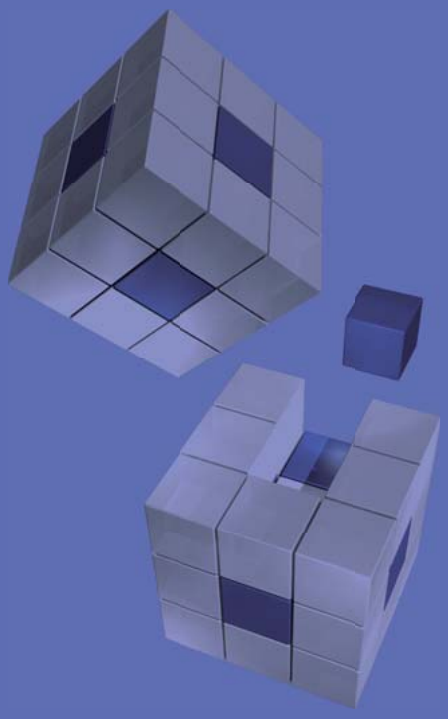


Medical & Electronic Equipment

Medical and Healthcare Systems

■

Biotechnology and Scientific Instruments

■

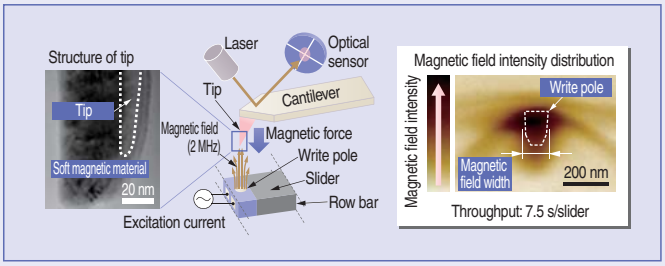
Semiconductor Manufacturing and Inspection Equipment

■

Electronic Equipment

Inspection System for Measuring Magnetic Field Width of HDD Magnetic Write Heads Using Magnetic Force Microscope

Conventionally, measurements of HDD magnetic head performance have been conducted after assembly because performing inspections at the early stages of the manufacturing process has presented a challenge. In response, Hitachi High-Technologies Corporation has worked with Hitachi, Ltd.'s Yokohama Research Laboratory to develop a technique for using a magnetic force microscope to measure the performance of HDD magnetic heads before the individual heads are separated. In this article, the researchers involved in developing key components describe this ground-breaking inspection technique for helping improve product yield and reliability.



Detection principle of magnetic force microscopy

Desire for Earlier-stage Performance Testing

Like semiconductors, the manufacturing process for the magnetic heads used in hard disk drives (HDDs) starts with forming the head elements on a wafer. These are then sliced into bar-shaped "row bars" before being cut into individual heads, called "sliders," and attached to the suspension to form head gimbal assemblies (HGAs). The magnetic field used for reading and writing data is generated from the write pole formed at the center of each slider. In the past, testing whether this magnetic field was being generated correctly could not be performed until the heads were assembled into HGAs, where they could be tested by reading and writing using actual disks.

However, the efficiency of this method was low, leading to a need for a way to test the heads at the earlier row bar stage under the same conditions as in an actual HDD. In response, Hitachi High-Technologies Corporation has devised a method for using a magnetic force microscope to measure the magnetic field produced by head elements. Hitachi has contributed to the development of the system, and of the cantilever in particular. Hitachi's Yokohama Research Laboratory has know-how through its many years of working on atomic force microscopes (which work on a similar principle to the magnetic force microscope).

Application of Soft Magnetic Materials in Magnetic Force Microscope

A magnetic force microscope detects the tilt of a cantilever to measure the magnetic force on a very small probe (tip) coated with a film of magnetic material. In the case of the new inspection system, the system supplies an excitation current to the head that causes the write pole to generate a high-frequency (2 MHz) oscillating magnetic field, similar to that used in an HDD, and then scans the probe over the write pole to measure the width of the generated magnetic field. The magnetic material used in a standard magnetic force microscope is normally made of hard magnetic materials (used in permanent magnets). A key aspect of the development was that we worked with Hitachi High-Technologies to assess a variety of different magnetic materials, and this led us to the conclusion that the best way to detect the high-frequency oscillating magnetic field used in the inspection system was to use soft magnetic materials.

