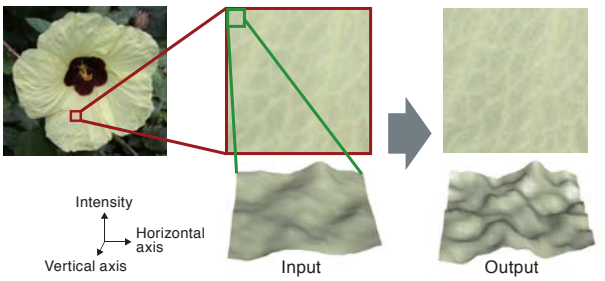
High-Quality Image Processing Technologies for 4K Ultra HD TVs

Toshiba has developed image processing technologies that transform high-definition (HD) video contents such as TV programs and Blu-ray Disc™ contents to 4K ultra-high-definition (Ultra HD: 3 840 × 2 160 pixels) resolution with four times the pixel count of HD resolution.

Although 4K Ultra HD TVs have the ability to display images with subtle changes in light and dark shades and a high degree of detail, video cameras do not have comparable performance, causing deterioration of video quality in terms of texture and gloss. We have developed texture and gloss restoration technologies to recover the lost details of texture and gloss to take full advantage of 4K Ultra HD TV.

The texture restoration technology generates fine texture patterns based on intensity variations in input images and adds them to the upconverted input images. This technology can recover up to 75% of the high-frequency components lost from input images. The gloss restoration technology extracts and enhances reflection components. Our newly developed technologies can correctly detect objects of the same color even in very noisy images and enhance the extracted components by three times without causing artificial color changes.

These technologies were incorporated into our 4K Ultra HD TVs launched in June 2013.



Processing result applying texture restoration technology

Blu-ray Disc™ and Blu-ray™ are trademarks of the Blu-ray Disc Association.

Processing result applying gloss restoration technology

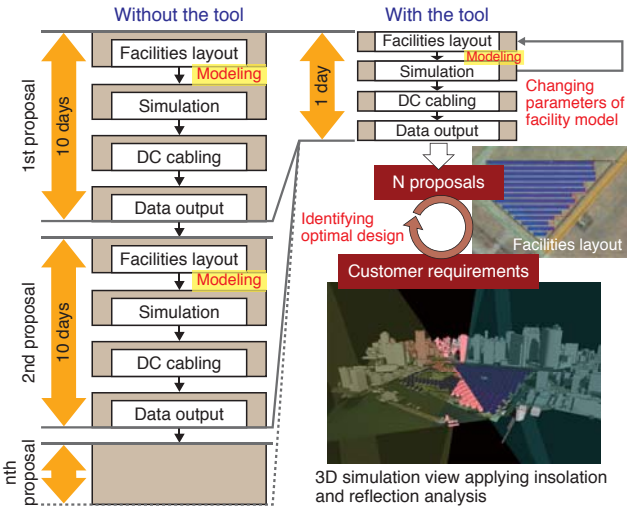
Automatic Design Optimization Tool for MW-Class Photovoltaic Power Generation Systems

Toshiba has developed a conceptual design tool for MW-class photovoltaic (PV) power generation systems for the public-sector and industrial markets that can automatically lay out solar cell modules and related facilities. We began offering PV engineering services in July 2012.

This conceptual design tool can generate various design alternatives at high speed, taking into account the impacts on sunshine caused by the geographical features and buildings around the installation site. It shortens conceptual design time from about 10 days to about 1 day.

Conventionally, much time was required to generate three-dimensional (3D) layout data for sunshine impact analysis. Due to the automated data generation process, the new tool produces layout data for tens of thousands of PV modules in only about 10 seconds on a PC. It also speeds up solar insolation and reflection analysis by using an original geometric algorithm. Furthermore, we have developed a unique data model that allows simultaneous processing of both layout and electrical design data. Using this data model, the conceptual design tool can perform the entire design process from facilities layout to simulation for annual cost estimation of power generation, as well as DC cabling.

Consequently, once a facility model has been created with this tool, various design alternatives can be rapidly and easily generated by changing the design parameters of the model in order to clarify the customer's requirements. Furthermore, we can interactively seek the optimal design with a customer during a meeting; for example, to minimize the cost of solar power generation. We are creating design frameworks using this tool in order to reach out to worldwide markets such as emerging-country markets, where PV demand is expected to increase.



