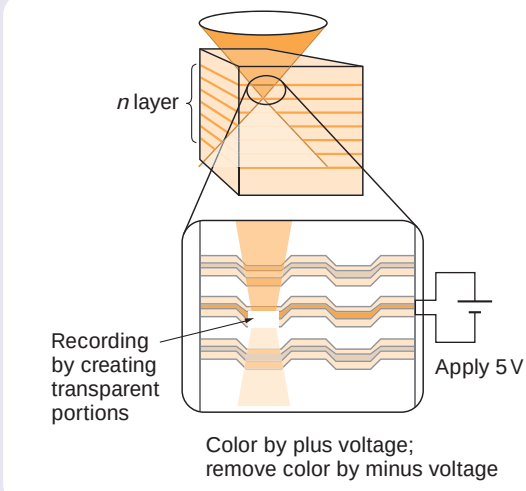
This research was performed under the auspices of the Support Program for Technological Development with the Aim of Practical Use from Japan's Ministry of Economy, Trade and Industry, and the New Energy and Industrial Technology Development Organization (NEDO).

Mobile and space-saving high-temperature superconducting magnetocardiograph system for heart disease screening tests

# Basic Technology for Selectable Super-multi-layer Optical Disks with Tbyte Recording Capacity

Hitachi has developed the basic technology for new-concept recording-layer-multiplexed optical disks. Each recording layer is sandwiched between transparent electrodes, and remains transparent in its basic state by applying a minus voltage. A selected recording layer for recording or reading is colored to absorb laser beams by applying a plus voltage. The portions irradiated by high-power laser pulses lose their ability to color by the generated heat and become recording marks. When another layer is selected, this recording layer becomes completely transparent, including the recording marks. This minimizes the interference between the layers. The recording layer consists of an electro-chromic material layer and an electrolyte layer. Voltage is applied to the disk from a voltage source in the disk-drive apparatus through a revolution-axis and contact electrodes, located between the axis and the disk.

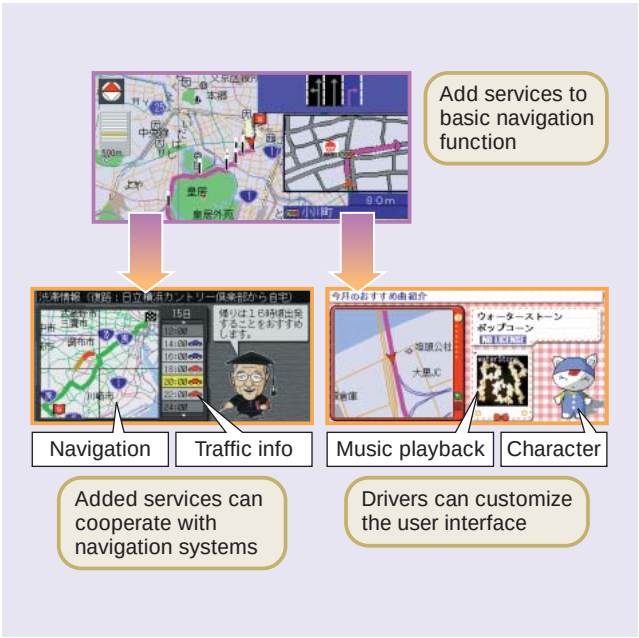
By developing an improved 40-layer disk using this technology, consumers can store 1-Tbyte of information, or about 200 movies, on a disk.




Recording principles of super-multi-layer optical disks using electro-chromism

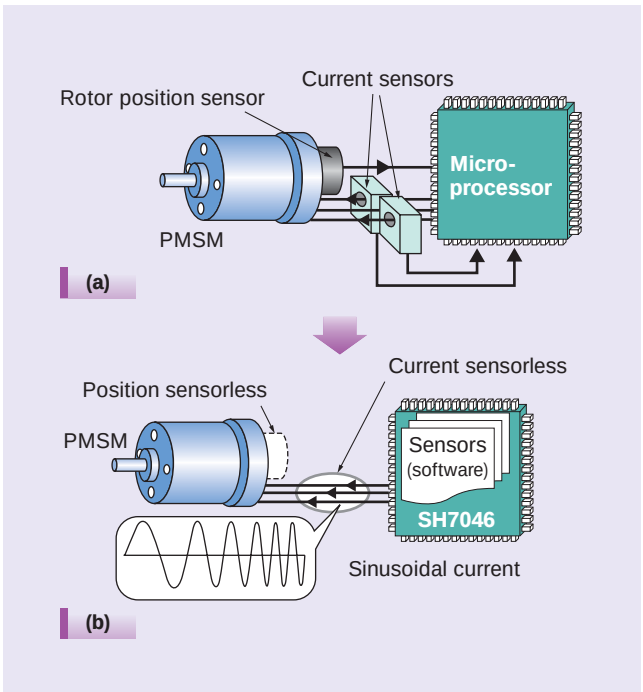
# Next-generation Java-based Telematics Platform