In the meantime, the ongoing increase in HDD capacity means that write pole magnetic field widths are getting narrow year by year. The 100-nm width used in 2010 has since shrunk to 40 nm in 2012, and the magnetic flux has similarly reduced to one-quarter its previous value. This means that inspection systems require a high level of sensitivity. After investigations that included consulting with specialists in magnetic materials from inside Hitachi, we found that the best way to improve sensitivity would be to use a material with a high saturation flux density.

High Sensitivity and Fast Scan Speed

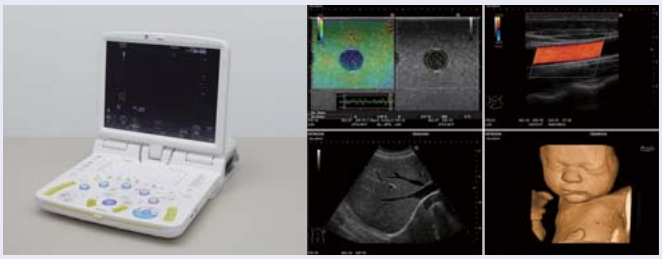
A Hitachi High-Technologies inspection system for measuring write magnetic field width that incorporated the newly developed magnetic field detection technique is able to achieve not only high sensitivity but also a fast inspection rate, something that had been a problem in the past for systems that worked by scanning a probe. As the only inspection system capable of the in-line inspection of all heads, the system has already been supplied to most head element manufacturers where it is helping them reduce defect rates and improve performance. A further improvement in detection sensitivity achieved by using a new magnetic material was incorporated in September 2012.

Manufacturers of magnetic heads for HDDs with production facilities throughout the world have a variety of inspection requirements. We intend to continue satisfying the needs of these users by further developing the system to improve its performance and enhance its functions.

Takenori Hirose (left), Senior Researcher; Kaifeng Zhang (right), Image Recognition and Inspection System Research Department, Manufacturing Technology Research Center, Yokohama Research Laboratory, Hitachi, Ltd.

Digital Diagnostic Ultrasound System that Combines Full Functionality with Flexible Style

Ultrasound diagnostic scanner can be used for non-invasive examinations in realtime, and are growing more common in medical settings as examination devices for the early detection of breast cancer, as well as for use in examining the abdomen, heart, and other body parts. Hitachi has been working to provide high levels of image quality and functionality in its ultrasound diagnostic scanner by, for instance, releasing products to the world that include functions for visually showing the stiffness of tissue. This includes efforts focused on meeting the needs of medical practices by developing a new type of digital ultrasound diagnostic scanner that offers the same level of image quality as traditional stationary mid-level devices, while providing full functionality and a flexible style as well. We interviewed the persons in charge regarding issues such as how the new device was developed to combine compactness with high image quality and high functionality, its features, and future prospects.



Digital diagnostic ultrasound system (left) and example screen display (right)

Product Concept Considered Based on Research Conducted in Medical Settings

The ultrasound diagnostic scanner is a device that has become indispensable at medical facilities, and is even being used with increasing frequency outside the examination room. In spite of this fact, most portable devices are currently inferior to high-end devices in terms of image quality, and the need for compact ultrasound diagnostic scanners that offer high image quality and high functionality for use in medical settings has been increasing.

This digital ultrasound diagnostic scanner was developed as a response to this need, by focusing the combined strengths of the entire Hitachi. Medical facilities cooperated with Hitachi at the start of this development process by assisting with the consideration of product concepts based on studies, hearings, and specific usage scenarios. As a result, "operational flexibility" and "patient-friendliness" were selected as product concepts, and development work on the new product was begun. The new device that was created based on this work features a major new benefit in that its full functionality does not limit its use in different examination categories, and it offers flexibility in usage styles for any scenarios as a result.

In Pursuit of Clear Image Quality, Compactness, and User-Friendliness

These two major characteristics were implemented by combining the critical development features of high image quality, high functionality, and user-friendliness with a compact design. No compromises were made in image quality, which was designed to be equivalent to that of stationary devices, and our own ultrasound-specific digital signal processing circuits, which are the same as those used in higher-end models, provide clear image quality that enables high-precision examinations. In terms of functionality, our own functions provide the ability to image tissue distortions in realtime while visually presenting stiffness information, just as in higher-end models. These capabilities show promise in a wide range of clinical applications, starting with the examination of prostate cancer, liver tissues, and other areas.

