2D3D Image Conversion

Both the left viewpoint image and right viewpoint image are required for three-dimensional (3D) TVs. Toshiba has developed a 2D3D image conversion technology that creates the two viewpoint images from one input image.

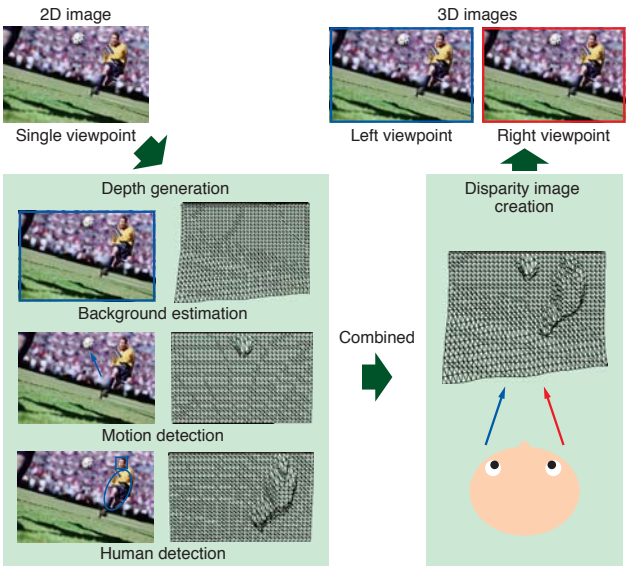
Depth structures of the scenes are generated using the following three image recognition technologies:

- Background estimation
  The input image is classified into one of a number of typical scenes and its corresponding depth data are applied.
- Motion detection
  A faster object is placed at a nearer depth.
- Human detection
  A human 3D model is applied to the detected positions of faces.

Next, each viewpoint image is calculated using the depth structure. 2D3D image conversion technology makes it possible to view standard 2D contents in 3D, in addition to 3D contents themselves, and is being incorporated into TVs and PCs in the Japanese market.

2D3D image conversion technology that creates nine viewpoint images from a single or two viewpoint images is also being incorporated into our glasses-free 3D TV models, which are the world's first 3D TVs(*) that do not require dedicated glasses.

(*) As of October 2010 (as researched by Toshiba)



Flow of 2D3D conversion

Integral Imaging 3D Display without Dedicated Glasses

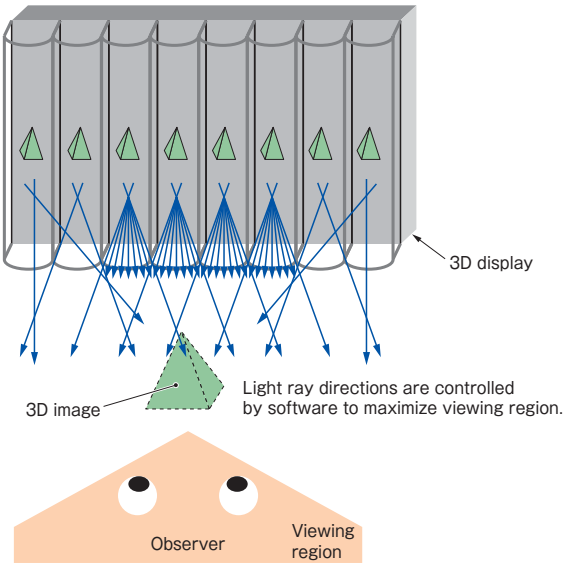
The integral imaging system is based on the principle of sampling and collecting the light reflected from an object, and then precisely reproducing the light through a display to realize smooth and natural images.

Toshiba's new algorithm simultaneously creates nine parallax images for the liquid crystal display (LCD) panel and controls and optimizes light emission and direction from the center, right, and left of the screen to realize a wide viewing angle. This technology results in an optimized display of high-quality 3D images whatever the position and angle to the screen of the viewer.

The high-definition (HD) LCD panel, whose pixels are specially designed for moiré suppression, has approximately four times the pixels of a full HD panel; i.e. 8.29 million pixels. It can display elemental images carrying information from nine parallax images created from a single frame in real time. The resolution of the final 3D image is 1 280 × 720 pixels.

The glasses-free 3D REGZA™ GL1 series employs the above technology.

Part of this work was supported by the Japanese Ministry of Internal Affairs and Communications under the "R&D of 3D Imaging Not Requiring Glasses" Project.



Optical properties of 3D display without dedicated glasses

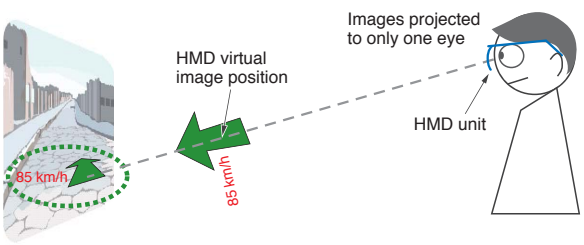
Monocular Augmented Reality Display

The augmented reality display (ARD) can superimpose virtual information such as guidance information or virtual arrows for navigation on real backgrounds such as shops or roads.