This platform should be situated on an in-vehicle terminal unit, and is part of a telematics system that also maintains remotely located telematics centers to provide terminals with various services through multiple communication lines.
Vehicle drivers want a wider range of services such as POI (point-of-interest) guidance, real-time traffic information ahead, and entertainment. However, a built-in application in a terminal unit can not meet the driver's variously changing demands. To address this point, we have developed a telematics terminal platform, to which new applications can be downloaded, and whose resources are shared amongst many applications.
On the base environment of this platform, Java technology was used to gain a higher compatibility of services between multiple hardware architecture. These services can be dynamically extended and customized by downloading and cooperating with new services, provided from a telematics center through a communication line.
With this platform, drivers can receive services customized to meet their preferences.




Display screen samples of in-vehicle terminal, based on next-generation telematics platform

# Position and Current Sensorless Motor Drive Systems for Home Appliances




Conventional drive system (a) and developed drive system (b)

In comparison with other motors, PMSMs (permanent magnet synchronous motors) will soon be widely used as actuators in many drive applications, because of their small size, high efficiency, and simple commutator-less construction.
Usually, sensors to detect the PMSM's rotor position and motor current are required to drive the PMSMs at random speeds. This is performed with a very high response and accuracy rate. But, expensive sensors are needed to achieve this performance.
Hitachi developed a new motor drive system suitable for home appliances. In this system, the rotor position and the motor current are estimated by our original software algorithm. Consequently, a high performance drive system without using any sensors has been realized. Hitachi has developed this control algorithm for the SH7046 (32-bit RISC) microprocessor.
This drive system is very suitable for home appliances, because of its usefulness and simplicity. Hitachi currently uses this system in its air-conditioners, refrigerators and cordless cleaners. This system will become the standard drive system for PMSMs.

# Ubiquitous Display Solutions

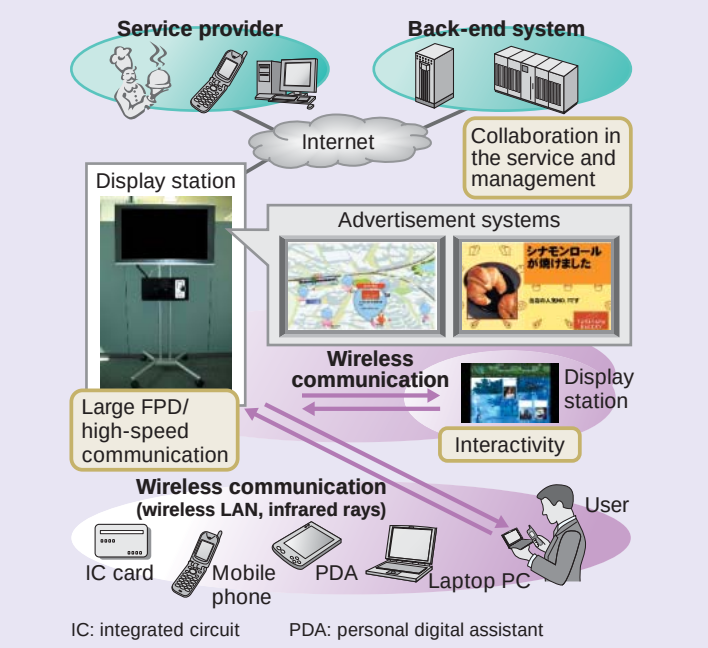
In ubiquitous information communities, it is more important than ever to activate areas using IT-driven and user-participatory information sharing systems. Recognizing this need, Hitachi has developed a ubiquitous display solution that realizes interactive communications between large FPDs (flat panel displays) installed in various locations, and the users' own mobile devices, such as mobile phones, IC cards, and μ-chip cards. This interactivity allows for easy sharing of information among users, service providers, and operators, leading to more active areas and improving the value.