In order to allow for the device to be used with the main unit on a desk, a unique storage design was adopted that allows the operation panel to flip up, which results in a space saving of approximately half when compared to notebook computer types. At the same time, in order to reduce size, the circuit board and heat radiation system were carefully redesigned, including the addition of a heat pump. Furthermore, from the perspective of user-friendliness, not only was the monitor made rotatable and tiltable for convenience during a wide range of examination scenarios, a probe holder was attached to a position that does not hit the monitor. The cart for examinations from ordinary standing or sitting positions was given five casters instead of the usual four in order to provide extra stability during movement, and was designed with meticulous attention given to ease-of-use.

The Japan Institute of Design Promotion recognized the groundbreaking design and functionality of this newly developed digital ultrasound diagnostic scanner by presenting it with its Good Design Award 2012.

In Pursuit of a Wider Range of Usage Scenarios through Further Advancements

Sales have already started in Japan, Europe, and the USA, and there are plans to achieve standard certification and start sales in China as well.

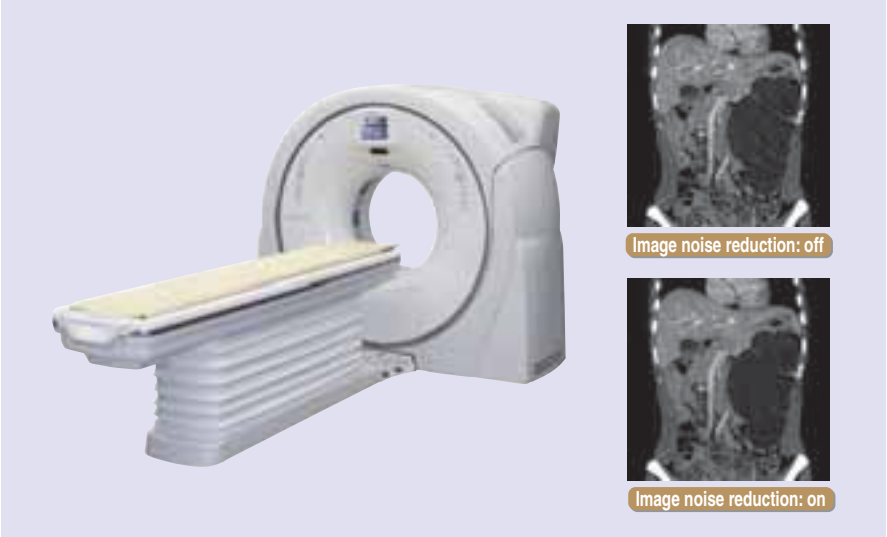
Hitachi is also still working on the development of further advancements in the device. This digital ultrasound diagnostic scanner was developed as a product that can be taken out of the examination room and brought closer to patients. Utilization is envisioned during house calls, emergency responses, medical care in remote areas, and other scenarios, and Hitachi would like to continue expanding usage scenarios and areas by improving the high image quality even further, increasing the number of types of probes that can be connected in order to widen the range of applications, and offering functions that are even easy to use for those who have never used an ultrasound diagnostic scanner before.

Makoto Tampo (left), Deputy Department Manager, Products Planning Department, Marketing Division, Hitachi Aloka Medical, Ltd.; Atsushi Ninomiya (middle), Senior Designer, Product Design Department, Design Division, Hitachi, Ltd.; Tsuyoshi Kimura (right), Senior Engineer, System Group, R&D Design Department, Hitachi Aloka Medical, Ltd.

SCENARIA 64-channel/128-slice CT Scanner

In addition to providing the same high-speed imaging capabilities, high image quality, and dose reduction features as the previous 64-channel model, the standard features on the newly upgraded SCENARIA* 64-channel/128-slice computed tomography (CT) scanner include a newly developed function for reconstructing 128-slice images and an image noise reduction function.