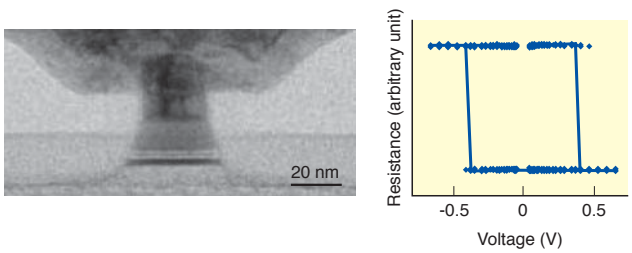
Flow of engineering for design optimization

High-Speed, Low-Power MRAM for Reducing Power Consumption of Processors

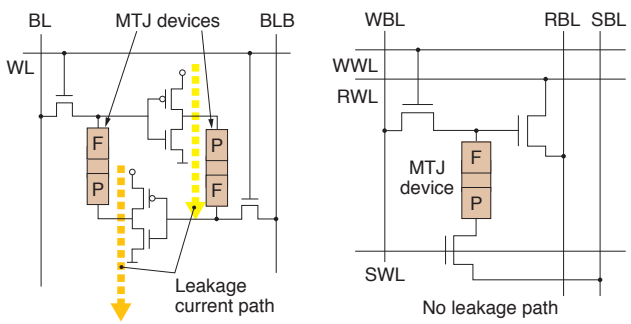
Since Toshiba succeeded in the development of the world's first perpendicular spin-transfer torque magnetoresistive random-access memory (p-STT-MRAM) in 2007, it has been leading the world in this field.

Recently, we improved the memory device and scaled down the process feature size to less than 30 nm to achieve a combination of high memory access speed and low power consumption that had previously been infeasible. Consequently, energy consumption during an active operation of a 1-bit memory has been reduced to approximately 1/10th that of the predecessor p-STT-MRAM. Furthermore, we have developed a new normally-off memory architecture by using a new memory circuit design.

Due to these breakthroughs, the leakage power of the memory circuit has been significantly decreased. It has also been theoretically shown that the power consumption of processors can be considerably reduced by replacing their static RAM (SRAM)-based cache memory with p-STT-MRAM.



Electron microscope image and typical memory characteristics of newly developed p-STT-MRAM



Conventional memory circuit (normally-on type)

Newly developed memory circuit (normally-off type)

MTJ: magnetic tunnel junction, BL: bit line, WL: word line, BLB: bit line bar, WBL: write bit line, WWL: write word line, RWL: read word line, RBL: read bit line, SBL: source bit line, SWL: source word line, F: free layer, P: pinned layer

Conventional normally-on and newly developed normally-off type memory circuits

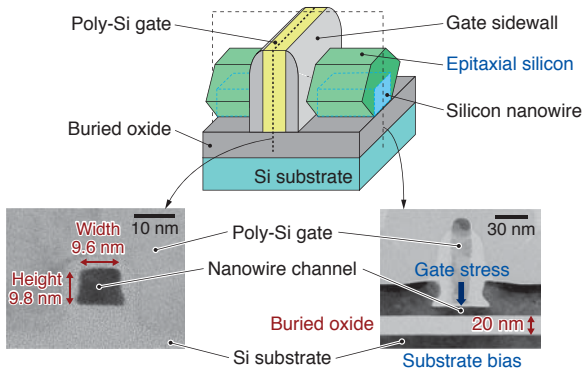
10 nm Nanowire Transistor for Ultralow-Power LSIs

Toshiba has developed a silicon nanowire transistor with a nanowire diameter of 10 nm as a solution for the realization of ultralow-power large-scale integrations (LSIs).

The nanowire diameter was reduced to 10 nm to improve its gate controllability, making it possible to greatly suppress off-leakage current of the nanowire transistor. Although the degradation of on-current had previously been a crucial issue, a significant improvement was achieved by using silicon epitaxial growth in the source and the drain, as well as gate stress techniques. Consequently, the newly developed nanowire transistor realizes both a reduction in power consumption and enhanced performance.

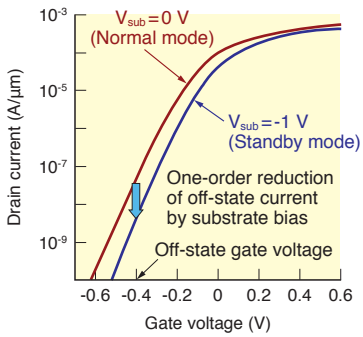
Furthermore, standby power consumption was reduced by an order of magnitude by applying substrate bias voltage to the nanowire transistor having a buried oxide as thin as 20 nm.

This work was partly supported by the Development of Nanoelectronic Device Technology Project of the New Energy and Industrial Technology Development Organization (NEDO), Japan.



Poly-Si: polycrystalline silicon

Schematic and cross-sectional electron microscope images of 10 nm-diameter nanowire transistor



V_{sub}: substrate bias voltage

Current-voltage characteristics of 10 nm-diameter nanowire transistor

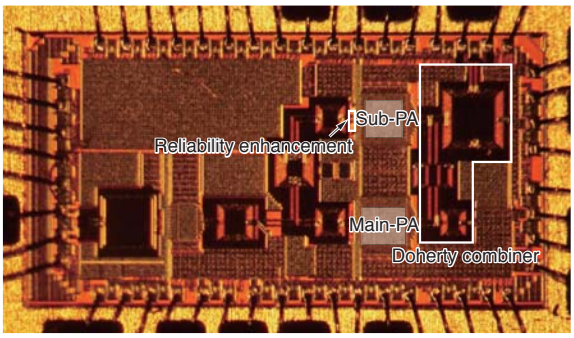
Watt-Level CMOS Doherty Power Amplifier

Toshiba has developed a 2.4 GHz complementary metal-oxide semiconductor (CMOS) Doherty power amplifier (PA) capable of watt-level output power. For radio-frequency (RF) PAs, CMOS implementation has recently been required to reduce the size, lower the cost, and improve the performance of mobile devices. However, CMOS implementation degrades the peak output power and efficiency of a PA. To overcome these problems, Doherty PA technology was utilized to enhance the output power of CMOS PAs. A Doherty PA generally consists of main- and sub-PAs, and improves power efficiency by turning off the sub-PA in the low output power range.