Conventional ARDs have suffered from a double-vision problem in which two divided images are seen simultaneously, due to the differences in convergence between the real background and the virtual displayed images.

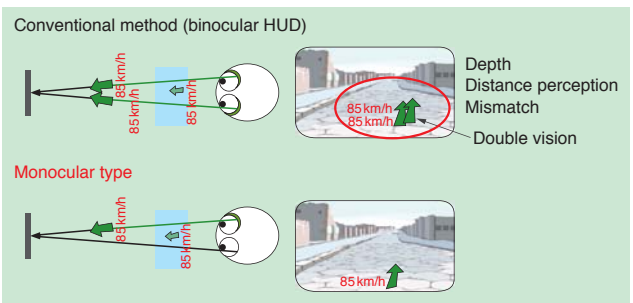
Toshiba has identified a new mechanism of vision recognition in which superimposed virtual images seen with monocular vision are recognized as being at the same depth as that of the real background images seen with binocular vision. Based on the new finding, we have solved the double-vision problem with a newly developed monocular head-up display (HUD) as a type of ARD that limits the scattering angle of the virtual images to the monocular viewing zone while the background is viewed by the eyes with binocular vision.

In addition, using motion parallax and perspective display technologies with head tracking, we have succeeded in free depth control of virtual displayed images at any real background position.



HMD: head-mounted display

Monocular ARD



Principle of monocular HUD system

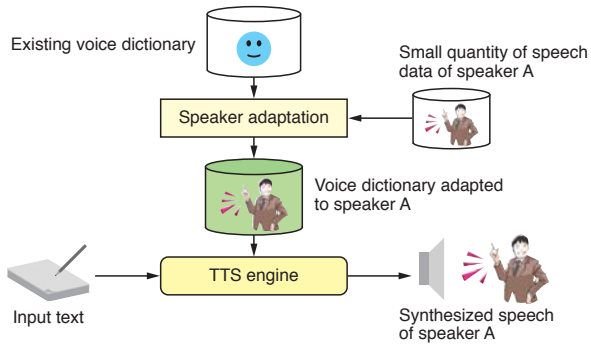
Speaker Adaptation Technique for Text-to-Speech System

Toshiba has developed a speaker adaptation technique for text-to-speech (TTS) by which a TTS system can be customized to the voice characteristics and manner of speaking of a specific speaker in a short time and at low cost.

In conventional TTS systems, at least a few hours of speech data have been required to create a voice dictionary that represents a specific speaker's voice characteristics, in order for the system to be able to synthesize any text. Our newly developed speaker adaptation technique converts an existing voice dictionary with sufficient phonetic/linguistic coverage into a dictionary having the voice characteristics and manner of speaking of a specific speaker, based on a small quantity of speech data of that speaker. This technique makes it possible to create a voice dictionary for a specific speaker with a practical level of voice quality from less than 10 minutes of speech data.

A method using statistical models of acoustic/prosodic feature parameters respectively representing voice characteristics and manner of speaking was newly adopted as an appropriate TTS technique for speaker adaptation. In speaker adaptation, such statistical models are converted to models for other speakers by identifying the best fit for the given small quantity of speech data.

First, the base TTS method was improved by introducing our original signal processing technologies to achieve top-level voice quality. During this work, it was found that the TTS method needs to use a specific acoustic feature parameter so as to realize high voice quality with a low computation cost for real-time processing, but that the existing speaker adaptation method was unable to handle this parameter stably. The problem was solved by introducing a stabilization process to the speaker adaptation and TTS processes, resulting in a new speaker adaptation technique that is applicable to practical TTS systems.



Speaker adaptation technique for TTS

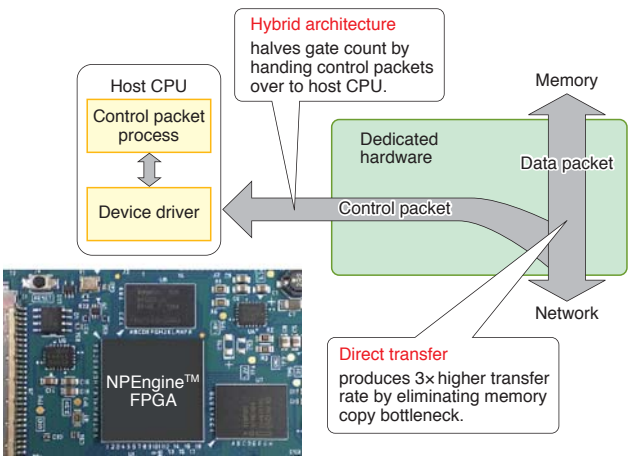
NPEngine™ Ultrahigh-Speed, Hardware-Based Network Processing Engine with Low Power Consumption

Toshiba has developed a hardware-based network protocol processing engine called NPEngine™, which realizes ultrahigh-speed Transmission Control Protocol/Internet Protocol (TCP/IP) processing with very low power consumption.