The 128-slice image reconstruction function reconstructs 128 images from each scan (rotation) of the 64-channel detector by halving the image acquisition interval compared to the earlier model. Meanwhile, the image noise reduction function uses iterative approximation to cut image noise by up to 56%, while also having the potential to reduce streak artifacts. Also, the automatic parameter setting function for electrocardiogram (ECG) scans and the automatic cardiac phase selection function significantly improve the workflow for cardiac scanning.
(Hitachi Medical Corporation)



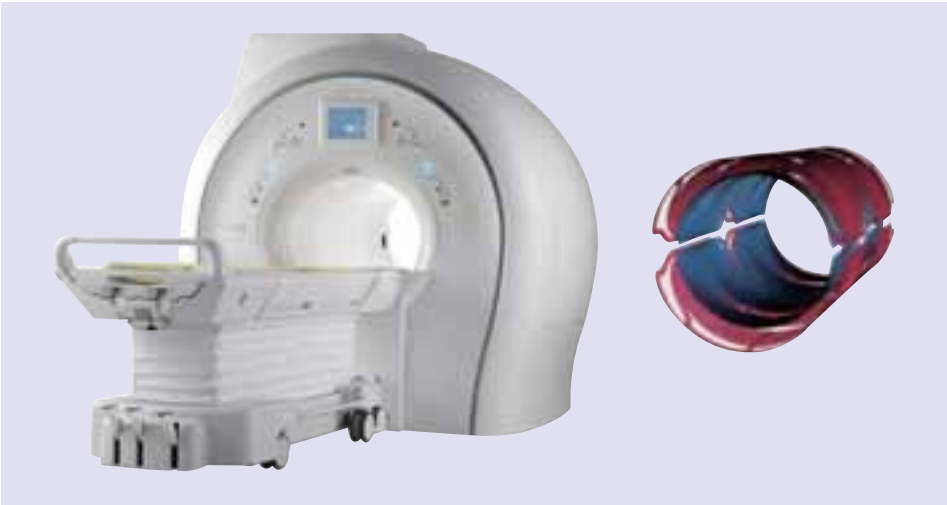
SCENARIA 64-channel/128-slice CT scanner (left) and example images processed by the image noise reduction function (right)

* SCENARIA is a trademark of Hitachi Medical Corporation.

1.5 T Ultra-wide-bore MRI Machine

This 1.5 T ultra-wide-bore magnetic resonance imaging (MRI) machine incorporates a superconducting magnet and combines both patient comfort and high image quality.

A major feature of 1.5 T ultra-wide-bore MRI is its oval bore (74 cm wide and 65 cm high). The oval bore has been expanded to a width of 74 cm to accept examinees with wide shoulders, creating a comfortable exam space for claustrophobic examinees to relax. In addition, the wide exam space enables off-center body parts such as shoulders and knees to be set at the center of the magnet to achieve high-quality imaging.



1.5 T ultra-wide-bore MRI machine (left) and elliptically shaped gradient field coil (right)

The oval bore not only provides a suitable scanning space, it also achieves good performance in terms of both the magnet and magnetic field gradient by allowing the use of an oval shape for the gradient field coil. While producing a gradient field coil with an oval shape was not easy, it was made possible by advanced technology for designing flat gradient field coils that was honed in the development of open MRI. This technology was first developed to design coils for controlling plasma in nuclear fusion reactors, and it allows the coil pattern to be determined directly from the desired magnetic field and coil position.

In the future, Hitachi intends to continue utilizing its own proprietary technologies to develop distinctive superconducting MRI machines.
(Hitachi Medical Corporation)

New Clinical Laboratory Automation System

Clinical laboratory automation systems are machines that automate the sample preparation steps (such as centrifugal separation, dispensing, and sorting) for blood test samples. The requirement from the testing market in recent years has been for fast and accurate reporting of data from pre-consultation testing and other similar tests. Hitachi has been supporting faster blood testing processes through the supply of its automatic analyzer that was first announced in 2004, and which is the fastest of its type in the world*.

The newly developed clinical laboratory automation system is designed to make sample preparation work even faster and efficient, enabling faster throughput throughout the laboratory when used in conjunction with biochemistry automatic analyzers. The main features are as follows.