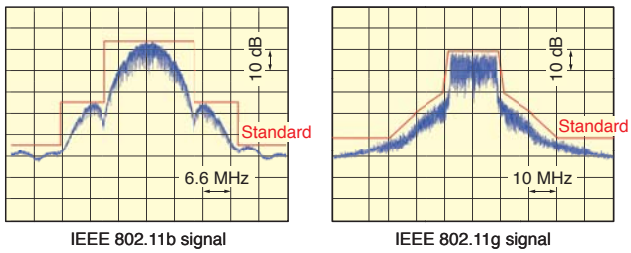
The newly developed Doherty power combiner uses a 65 nm CMOS process and reduces magnetic interference between passive components while requiring less than half the area for passive components compared with conventional combiners. The new combiner also provides the world's highest peak output power(*) of 1.1 W for a CMOS Doherty PA and achieves a power-added efficiency of 23% at the 6 dB power back-off level, which is a performance index used to determine whether to use a PA in wireless local area network (LAN) terminals. Degradation of device reliability is one of the challenges to be solved when fabricating a Doherty PA with a deep-submicron, low-threshold-voltage CMOS process. As a solution, we developed a reliability enhancement technique that is expected to provide an approximately 75% improvement in theoretical time-to-failure (TTF) for IEEE 802.11b wireless LAN signals.

(*) As of June 2012, at the 2012 IEEE Symposium on VLSI Circuits (as researched by Toshiba)

IEEE: Institute of Electrical and Electronics Engineers



2.4 GHz 1.1 W CMOS Doherty PA



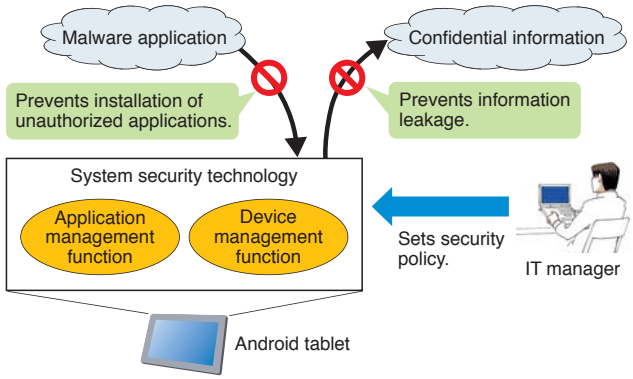
Output spectra of wireless LAN (IEEE 802.11b/g) signals

Android™ Security Technology for Enterprise Use

Toshiba has developed an Android platform with enhanced security for tablets designed for enterprise use.

The existing Android platform does not fully support security and device management features that are essential for the use of tablets in enterprises.

We added enhanced features for security and device management to the Android platform by utilizing our system security technology to make it possible to prevent users from installing and invoking unauthorized applications, and restrict the use of secure digital (SD) cards and universal serial bus (USB) and Bluetooth® devices. These features can be controlled under a policy defined by an information technology (IT) manager through the management application installed in our Android tablets. The new Android platform prevents the use of unauthorized applications on and leakage of information from tablets.



Overview of tablet security system for enterprise use

Android is a trademark of Google Inc.

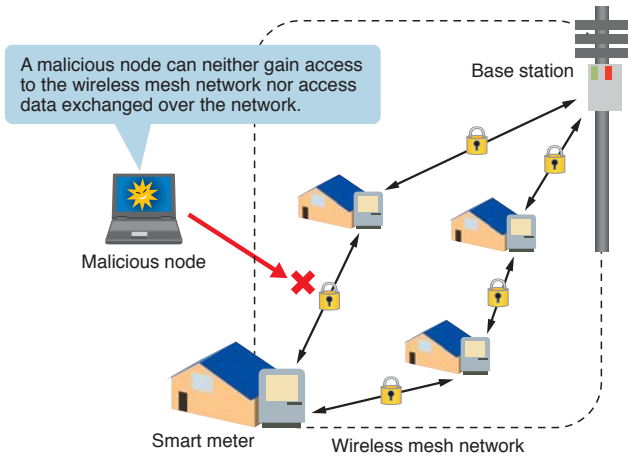
The Bluetooth® word mark and logo are registered trademarks owned by Bluetooth SIG, Inc.

AMSO™ Unified Key Management Mechanism for Secure Wireless Mesh Networks

Wireless mesh networking technology is widely used for smart meters. Toshiba has developed a unified key management mechanism called AMSO™ (advanced meter sign-on) for wireless mesh networks. AMSO™ provides two main functions to ensure the security of wireless mesh networks: network access authentication and key delivery.