Due to its hybrid architecture that reduces the gate count and a direct data transfer technology that eliminates the bottleneck of data transfer, NPEngine™ configured for Gigabit Ethernet can achieve an 80 times higher TCP/IP throughput at the same frequency or 1/20 the power consumption at the same throughput compared with a typical 32-bit embedded CPU, and a three times higher throughput with 1/2 the gate count compared with a conventional hardware-based engine. In addition, NPEngine™ configured for 10 Gigabit Ethernet can also achieve 10 Gbits/s throughput with an operating frequency of only 100 MHz.

NPEngine™ has been applied to the VIDEOS neo™ (ON-AIR MAX FLASH for global markets) flash-memory-based video server for broadcasting systems, contributing to the reduction of its power consumption and improvement of its data transfer performance.

CPU: central processing unit



FPGA: field-programmable gate array

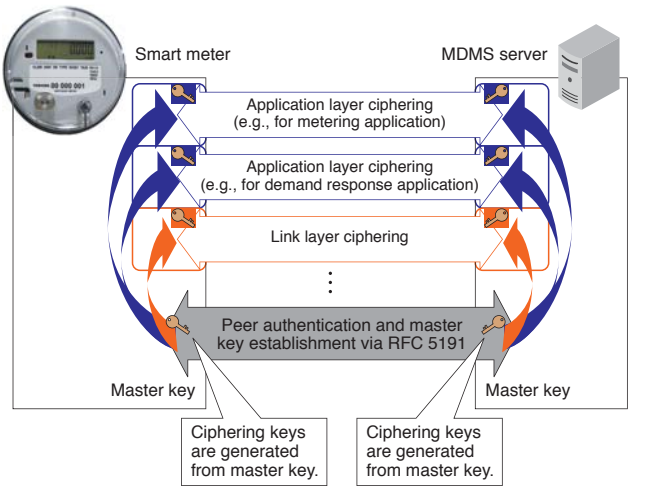
Top view and internal structure of NPEngine™ burned-in FPGA

Secure Smart Meter

There is increasing demand for secure smart meters capable of performing device authentication and cryptographically protecting exchanged data in order to provide various information services including metering applications.

Toshiba and Toshiba Toko Meter Systems Co., Ltd. have jointly developed a prototype smart metering system consisting of secure smart meters that incorporate the AMSO™ (advanced meter sign-on) unified key management mechanism developed by Toshiba and a meter data management system (MDMS) server for the North American market.

In order to reduce the processing cost for key management, AMSO™ makes use of RFC (Request For Comments) 5191. This is a standard network access authentication protocol, whose design Toshiba was closely involved in, that allows ciphering keys for multiple different uses to be generated from only one-time execution of device authentication.



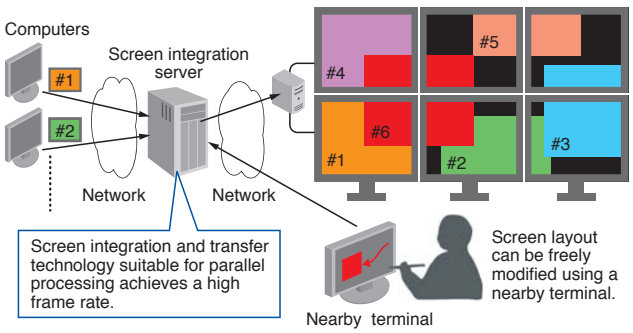
Prototype of AMSO™ unified key management system with smart meter

Multiscreen Integration System

Toshiba has developed a multiscreen integration system that integrates and displays screens distributed over the network on a large screen display. The number of screens and the size of the display can be freely varied.

A screen integration server integrates screens received from various machines, and transfers the result to a large screen display terminal. We have developed a screen integration and transfer technology that is suitable for parallel processing using multicore CPUs. This technology realizes a screen transfer frame rate according to the number of cores in the range from 1 to 8 cores, but with minimal performance deterioration due to process blocking that normally accompanies an increase in the number of CPU cores.

Additionally, the layout of each screen within the large screen can be freely modified, thereby enhancing usability.