(1) Use of radio-frequency identification (RFID) to cut the time taken for sample identification in each sample preparation step and increase the overall processing capacity of the system.

(2) Use of a dual conveyor line (consisting of a main line for transporting sample holders that contain a sample and a sub line for empty sample holders) speeds sample transport by reducing congestion on the main line.

(3) Use of single-sample holders in place of the five-sample racks used previously provides flexible sample processing by allowing samples to be processed one at a time.

In the future, Hitachi intends to improve integration with analyzers to develop the clinical laboratory automation systems into a total solution.

(Hitachi High-Technologies Corporation)

(Release date: October 2012 in Japan)

*As of January 2012, based on research by Hitachi High-Technologies Corporation.

New clinical laboratory automation system

ZA3000 Series of Atomic Absorption Spectrophotometer

Atomic absorption spectrophotometers are instruments capable of making precise measurements of trace quantities of metal elements contained in samples of liquid or of solids that have been dissolved to form a solution. They are used in fields such as chemistry, industrial materials, environment, and food.

Compared to inductively coupled plasma (ICP) spectrophotometers or ICP mass spectrometers, which are used for the same purpose, the advantages of atomic absorption spectrophotometers include better measurement reliability and lower initial and running costs. In particular, because they are well suited to measuring samples with a complex composition containing numerous different elements, their uses include research and development and quality control. The newly developed ZA3000 series of atomic absorption spectrophotometers include a twin injection function that achieves high measurement sensitivity by smoothly increasing the sample injection amount, using new technology that is proprietary to Hitachi. Other newly developed functions for improving the reliability of measurement results include automatic detection of sudden boiling and the prevention of cuvette memory. The main features are as follows.

(1) Twin injection function for high sensitivity

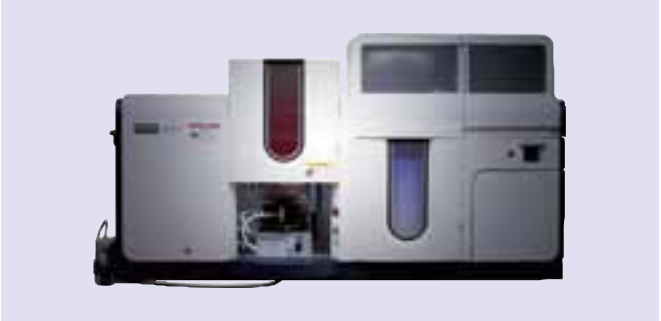
(2) Improved data reliability achieved by functions for automatic detection of sudden boiling and prevention of cuvette memory

(3) Faster dispensing using auto sampler

(4) Light-emitting diode (LED) light provides improved visibility when adjusting nozzle position or inserting cuvette

(5) Lower power consumption when instrument is idle

(Hitachi High-Technologies Corporation)



ZA3000 atomic absorption spectrophotometer

SU3500 Versatile SEM

Versatile scanning electron microscopes (SEMs) are used in a wide range of industries to observe microscopic features on material surfaces. The low-vacuum observation function, in particular, is used in applications such as research and development or quality control to observe samples that contain water or are made of insulating materials without pre-treatment. The new SU3500 utilizes newly designed electron lens and signal processing techniques to make operations such as focus and astigmatism correction easier by enabling the acquisition of bright images with low noise even when using a fast scan speed. The main features are as follows.

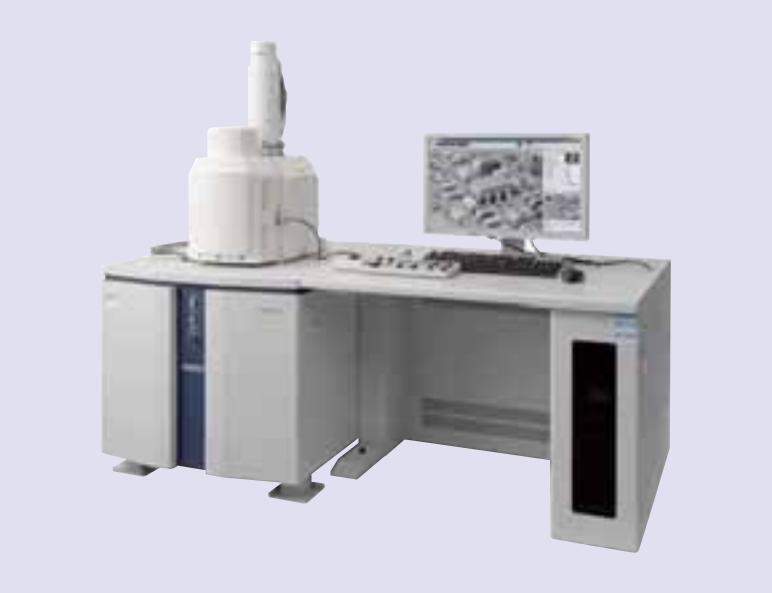
(1) Resolution of 7 nm for secondary electron images (3-kV acceleration voltage), and 10 nm for backscattered electron images (5-kV acceleration voltage)