[Main features]

(1) The combination of highly portable and installable large FPD and display stations, with high-speed communication features, offers users new information spaces.

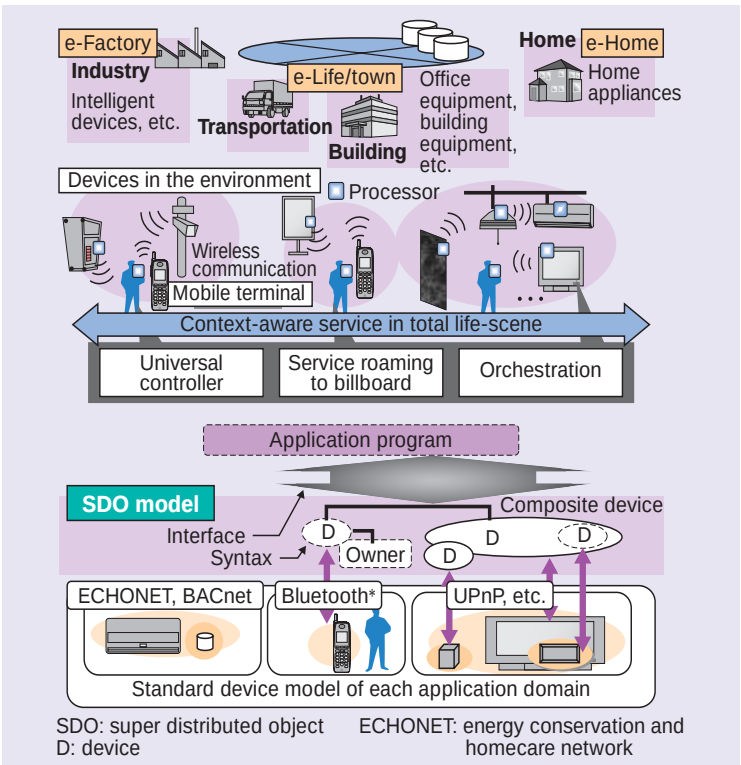
(2) The interactivity between the users' own mobile devices and large FPD allows users to send and receive information easily.

(3) The functional collaboration with back-end systems in management and operation provides users with new services that meet their preferences and lifestyle.




Structure of ubiquitous display solutions

# Super Distributed Objects Based on Autonomous Decentralized System Concept




Much attention is being paid to the ubiquitous information society, where the real world and computer systems are integrated through computerized devices. One of the expected features in this society is context-aware services. Devices cooperate to provide a service, tailored to the end-users, by using detailed information around the users through devices. Several standards that use conventional modeling techniques have been proposed. However, it is difficult to handle devices in a unified way because they are extended by adding peripheral software devices. Hitachi proposes a new object model called super distributed objects that can provide inter-operable descriptions and management interfaces among network standards or multi-vendor devices. Devices manage themselves autonomously, and they are interconnected via the network in an ad hoc manner with this model. The proposed model has been chosen as an international standard by the Object Management Group (The OMG*).

* See "Trademarks" on page 90.

Super distributed objects based on autonomous decentralized system concept chosen as international standard by OMG

# New Technique Using Superconducting Magnetic Separation to Treat Oily Water

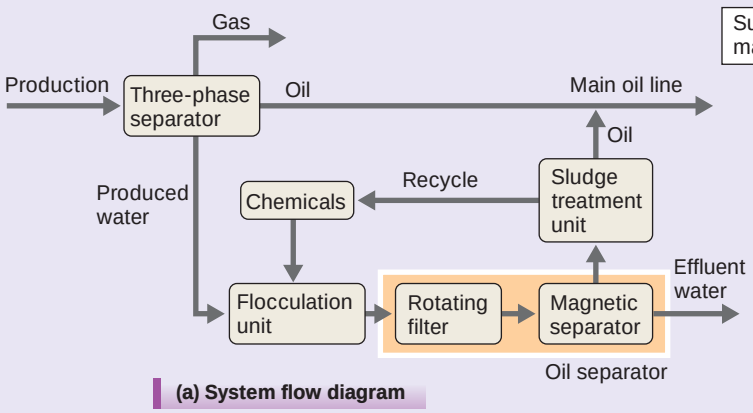
Offshore oil production is normally maintained by injecting seawater into oil reservoirs to increase the oil pressure and also the water-to-oil ratio. Furthermore, since the water extracted from the oil contains a lot of oil, it has a large impact on the environment when it is dumped back into the ocean. Therefore, there is a need for high-performance, compact equipment to separate the oil from the water. Hitachi's new water treatment technique removes the oil rapidly. It uses a compact system, comprised of a flocculation unit, a rotating filter, and a magnetic separator with a superconducting magnet, using high-temperature bulk superconductors, cooled with a small cryocooler.