Network access authentication is essential to prevent a malicious node from connecting to a wireless mesh network. However, it is difficult for a centralized server to authenticate a smart meter that is not directly connected to a base station. To overcome this difficulty, AMSO™ makes use of an authentication relay technology. Once a smart meter is authenticated, the smart meter acts as a relay node to mediate the network access authentication process between the centralized server and newly connecting smart meters.

Data protection is also required because data in a wireless mesh network are exposed to threats such as eavesdropping and data alteration. In a network secured by AMSO™, a centralized server supplies smart meters with keys for data protection. Keys are delivered by the centralized sever in encrypted form so that the keys themselves are not leaked to unauthorized nodes. Furthermore, AMSO™ supports automatic rekeying by periodically delivering new keys.



Outline of AMSO™ unified key management technology realizing secure wireless mesh networks

Intelligent Camera Incorporating Visconti™2 Image Recognition Processor

Toshiba has developed an intelligent camera incorporating the Visconti™2 image recognition processor.

In a wide-area surveillance system, a centralized image recognition server may be overloaded with computational demands if it receives images from many network cameras simultaneously. Our newly developed intelligent camera incorporating Visconti™2 alleviates this problem because Visconti™2 makes it possible to perform advanced image processing in the camera. This intelligent camera also helps to reduce the power consumption of PCs used in the system and relax constraints on their installation sites. Visconti™2 is a flexible processor designed to perform various image processing tasks at high speed. The same camera can be tailored to meet diverse requirements such as human detection, vehicle detection, and face recognition as a security feature simply by modifying the firmware for Visconti™2.

Operators can efficiently evaluate the worth of each video frame produced by the camera and quickly focus on important scenes showing persons or vehicles. Thus, the intelligent camera incorporating Visconti™2 provides an excellent video surveillance solution that combines a high level of operator efficiency and a simple system organization.

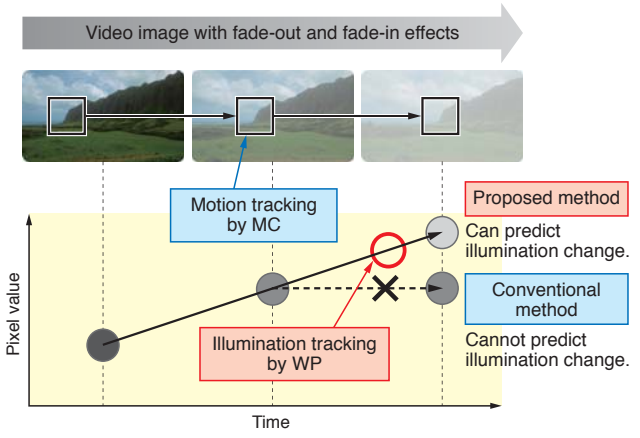
Prototype of intelligent camera and Visconti™2 board

High-Efficiency Weighted Prediction for H.265/HEVC Standard

To achieve high coding efficiency, hybrid video coding consisting of block-based motion compensation (MC) and block-based transform is widely used in many video coding standards such as MPEG-4 and H.264 Advanced Video Coding (AVC). Since temporally successive video images are highly correlated, redundant data in successive frames can be reduced by using MC. However, MC does not work well when temporal illumination variations such as fading and dissolving are present because MC relies on motion estimation based on a block matching technique.

To resolve this issue, Toshiba has developed a weighted prediction (WP) technology with a view to its adoption as part of the H.265 High Efficiency Video Coding (HEVC) standard. H.265/HEVC dramatically improves coding efficiency for such images by performing linear pixel value prediction using a multiplicative weighting factor and an additive offset after MC. In order to determine the optimal WP parameters for an encoder, we have proposed a WP parameter derivation method using image characteristics between the target and reference pictures. This method is incorporated into the H.265/HEVC reference software. H.265/HEVC using the WP technology provides much higher coding efficiency than H.264/AVC and is expected to realize the distribution of high-quality video contents to various audiovisual devices including tablets, TV sets, and PCs.

MPEG-4: Moving Picture Experts Group Phase 4



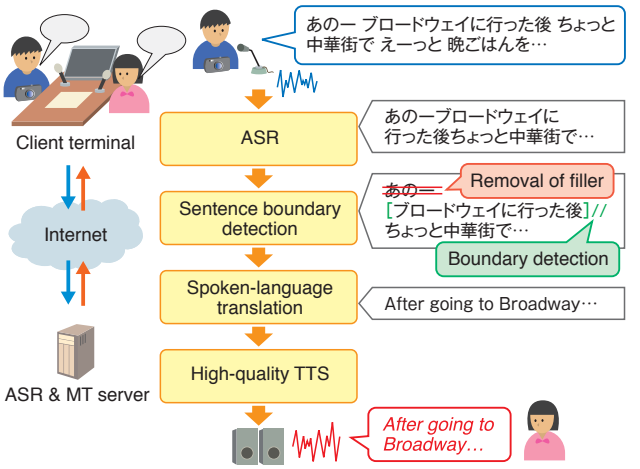
Outline of motion-compensated WP for H.265/HEVC standard

Simultaneous Interpretation for Face-to-Face Services

Toshiba has developed simultaneous machine interpretation technologies that support translation from Japanese to English, Chinese, and Korean, and vice versa, as well as a software interpretation system intended for people engaged in face-to-face services who need to communicate with people speaking those languages.