(2) Newly designed electron optics and signal processing techniques can display images with low noise using a low acceleration voltage and fast scan speed.

(3) New high-speed automatic control functions (brightness and focus)

(4) Live stereoscopic function provides powerful stereo SEM image observation in realtime.

(5) Newly developed ultra variable-pressure detector (UVD) can perform observations at a wide range of acceleration voltages and sample chamber pressures.



SU3500 versatile SEM

(Hitachi High-Technologies Corporation)

New Functions for HT7700 TEM

The HT7700 is a transmission electron microscope (TEM) with a maximum acceleration voltage of 120 kV that has been developed for use in a variety of fields, ranging from bio-medical uses through to nanotechnology and soft materials. All viewing of TEM images is performed using the monitor screen, facilitating observation and operation in the bright room. The system also includes a screen camera so that the monitor can be used to display fluorescence-plate images that are too dark to distinguish by the human eye. While these features have been supported since the system was first released in September 2010, the following optional functions have also now been added to support a wider range of market requirements.

HT7700 TEM (with options)

(1) Scanning transmission electron microscope (STEM) unit (Released: August 2011)

This supports high-resolution STEM observations (1.5 nm for bright field STEM images defined by measuring the gap of sputtered gold particles, acceleration voltage: 100 kV) and high-definition image recording (up to 5.120 × 3.840 pixels). The unit can be used for observation of sectioned biomedical samples with a thickness of 1 μm, and combined with energy-dispersive X-ray spectrometry (EDX) to produce element maps.

(2) High-resolution lens (Released: July 2012)

The newly designed high-resolution objective lens with low spherical aberration achieves a lattice resolution of 0.144 nm for an acceleration voltage of 120 kV. This provides high-contrast, high-resolution observations with low damage at a low acceleration voltage.

(Hitachi High-Technologies Corporation)

M-9010XT Silicon Etch System

20-nm and later device generations require double patterning, three-dimensional (3D) structures, and also complex, high-precision processes, including protective layer formation and finishing techniques that support new materials. The M-9010XT silicon etch system was developed to support these next-generation device processes.

The main features are as follows.

(1) Use of the new 9000 platform provides Hitachi's proprietary low-contaminant, high-speed transfer system that supports high productivity. The linked common platform also permits different chambers to be fitted to allow additional processes to be added in the future.

(2) Standardization on the same platform and user interface as forthcoming 450-mm wafer machines facilitates a smooth transition to larger wafer sizes

(3) Incorporation of a new microwave electron cyclotron resonance (ECR) plasma etching chamber that is provided as a module and has already been proven in use

(Hitachi High-Technologies Corporation)

M-9010XT silicon etch system

Multi-purpose SEM RS6000 Series

The mechanisms and root causes of defects, which affect yield, are becoming more complex as semiconductor devices are miniaturized, and furthermore, the number of these defects is increasing rapidly. The RS6000 multi-purpose scanning electron microscope (SEM) provides a method for the rapid and effective extraction of valid data from large volumes of defect data in order to determine whether the root cause lies in the design, in the process conditions, or in the manufacturing equipment, for example.