Multiscreen integration system

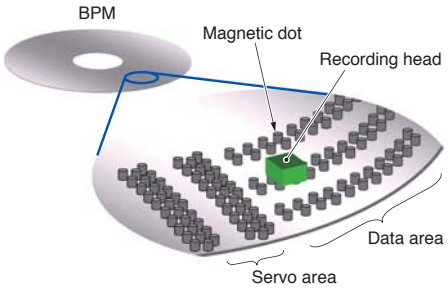
Bit-Patterned Media for High-Density HDDs

Bit-patterned media (BPM) are a type of magnetic recording medium in which the magnetic layer is reduced to the size of one bit (one magnetic dot and space). This technology is attracting attention as a candidate high-density magnetic recording medium for hard disk drives (HDDs). When BPM technology is used for a recording density exceeding 2.5 Tbits/in^2, the size of the magnetic dot must be reduced to not more than 10 nm. This size is challenging for the manufacturing process, even when cutting-edge semiconductor processing technology is used. An etching mask made of a self-assembled polymer has been proposed as a solution to this issue. However, it is difficult to shape an ordered dot array into complicated structures such as servo patterns, which are necessary for the read and write operations of a HDD.

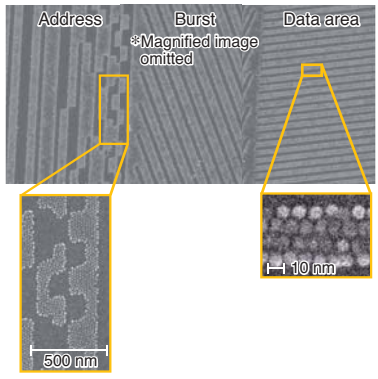
Toshiba has developed a manufacturing method using guide patterns to control an array of self-assembled dots, and has successfully fabricated a BPM that has servo patterns made of dot arrays with a pitch of 17 nm corresponding to 2.5 Tbits/in^2 as well as data tracks with ordered dots. We have also succeeded in making a recording head fly over and stay at a data track of the fabricated BPM, enabling us to demonstrate the servo-control operation of a recording head flying on a BPM with self-assembled dots for the first time in the world(*). With further development, this technology will become applicable to the fundamental operations of HDDs; that is, the writing and reading of data to and from individual dots.

This work was partly supported by the New Energy and Industrial Technology Development Organization (NEDO) under the “Green IT” Project.

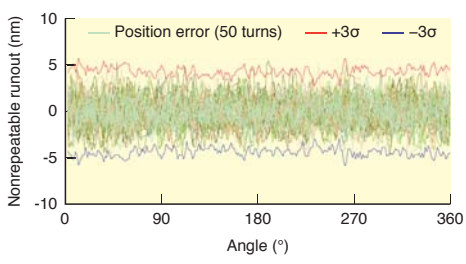
(*) As of August 2010, at the 21st Magnetic Recording Conference 2010 (TMRC 2010) (as researched by Toshiba)



Schematic image of BPM



Scanning electron microscope (SEM) image of BPM



σ: standard deviation

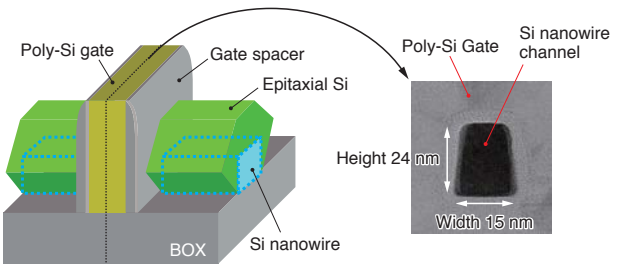
Nonrepeatable runout of BPM

Silicon Nanowire Transistor for Ultralow-Power LSIs

The nanowire transistor has a device structure that is promising for future ultralow-power large-scale integrations (LSIs). Since the nanowire channel is surrounded by the gate, off-state leakage current is strongly suppressed.

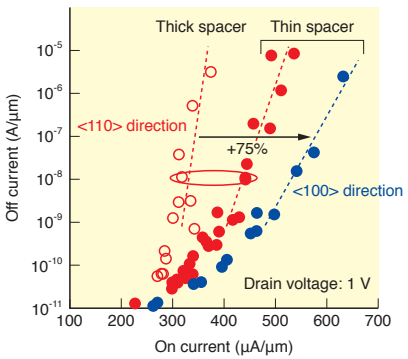
Toshiba has developed high-performance silicon nanowire transistors with a nanowire width of 15 nm. With the aid of selective silicon epitaxial growth on the source/drain regions with thin gate spacers, the parasitic resistance in the nanowire-shaped source/drain regions is greatly reduced. Furthermore, by changing the nanowire channel directions from the conventional <110> direction to the <100> direction, carrier mobility in the nanowire channel is increased. As a result, we have realized 75% improvement in the on-state current of the nanowire transistor.

This work was partly supported by NEDO under the "Development of Nanoelectronic Device Technology" Project.