Fig. (a) shows a flow diagram for our new oil-separation system, which is designed to treat the water initially removed from the raw crude, and it should thus be installed downstream from the two- or three-phase separator. This system consists of four components: a flocculation unit that gathers the oil particles in the water and generates magnetic flocs by the addition of chemicals (flocculant, $Fe_3O_4$ particles); a rotating filter that filters the magnetic flocs from the water; a magnetic separator that attracts the magnetic flocs from the surface of the rotating filter and collects them as highly concentrated oil sludge; and a sludge treatment unit that decomposes the oil sludge and recovers the oil. The chemicals added to the flocculation unit are recovered from the sludge treatment unit and then recycled.

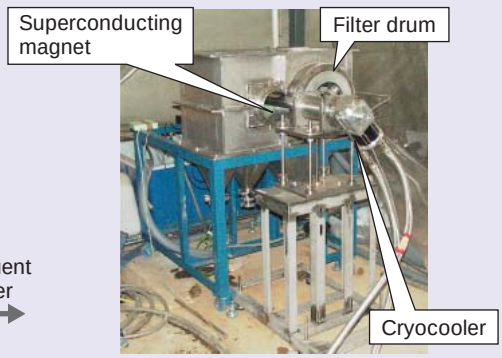
Fig. (b) shows a prototype oil separator, with a capacity of 100 $m^3$/day. The height of the unit is about 1,380 mm. The new oil separator passes flocculated water from outside to inside the filter drum, the magnetic flocs are trapped on the surface of the rotating filter drum, and purified water is obtained. The magnetic flocs that accumulate on the filter nets are pulled from the net toward the positioned near the water surface. They are removed from the filter by a strong magnetic force, so the filter is continuously cleared and provides continuous purification. Fig. (c) shows samples of the influent and the effluent, which is so clear that it can be dumped into the sea with little impact.

These continuous test results are accordance with the basic test results shown in Fig. (d). A TOC (total organic carbon) evaluation shows that the removal rate is 90% or more. The oil concentration in the effluent was about 5 mg/L or less. The concentration of TOCs in the recovered sludge was 23,000 mg/L, which is 960 times thicker than the original contaminant concentration. The field test results agreed with the laboratory test results, and showed that this system is effective in reducing the effluent concentrations to less than 5 mg/L.

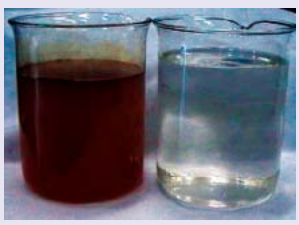
This technique is suitable for use on offshore platforms because the treatment system is compact, and the high removal rate prevents environmental pollution when the effluent is returned to the sea. This technique is applicable to the treatment not only of produced water but also of sewage, industrial waste, and polluted water.