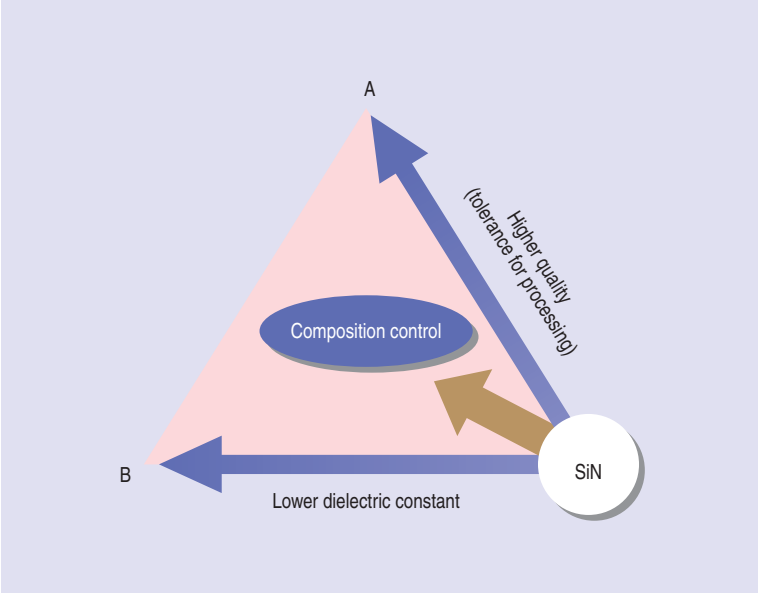
Multi-purpose SEM RS6000 series

Compared to the previous model, the RS6000 features improvements to the SEM image resolution, high-throughput automatic defect review (ADR) capture rate, and automatic defect classification (ADC) accuracy. New functions on the RS6000 include ultra-sensitive SEM inspection (pixel based inspection) and systematic defect classification (defect classification based on design data) for the latest devices. For analysis and control of particles caused by manufacturing tools that affect yield, the RS6000 incorporates a high-sensitivity (25-nm sensitivity) dark field optical microscope (DF-OM) and energy dispersive X-ray spectrometer (EDS). This is equivalent to the level of the latest wafer inspection equipment.

The RS6000 can be used for a variety of purposes such as high-speed automatic SEM imaging, inspection, and analysis. Used as a multi-purpose SEM, it will make a major contribution to the development and production of next-generation devices.

(Hitachi High-Technologies Corporation)

Technique for Forming Spacers with Low Dielectric Constant for Use in Advanced Devices



Lower dielectric constant and higher quality achieved using composition control

Reducing parasitic capacitance in the structure of individual devices (such as transistors) is an important aspect for the sophisticated semiconductors used to achieve the low power consumption and high-speed communications that are critical to communication products such as mobile phones. The parasitic capacitance can be reduced by lowering the dielectric constant (*k* value) of the spacer (insulating film) around the gate. Therefore, there is a need for insulating film with a lower dielectric constant than the conventional silicon nitride film (SiN).

To achieve this, Hitachi has developed balance controlled deposition (BCD) technique for composition control of the specific elements to form high quality low-*k* spacers, including in terms of their ability to tolerate processing. It is anticipated that cost-competitive low-*k* spacer that utilizes this technology will be used in the production of advanced devices.
(Hitachi Kokusai Electric Inc.)

High-speed (×3) HD Camera

To meet the requirement for crisp slow-motion video in television sports broadcasting, Hitachi has developed a three-charge-coupled-device (CCD), full-high-definition (HD) camera that is able to operate at three times normal speed.

The imaging unit features high sensitivity and low noise, incorporating a newly developed two-thirds-size, 2.3-Mpixel CCD and proprietary double-speed drive circuit. The camera's digital electronics, meanwhile, in addition to using a 16-bit analog/digital (A/D) converter and digital video signal processing technology to achieve high image quality, also include a flicker cancelling function to eliminate concerns about flicker when operating under fluorescent lighting. Also, the composite optical cable used to connect the camera to the camera control unit is capable of 6-Gbit/s bidirectional optical transmission, meaning that even an uncompressed HD video signal can be carried over long distances without quality degradation.

In the future, Hitachi intends to contribute to the further development of broadcast cameras through the adoption of metal-oxide-semiconductor (MOS) image sensors and the use of proprietary image processing technology and high-speed optical transmission technology.
(Hitachi Kokusai Electric Inc.)