The simultaneous interpretation technologies consist of (1) an automatic speech recognition (ASR) technology that recognizes users' spontaneous and continuous utterances, and (2) a spoken-language machine translation (MT) technology that detects sentence boundaries and translates only the significant parts of sentences. These technologies are designed for cloud services and work together in a coordinated manner, enabling the system to interpret users' utterances within a short interval. Consequently, the system achieves an interpretation time 44% shorter than that of a conventional sentence-by-sentence interpretation system.

An evaluation experiment conducted in the city of Chiba showed an 81% interpretation success rate for predefined situations in tourist guidance and daily conversations.



TTS: text-to-speech

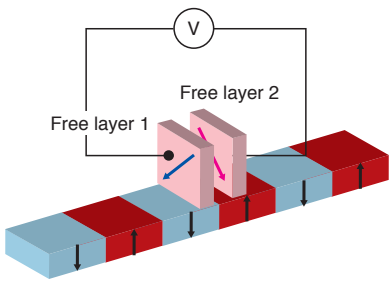
Outline of simultaneous machine interpretation for face-to-face communication

SNR Simulation Analysis of Read Head with Trilayer Structure for 5 Tbits/in^2 HDDs

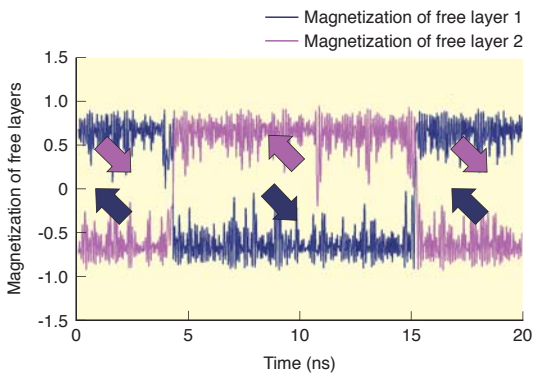
Toshiba has developed a fundamental technology for a high-resolution magnetic read head that can read a hard disk drive (HDD) with a recording density exceeding 5 Tbits/in^2.

Although the read head with a trilayer structure is a prime candidate for the next-generation HDDs, it has a disadvantage in that its signal-to-noise ratio (SNR) is lower than that of the currently mass-produced read heads with a spin valve structure. To identify thermal magnetic noise sources, we utilized a unique simulator capable of estimating thermal fluctuation noise and succeeded in devising an optimal structure that provides an SNR 5 dB higher than that of the typical trilayer type.

This study was partly supported by the NEDO Project for Development of Nanobit Technology for Ultra-high Density Magnetic Recording (Green IT Project).



(a) Read head with trilayer structure



(b) Fluctuations in magnetization of free layers of trilayer read head causing thermal magnetic noise

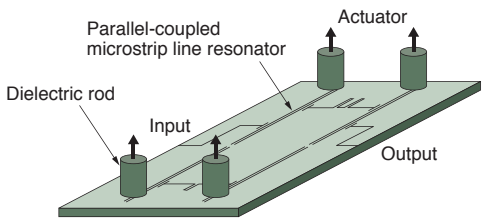
Result of magnetic switching simulation of optimally designed trilayer read head

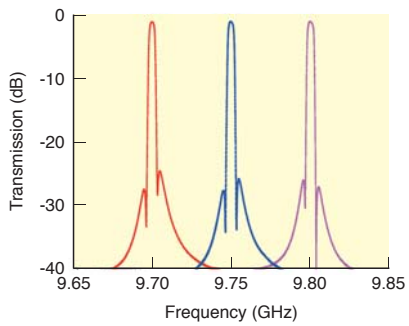
Narrowband Tunable Superconducting Filter

Precise weather observation using a 9 GHz-band weather radar network is expected to mitigate disasters caused by sudden torrential rains in urban areas. To simplify the deployment of a weather radar network, weather radars having a frequency-tuning function are required to suppress radio wave interference between weather radars and make it possible to adjust the radar frequency for easy installation in any location.

In response to this requirement, Toshiba has developed a narrowband tunable superconducting filter for weather radar applications, which has a narrowband characteristic to suppress radio wave interference from adjacent radar frequency channels as well as a wide frequency tuning range exceeding the allocated weather radar frequency band.

The proprietary tunable filter with a coupled microstrip line resonator and dielectric trimmer structure provides an outstanding low-loss property and thus a bandwidth 1/50th as narrow as that attainable with the conventional technology. It was commonly thought that a frequency-tuning function with low loss and constant bandwidth would be difficult to realize with conventional technology. However, our innovative technique has achieved a ratio of the tuning range to the bandwidth more than five times higher than the conventional method.