Si: silicon
BOX: buried oxide

Schematic of silicon nanowire transistor



On-current vs. off-current characteristics of fabricated silicon nanowire transistors

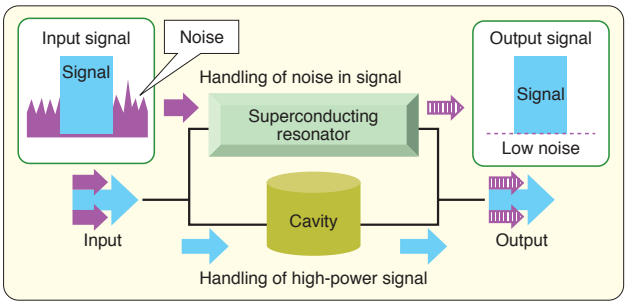
Transmitting Hybrid Filter with Cavities and Superconducting Resonators for Weather Radar

9 GHz-band transmitting hybrid filter

In Japan, there is a plan to introduce a 9 GHz-band weather radar network for observation of localized torrential downpours. However, a technology to decrease the noise of the amplifiers in the weather radar is required, in order to reduce interference between the radars.

Toshiba has developed a transmitting hybrid filter with conventional cavities and superconducting resonators, giving it the advantages of both high power handling capability and sharp skirt characteristics. As a result, this filter can handle power of 100 kW required for a weather radar system while reducing the noise of the signals to 1/100 or less. Given these features, high-density carrier frequency assignment for next-generation radar applications is expected to be realized by applying these filters.

This research was supported by the Ministry of Internal Affairs and Communications, Japan.



Simple structure of transmitting hybrid filter

Highly Reliable Oxide TFT

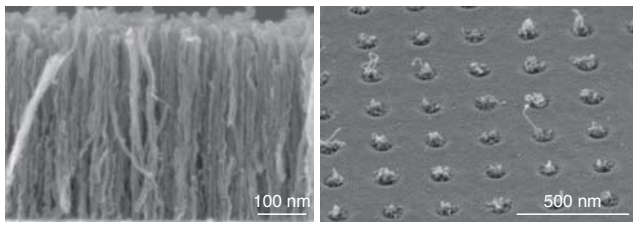
3.0-inch OLED panel driven by oxide TFTs

Oxide thin-film transistors (TFTs) have recently been attracting attention as a backplane to drive next-generation flat-panel displays. Instability of the threshold voltage under bias-temperature stress (BTS) is one of the crucial issues to be solved for the practical realization of this technology.

Based on studies of the degradation mechanism of oxide TFTs with respect to BTS, Toshiba optimized the deposition conditions of the oxide semiconductor and the annealing temperature, and controlled the hydrogen concentration in the insulators.

As a result, BTS instability was improved to within 50 mV after 2 000 seconds at 70°C with a gate voltage of Vg±20 V. Using this oxide TFT with high stability against BTS, we have successfully fabricated a 3.0-inch organic light-emitting diode (OLED) panel (160 × RGB × 120 pixels) with integrated gate driver circuits.

Growth of Closely Packed Carbon Nanotube Forest for Interconnects



SEM photographs of closely packed CNT forest (left) and ultrafine via array (right)

According to the latest report of the International Technology Roadmap for Semiconductors (ITRS), copper-based interconnects are expected to reach a physical limit in 2015 due to miniaturization of LSIs. The carbon nanotube (CNT), which has 1 000 times higher current density durability compared with copper, is an attractive material for next-generation interconnect applications. Dense growth of CNTs is indispensable for the realization of CNT-based interconnects.

Toshiba has achieved the growth of a closely packed CNT forest at low temperature by a multistep growth method using plasma chemical vapor deposition. This method was newly introduced in order to obtain a CNT packing density on the order of 10^{12} cm^{-2}. Our approach led to a CNT packing density of 2×10^{12} cm^{-2} at a growth temperature of 450°C. This is the highest density(*) ever reported for multiwalled CNTs. In addition, this method achieved high-density CNT growth in an ultrafine via hole as small as 70 nm in diameter, suggesting that it is a promising technique for CNT-based interconnects.

This work was conducted as part of the MIRAI Project under contract to NEDO.

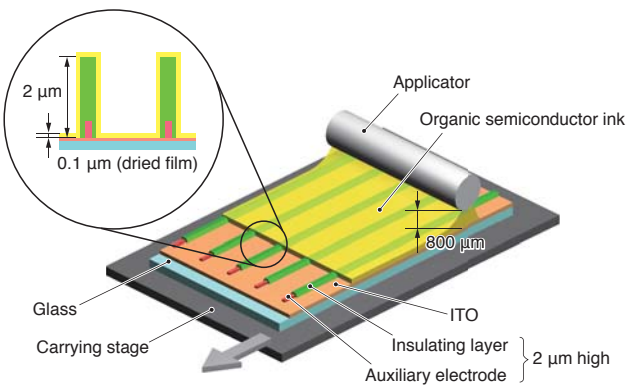
(*) As of September 2010 (as researched by Toshiba)

Solution-Processed OLED Lighting

Organic light-emitting diodes (OLEDs) are a focus of expectations as a possible new flat-panel light source. Although OLEDs with higher efficiency than fluorescent lights have been reported, they were fabricated by a vacuum evaporation process that is known to be expensive. In order to commercialize OLED lighting, it is necessary to reduce the fabrication cost.