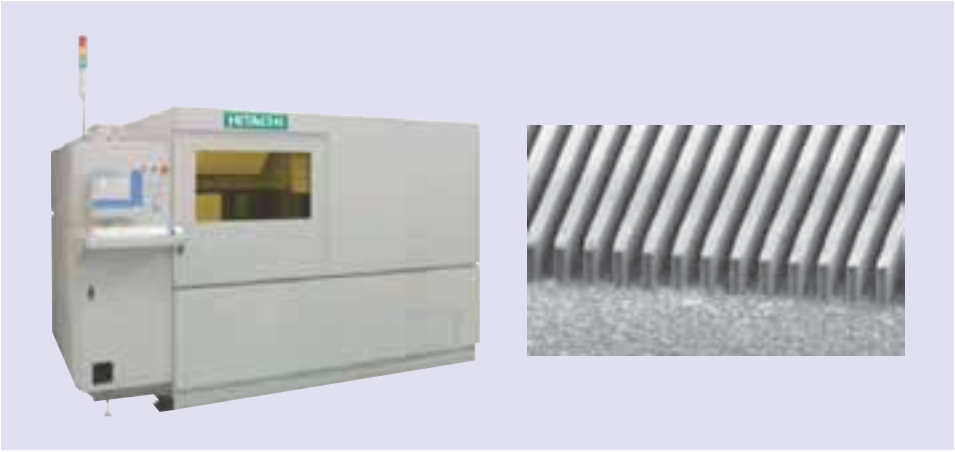
SK-HD1500 high-speed (×3) HD camera (left) and CU-HD1500 camera control unit (right)

DE-6UH Digital Direct Exposure Machine for Next-generation Packages

In addition to the miniaturization and performance improvement of semiconductors and other electronic components, the creation of more advanced electronic products also requires that the circuit boards on which they are mounted have higher densities and multi-layer configurations. The resulting requirements for finer pattern widths and better alignment accuracy (10 µm or less for alignment of wiring holes in pads) in the circuit forming process have led to growing interest in direct lithography, and a rapid shift toward its use as a replacement for mask lithography is currently in progress.

The DE-6UH digital direct exposure machine can reprocess in realtime image data to align it with expansion or contraction in the order of 1 mm in a 500 × 600 mm circuit board, and achieve an alignment accuracy of 10 µm or less. Also, the processing capacity of the image processing system has increased approximately 22 times, from 0.1 Gbyte/s on the initial 2004 model to 2.24 Gbyte/s on the new machine (every frame from one hour of video can be converted to bitmap data in one second). This means that alignment accuracy is improved further by performing free deformation/multi-zone correction for each circuit board.

Hitachi has conducted evaluation testing to demonstrate the finer pattern widths achieved by the new machine, with a line/space (L/S) of 5 µm achieved through improvements to the imaging optics, the adoption of uniformly narrow beam spots, and the inclusion of various automatic correction functions.
(Hitachi Via Mechanics, Ltd.)



DE-6UH digital direct exposure machine (left) and scanning electron microscope image (right) with L/S = 5/5 µm and dry film resist thickness = 15 µm

CS33EDTP Engine-powered Top-handle Type Chain Saw

Hitachi has released the CS33EDTP engine-powered top-handle type chain saw with its original low-emission engine. Given the need in recent years to consider both users and environments, the CS33EDTP features lower vibrations, easier operation, and faster cutting speed. It also complies with the second emission regulations in the USA and the second voluntary emission regulations in Japan. The main features are as follows.

(1) Coil spring anti-vibration mechanism reduces vibration.
(2) Optimized handle shape improves ease-of-use.
(3) Faster cutting speed achieved through the use of fluid analysis to improve the filling efficiency of the combustion chamber
(4) Reduced emissions of hydrocarbons and nitrogen oxides in compliance with the second emission regulations in the USA and the second voluntary emission regulations in Japan

The CS33EDTP was recognized with an award at the iF Design Award 2013 in Germany. The iF Design Awards are the world's most prestigious international design awards, and the success of the CS33EDTP was in recognition of its overall product value, including its design, quality, and price as well as the features described above.
(Hitachi Koki Co., Ltd.)

iF Design Award logo and CS33EDTP engine-powered top-handle type chain saw