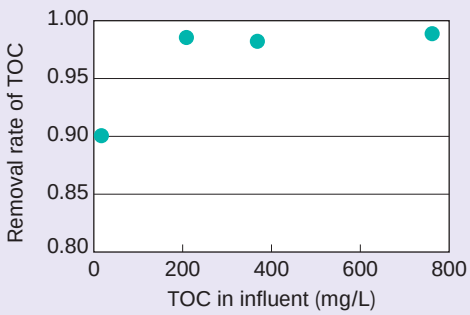

(a) System flow diagram




(b) Prototype of separator



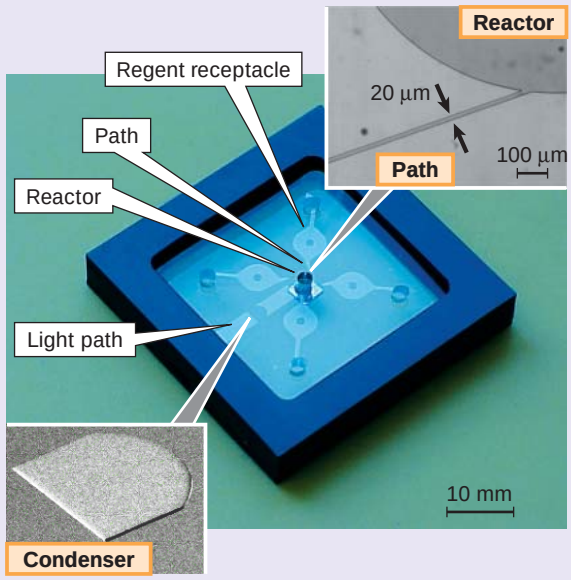

(c) Samples of influent and effluent




(d) Efficiency of TOC removal by basic tests

# Microanalysis Chip Using Micro-machining Technology

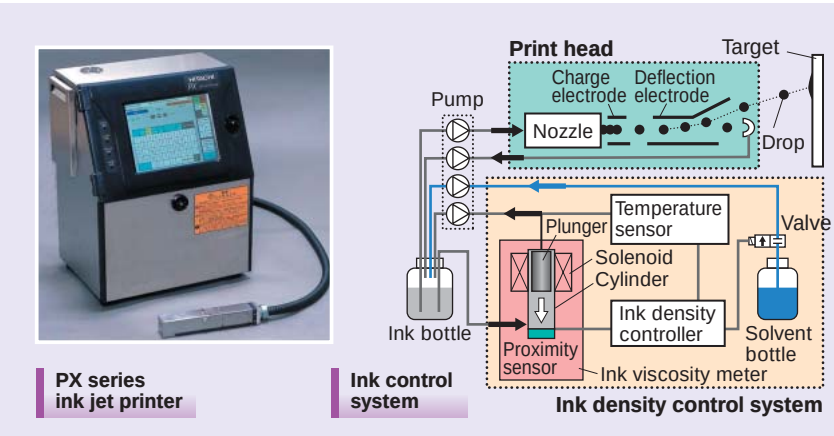
Hitachi is developing analysis chips designed to enable simple, high-precision diagnostics of the human body and the environment, especially human DNA (deoxyribo nucleic acid) and viruses. By using micro-machining technology, chip components, such as micro-liter regent receptacles and micro-scale condenser lenses, are integrated into a few-square cms.
Hitachi manufactured an analysis chip with the following characteristics.
(1) Because the regent is prepackaged in the chip, handling and contamination are reduced, making it suitable for on-site detection.
(2) The chip has no mechanical valves. To avoid regent leak and diffusion from receptacles into the reactor, the path between the regent receptacles and the reactor has microscopic structures only a few-micrometers deep and a few-micrometers wide.
(3) The volume of the reactor in the chip is a few microliters. After regents prepackaged in the receptacles are pushed into the reactor, they are rapidly mixed with the sample in the reactor without a stirrer, because of the micro-scale effect.




Composition of analysis chip

# Ink Density Control System for Industrial Ink Jet Printers

Continuous ink jet printers have been widely used for industrial marking, such as bar codes and product dates. Printing is carried out using an electronically controlled drop to ensure accurate printing positioning.
An ink density control system has been developed to improve the stability of drop formation and the print quality. The key features are the unique ink viscosity meter and the ink density control system. Ink density is constantly checked by measuring the ink viscosity and temperature. The ink density control system can accurately maintain ink density by adjusting the ratio of solvent in the ink.

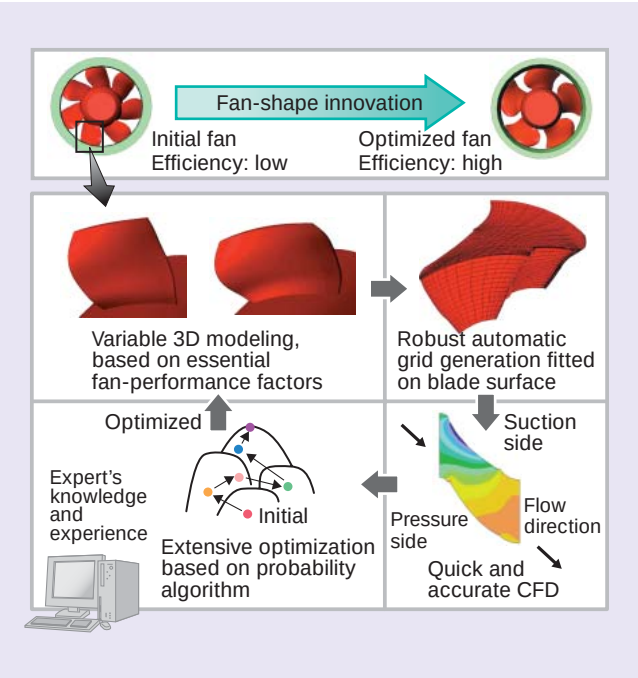



PX series ink jet printer (left) and Ink control system (right)