Toshiba focused on solution-processed OLEDs because of their potential for low-cost fabrication without the need for a vacuum apparatus. We employed a substrate with stripe-shaped auxiliary electrodes in order to lower the effective resistance of an indium tin oxide (ITO) anode and reduce the electric potential drop. In addition, we applied a meniscus printing method (shown below), which is a suitable process for uniform coating onto a relief structure.

Consequently, a white OLED panel with a large emitting area of 58 mm × 52 mm and a luminance of 10 000 cd/m^2 was obtained, achieving the highest level of luminance for solution-processed OLEDs.



- Gap between applicator and ITO glass substrate: 100-800 µm
- Height of stripe-shaped auxiliary electrodes: 2 µm
- Thickness of organic semiconductor layer: 0.1 µm (dried film)
- Printing speed: 4-5 mm/s

Schematic illustration of meniscus printing method applied to ITO glass substrate with 2 µm-high stripe-shaped auxiliary electrodes

Nano/Microelectromechanical Systems Probe

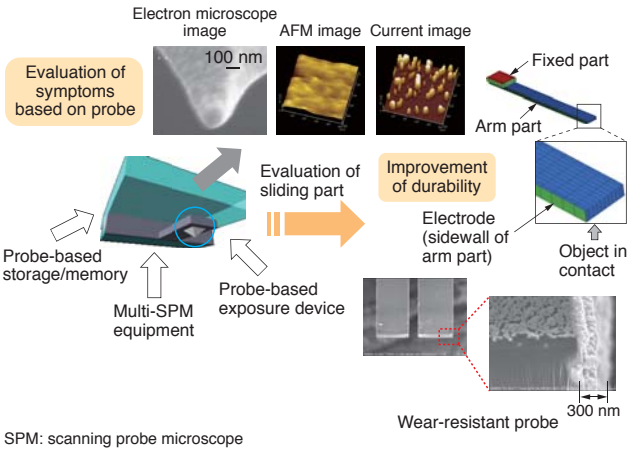
Novel devices, such as nanopattern drawing devices and data-storage and memory devices having probes with nanoscale electric contacts in the tip, are being proposed that have the potential to surpass the performance of conventional devices. The main obstacle to the commercialization of these devices is considered to be the durability and reliability of sliding between the probe tip and the object with which it is in contact.

Toshiba has established a quantitative evaluation technology focusing on the electrical contact characteristics of a probe before and after sliding in order to reveal friction and wear characteristics at the nano scale, which are significantly different from those at the macro scale.

Utilizing this evaluation technology, we have developed a wear-resistant probe having nanoscale electric contacts and microscale mechanical contacts separately in the tip. Compared with a conventional atomic force microscope (AFM) probe having a similar tip scale, the newly developed probe has demonstrated more than 100 times longer sliding durability while maintaining stable performance.

In the future, we aim to commercialize devices equipped with this wear-resistant probe.

A part of this work was supported by NEDO.



SPM: scanning probe microscope

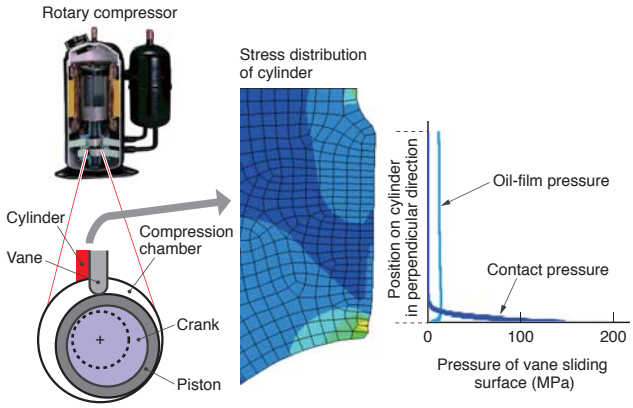
Improvement of tribology characteristics in nano area

Technique for Numerical Analysis of Mixed Lubrication in Compressors of Air Conditioners and Hot-Water Heaters

Toshiba has developed a technique for the numerical analysis of mixed lubrication for application to compressor mechanisms in order to improve the performance and reliability of compressors in air conditioners and hot-water heaters.