Structure and measured characteristics of narrowband tunable superconducting filter

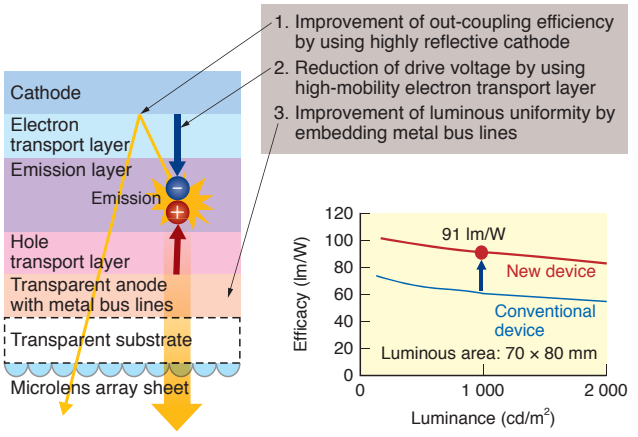
High-Efficacy OLED Lighting Panel

Organic light-emitting diode (OLED) lighting is a potential candidate for application to high-quality, high-efficacy flat light sources. However, most reports so far on the efficacy of white OLEDs have focused on small devices measuring approximately 2 × 2 mm. Toshiba has now developed a high-efficacy OLED lighting panel with a large luminous area.

While the internal quantum efficiency of OLEDs is considered to have already reached almost 100%, their efficacy can be further improved by reducing the drive voltage and improving the light out-coupling efficiency. In order to realize large OLED lighting panels, it is also necessary to reduce the voltage drop at the transparent anode and improve luminous uniformity. We adopted the following three approaches: (1) improvement of the out-coupling efficiency by using a highly reflective cathode, (2) reduction of the drive voltage by using a high-mobility electron transport layer, and (3) improvement of the luminous uniformity by embedding metal bus lines.

Our newly developed OLED lighting panel with a luminous area of 70 × 80 mm has achieved the world's highest-level efficacy(*) of 91 lm/W at 1 000 cd/m^2. The external quantum efficiency, chromaticity coordinates, correlated color temperature, and voltage were 43.4%, (0.45, 0.42), 3 010 K, and 3.1 V, respectively.

(*) As of June 2012, at the SID International Symposium, Seminar and Exhibition, Display Week 2012 (as researched by Toshiba)



Device structure and luminous efficiency of highly efficient OLED

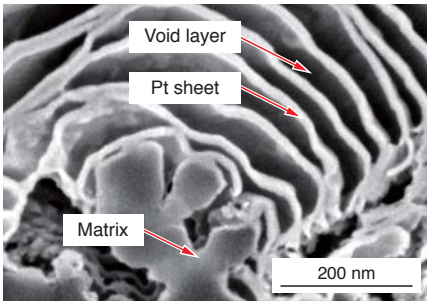
Development of Low-Platinum-Loaded Electrocatalyst for Polymer Electrolyte Fuel Cells

Polymer electrolyte fuel cells (PEFCs), which have excellent features including compactness and high-current-density operation, have already been utilized in the ENE-FARM residential fuel cell system, and their full-fledged dissemination in PEFC-based fuel cell vehicles is expected in the near future.

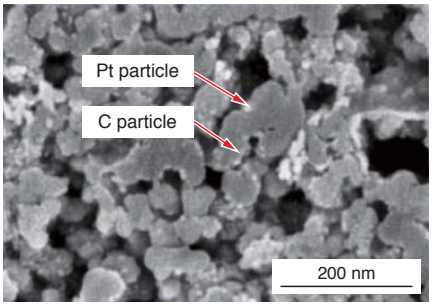
The conventional PEFC cathode electrocatalyst is generally based on a structure called platinum-on-carbon (Pt/C), consisting of nanoparticles of Pt that are supported by or loaded on larger C particles. It is technically challenging to reduce the amount of Pt without compromising the durability of the fuel cell.

As a solution to this issue, Toshiba has developed a unique electrocatalyst synthesis process using a sputtering method to produce a thin Pt catalyst layer. From the results of galvanodynamic polarization testing, it was determined that the start-stop durability and per-site specific activity of the new electrocatalyst are double those of the conventional Pt/C catalyst.

ENE-FARM is a trademark of Tokyo Gas Co., Ltd., Osaka Gas Co., Ltd., and Nippon Oil Corporation.



Newly developed catalyst layer



Conventional Pt/C catalyst layer

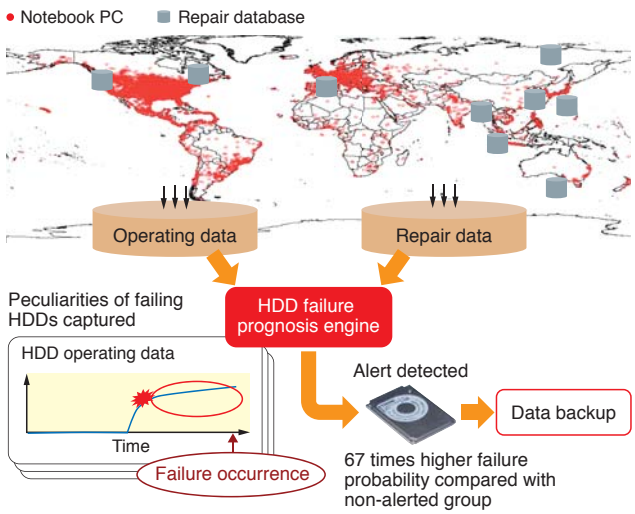
Cross-sectional scanning electron microscope (SEM) images of newly developed and conventional Pt/C catalyst layers