The ink viscosity meter consists of a plunger moving vertically within a cylinder, a solenoid for raising the plunger by electromagnetic force, and a proximity sensor for detecting the position of the plunger. The ink viscosity can be calculated by the free-falling time of the plunger from the top of the cylinder to the bottom. In only a matter of seconds, the ink viscosity meter can measure the ink viscosity precisely, and automatically. Also, the reliability of the ink viscosity meter is improved by continuously measuring the free-falling time of the plunger over a short period of time.
The ink density control system is used in Hitachi's PX series ink jet printers.

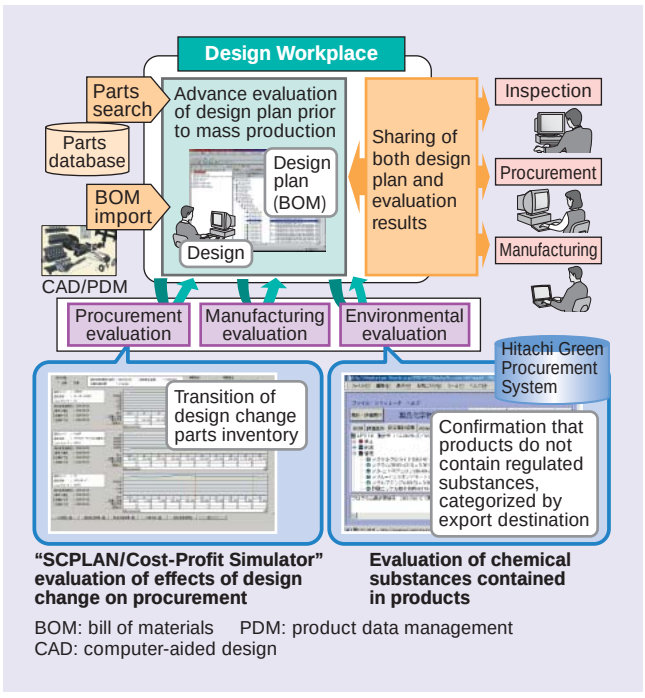
# Autonomous Design Technique for Propeller Fans Using Numerical Optimization

Hitachi has developed an autonomous design technique for a propeller fan to cool servers. This technique combines CFD (computational fluid dynamics) with a numerical optimization method, and can achieve a "virtual fan-shape-design environment" in a computer. This technique enables even novice designers to design high-efficiency fans in the same way as experts do.
[Main features]
(1) A designer can automate the processes of the parameter survey. It is therefore possible to design a high efficiency fan in a short time. The design time can be reduced by one third, compared to conventional design times.
(2) A designer is free from conventional design schemes through an autonomous fan-shaped definition and effective survey, where the design space is large. It is therefore possible to create an innovative fan-shape.
This technique is now being used in JAPAN SERVO CO., LTD.'s products.




Structure of autonomous design technique for propeller fans using numerical optimization

# "Design Workplace" Product Evaluation and Design Support Technology




Overview of design workplace

Factors such as shorter product life cycles, cost reductions, and dealing with environmental and global concerns are increasing the burden on design and development.
The Design Workplace support system seamlessly integrates the technology used to evaluate procurement, manufacturing, and environmental factors with the design work at the design stage. It was developed in response to this increased burden.
[Main features]
(1) The parts configuration data (BOM) that formulates the product design plan is linked to the evaluation tools used to evaluate procurement, manufacturing, and the environment, offering a multi-faceted support system for product evaluation.
(2) This function automates the evaluation process, making it possible to work with large-scale products with tens of thousands of parts.
(3) The procurement effects caused by design changes are assessed, keeping surplus parts to a minimum.
(4) The aggregate totals of the chemical substances contained in the products are compiled, making it possible to check products and to ensure that shipping destination regulations are met.
In addition to using these technologies in-house, Design Workplace is being marketed as a design support solution.