Almost all of the parts of compression mechanisms have sliding surfaces. The lubricating condition of a sliding surface varies depending on the type of contact and form of movement. Equations expressing the oil-film pressure of a sliding surface, the elastic contact of a sliding surface, the equilibrium of forces, and the elastic deformation of the parts of compression mechanisms are solved as a coupled problem in this analysis. Moreover, the pressure distribution of a sliding surface can be obtained for mixed lubrication in cases where solid contact occurs in hydrodynamic lubrication. Friction loss can be predicted and reliability can be evaluated by investigating the accurate lubricating condition of a sliding surface.

This technique has been applied to the development of a natural refrigerant carbon dioxide (CO_2) compressor, contributing to the realization of an efficient and reliable product.



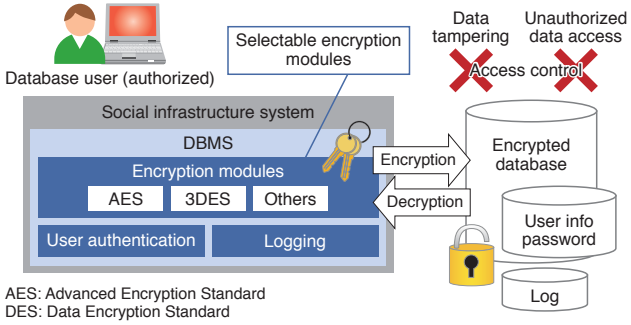
(a) Compression mechanism (b) Analysis result

Numerical simulation of mixed lubrication in compression mechanism

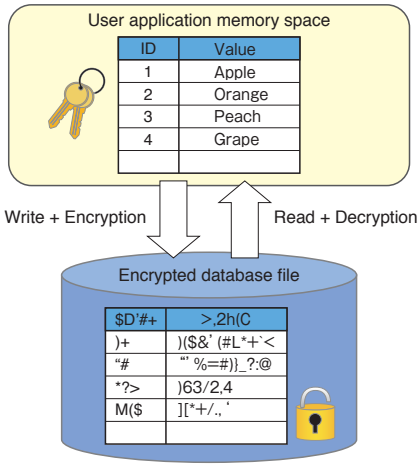
Secure Embedded Database Management System

Toshiba has developed a secure embedded database management system (DBMS) by enhancing an open source DBMS with user authentication and data encryption functionalities. The DBMS has been introduced into a social infrastructure system. A transparent data encryption (TDE) method was incorporated into the DBMS, so that a user application can read/write data along with decryption/encryption. Therefore, there is no need to change the structure of a user application program.

The TDE method makes it possible to skip the decryption step after loading the data into memory space, and inhibits the negative effect on performance to a maximum of 8% performance degradation. The encryption module is separated from the main DBMS module, allowing an encryption library to be easily replaced.



Structure of secure embedded database components



Transparent data encryption method

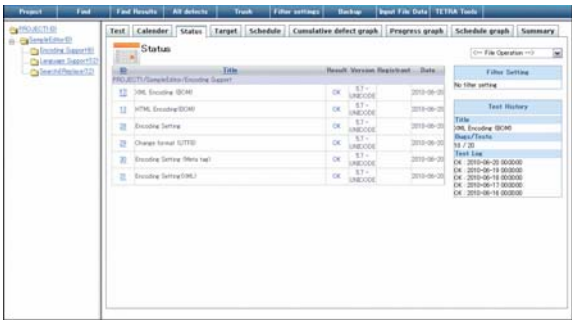
Test Management System for Effective Software Development

The performance of embedded software has become higher in recent years, but it has also become more complex. While the number of items to be tested has increased with the expansion of large-scale software systems, software development periods have become shorter year by year, leading to a need for improvement of efficiency in the testing process.

Toshiba has developed a test management system that makes it possible to perform centralized management of the number and types of tests, logs of executed tests, and test scheduling on a website.

When test items and test results are input from a report tool, or input on the website, the system automatically totals the executed tests and failed tests, then immediately displays a software bug graph and outputs a progress report. Moreover, the system can automatically calculate and report the trend of quality stabilization based on the frequency of failed tests, so that a decision on when to end the testing process can be made according to this report.

This system assists users to intuitively understand the situation of testing processes, which are constantly changing in software development projects, and to respond to delays in work and failures of tests. It has also been confirmed that the costs of test management (creation of test reports) can be reduced by using this system.