Failure Prognosis Engine for HDDs in Notebook PCs

With users' approval, Toshiba has been collecting operating logs from more than 1.66 million notebook PCs around the world via the Internet. We analyzed the relationships between these logs and repair data by means of a data mining technique to develop an HDD failure prognosis engine. As a first step, we defined more than 700 characteristic variables for time-series data that capture peculiarities of a failing HDD. In creating the engine, these variables were combined in an optimal manner to achieve the maximum accuracy.

It was verified that the HDD group alerted by this engine had 67 times higher failure probability compared with the non-alerted HDD group, indicating that PC users can prevent data loss if they are aware of a sign of a failing HDD.

The HDD failure prognosis engine is being incorporated into the management tool of our notebook PCs and will be available in 2013.



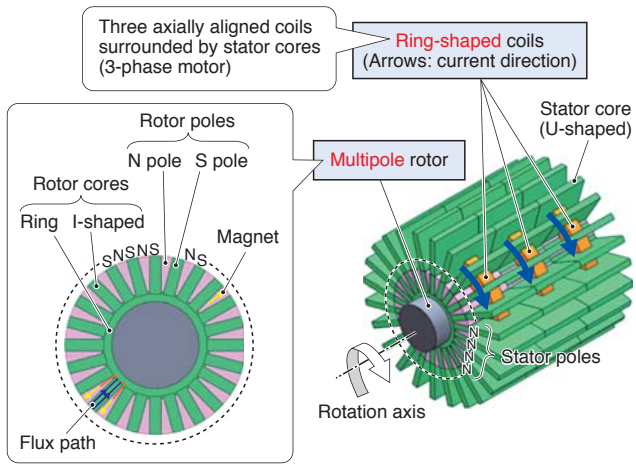
Failure prognosis engine for HDDs using data mining analysis

Space-Saving Motor with High Torque Density for Industrial and Transportation Drive Systems

Toshiba has developed a space-saving motor with high torque density (torque per volume) for industrial and transportation drive applications. Generally, torque density can be improved by increasing the number of magnetic poles and magnets, and the motor current. However, the industry has almost reached the limit of its ability to increase torque by increasing the number of magnets and the motor current, due to magnetic saturation of the iron cores and heat generation in the coils. In conventional motors, it is also difficult to increase the number of magnetic poles, considering the complexities of their coil design.

To solve this problem, we have designed a new motor having a simple coil structure to allow a further increase in the number of magnetic poles. The new motor also has low magnetic resistance (which translates into higher magnetic field intensity with the same current). The stator consists of ring coils and U-shaped iron cores surrounding them, making it possible to increase the number of poles simply by increasing the number of U-shaped cores. The rotor has magnets and I-shaped cores on the ring cores. Consequently, N and S poles are formed alternately on the rotor surface, since magnetic flux passes through the ring and I-shaped cores. The motor has three different phases that are axially aligned. Therefore, regardless of the rotational position, the motor can be driven by supplying a three-phase alternating current to the three stator coils. Furthermore, since the rotor and stator cores with low magnetic resistance face each other with only a narrow gap, an intense magnetic field is produced by the motor current.

The results of a magnetic analysis showed that the new motor has larger torque than a conventional motor under the same volume and electrical input conditions. Our new motor design will make it possible to construct high-torque-density motors of various sizes and realize compact gearless drive systems having a low maintenance cost.



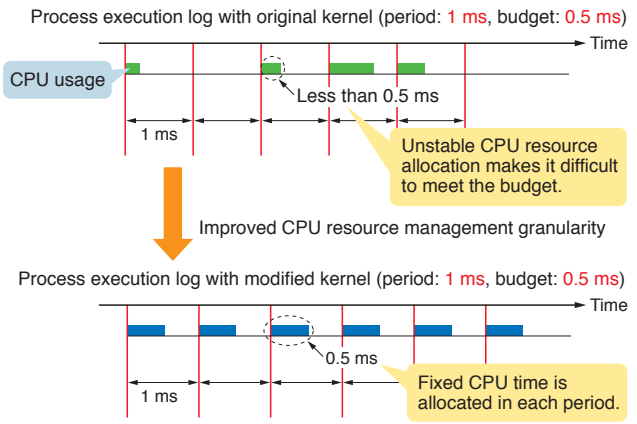
Structure of high-torque-density motor

Improvement of Real-Time Performance of Linux®

Embedded control systems for social infrastructure applications such as energy and transportation systems impose strict real-time constraints on an operating system to guarantee a response to an event within a given time and complete the execution of a process within a certain time constraint. To guarantee a response time, the operating system must not only respond to an event in a short time but also allocate sufficient central processing unit (CPU) time to the spawned process. However, Linux cannot allocate CPU time at a granularity of less than one millisecond.

To solve this problem, Toshiba has developed a technology to improve the real-time performance of Linux that makes it possible for the Linux kernel to guarantee CPU allocation at a granularity as fine as one microsecond for real-time processes. This technology will expand the range of Linux applications in the social infrastructure field.

Linux® is a registered trademark of Linus Torvalds in the United States and other countries.



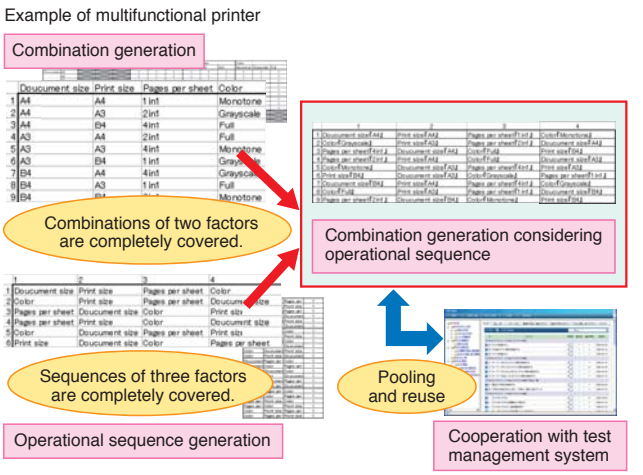
Improvement of real-time scheduling granularity of Linux

Development of Combination Test Generation Tool

With the increasing diversification of customer requirements, systems and software are becoming larger and more complex, dramatically expanding the number of combinations of software test cases. In response to this situation, Toshiba has developed the APTNavi™ combination test generation tool based on an orthogonal table and all-pair method, which makes possible exhaustive, efficient, and effective combination tests. APTNavi™ is being widely deployed throughout the Toshiba Group.

In generating combinations of test cases, APTNavi™ covers 100% of the combinations of two factors and applies the sequence covering array technique, considering the operational sequences of any three factors. Furthermore, it is not only fully automatic but also allows users to generate test cases that identify defects more efficiently by taking account of the results of failure cause analysis, risks, or other user intentions.

We investigated the effectiveness of this tool and found that the work hours required for testing were reduced by 30% to 70%. We will continue to develop high-quality software using efficient and effective combination test techniques.



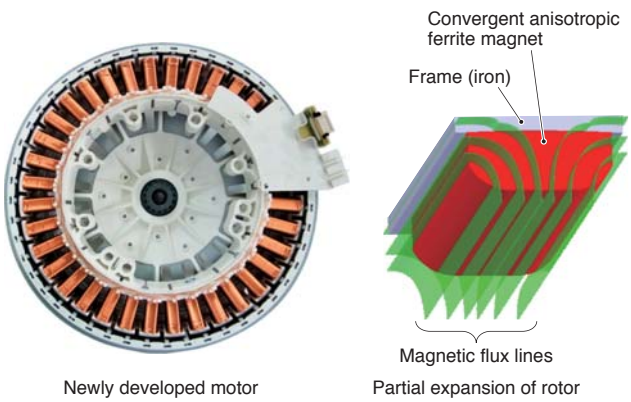
Outline of APTNavi™ combination test generation tool

High-Efficiency Motor for Washers

Although neodymium magnets have been widely used in high-efficiency motors in recent years, the continued use of such magnets, which contain a small amount of the rare-earth metal dysprosium, has become a critical issue in terms of the supply risk.

In order to rectify this situation, Toshiba has developed a new motor for washers using ferrite magnets without any rare-earth content. To enhance the magnetic force, we adopted convergent anisotropic ferrite magnets in which the magnetic flux lines are deflected and converge toward the center of the magnetic poles. Furthermore, the number of magnetic poles was increased from 24 to 48 to improve the magnetic design.

The AW-80DL/70DL fully automatic washer equipped with the newly developed motor was released in September 2012. It achieves a reduction in power consumption of 6%, from 83 Wh to 78 Wh, compared with our 2011 model.



Newly developed motor with ferrite magnets for automatic washers and its magnetic orientation distribution

Cellular Manufacturing System to Achieve High Productivity

Toshiba has developed a rationalized cellular manufacturing system to improve flexibility in producing a wide variety of low-demand products while maintaining the high productivity of large-scale production. The rationalized cellular manufacturing system has been installed at Toshiba Consumer Products (Thailand) Co., Ltd., making it possible for washers and refrigerators to be assembled by small teams.

Compared with traditional conveyorized production lines, cellular manufacturing contributes to reductions in setup time and waiting time between processes. Furthermore, the cellular manufacturing system assists in balancing production with market demand and in reducing overall costs, ranging from parts costs to distribution costs. Cost reductions have been realized by work qualification systems, cultivation of multi-skilled workers using training tools, and the use of automatic guided vehicles (AGVs) to supply parts in a timely manner. Consequently, labor productivity has been improved by approximately 50%.

We are planning to deploy the rationalized cellular manufacturing system to other subsidiaries and build a global production network.

Cellular manufacturing of washer at facility of Toshiba Consumer Products (Thailand) Co., Ltd.