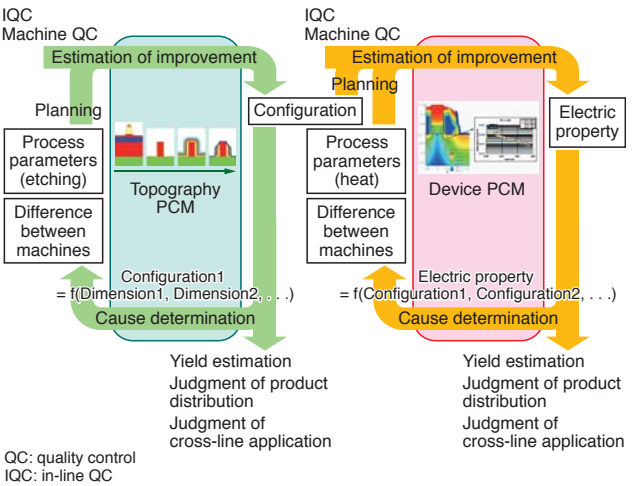
Example of test management system display

Semiconductor Process Control in Mass Production Phase Utilizing PCM

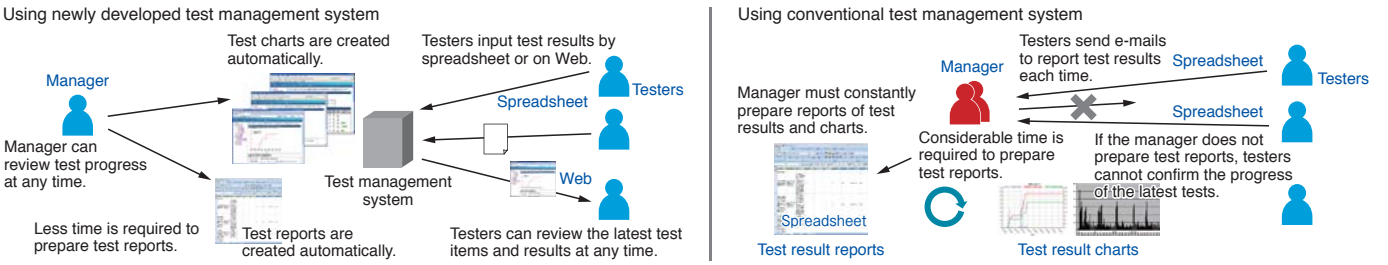
Toshiba has developed a methodology for controlling a semiconductor process based on a process compact model (PCM) representing the relationship between topography and electric property, and applied it for the first time in the mass production phase.

We selected dimension parameters critical to line topography via technology computer-aided design (TCAD), and established the PCM through statistical analysis of the parameters. Finally, we quantified the correlation between topography and sheet resistivity.

We have applied the PCM to advanced process control (APC) in the mass production phase of a 40 nm complementary metal-oxide semiconductor (CMOS), and constantly controlled the topography so as to avoid changes in the sheet resistivity. As a result, a 30% reduction in the variation of sheet resistivity has been achieved in the mass production phase.



Utilization of PCM in mass production phase



Comparison of newly developed test management system and conventional test management system

Glasses-Free 3D LCD Manufacturing Technology

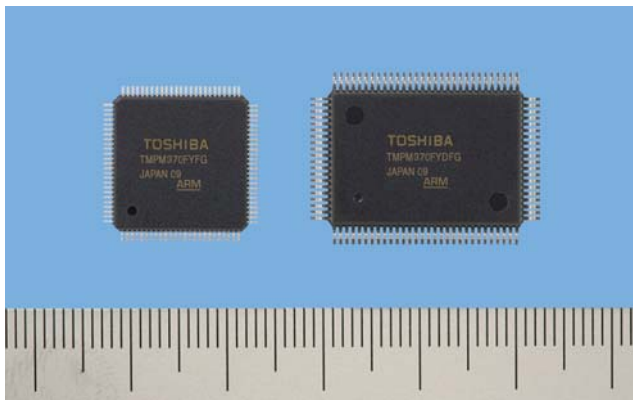
Lens unit adhering equipment for production of 3D LCDs

Toshiba has developed a three-dimensional liquid crystal display (3D LCD) on which 3D movies can be viewed without wearing special glasses.

To maintain the optical properties of the 3D LCD, such as the viewing zone and resolution, the lens unit and LCD need to be aligned with micrometer accuracy. Using the characteristic features of a lens, we have been able to align the lens unit and LCD with high accuracy. We have also developed a decompression sealing technology to reduce variability of the gap between the lens unit and LCD module.

These technologies have been applied to the production of 12- and 20-inch 3D LCDs.

TMPM370 32-bit Microcomputer for Motor Control in Home Electrical Appliances



TMPM370 32-bit microcomputer for motor control in home electrical appliances

Toshiba has developed the TMPM370 32-bit microcontroller for home appliance manufacturers in developing countries.

The new device integrates an intellectual property (IP) called Vector Engine that realizes vector control technology to efficiently drive a motor with low noise, 12-bit analog-to-digital (AD) converters (conversion time: 2.0 µs), and a 256 Kbyte high-speed flash read-only memory (ROM). Compared with conventional devices, the new device implements most of the vector control process by hardware. Therefore, programs to be prepared by the user can be reduced to one-fifth, dramatically lowering the burden of development. The processing speed can also be improved to five times that of traditional devices.