7 kW Wireless Power Transmission Technology for EV Charging

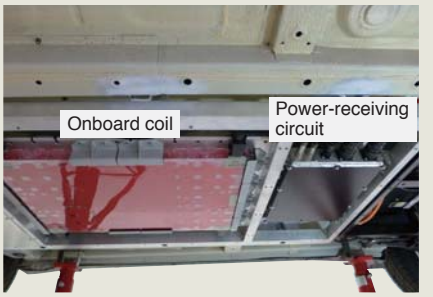
Toshiba has developed a safe, easy-to-use contactless battery charger using wireless power transmission for electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs). Wireless power transmission simplifies the charging process.

The newly developed charger has been tested in combination with the controller of an SCiB™ secondary battery mounted on an EV. The test has verified that the charger has a capacity of 7 kW, which halves the charging time compared with the 3 kW-class wired onboard chargers that are most widely used in Japan.

The transmitting pad placed on the ground, measuring 60 × 40 cm, can be up to 16 cm away from the receiving pad of the same size mounted on the underside of a vehicle. This means that the contactless charger can be used to charge the battery of most EVs and PHEVs. The charger provides high power transmission efficiency even when the transmitter and receiver coils are laterally misaligned by up to 15 cm.

The charger controls both the power transmitter and receiver via wireless LAN and dynamically selects the optimal charging voltage according to the changes in the state of charge of the secondary battery, maintaining an almost constant power transmission efficiency.

EV incorporating 7 kW wireless power transmission system



Coil and power-receiving circuit installed on underside of EV

Dysprosium-Free High-Performance Samarium-Cobalt Magnets for Motors

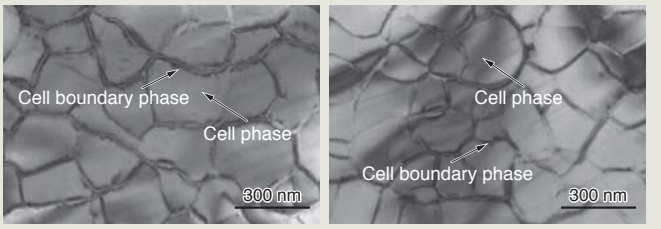
Traction motors for hybrid and electric vehicles, rolling stock, and industrial equipment operate at relatively high temperatures. Heat-resistant neodymium magnets are therefore generally used for these applications.

However, dysprosium, a key material of neodymium magnets, has high supply risk. In order to rectify this situation, Toshiba has developed samarium-cobalt (SmCo) magnets with higher magnetic force by using a unique heat-treatment technology. The newly developed SmCo magnets exhibit a maximum energy product of 280 kJ/m^3 at room temperature, the highest level in the world for SmCo magnets under laboratory conditions(*).

This strong magnetic force has been achieved by increasing the weight content of iron (Fe) in the magnet from 10–15% to 20–25% and by homogenizing and refining the crystal grains through an original heat-treatment process. We have also controlled the powder particle size of the raw material in order to reduce the content of oxides in the magnets.

These magnets, which are now commercially available, are well suited for rolling stock applications.

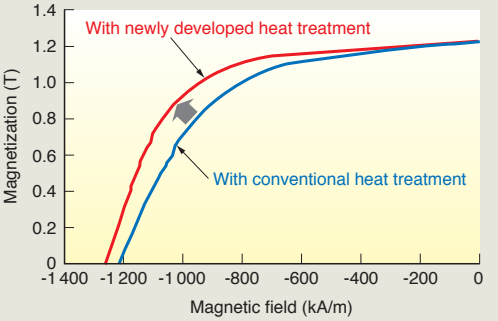
(*) As of February 2014 (as researched by Toshiba)



Average cell size: 220 nm
With conventional heat treatment

Average cell size: 160 nm
With newly developed heat treatment

Transmission electron microscope (TEM) images of conventional and newly developed high-iron-concentration SmCo magnets



Demagnetization curves of SmFeCo magnets

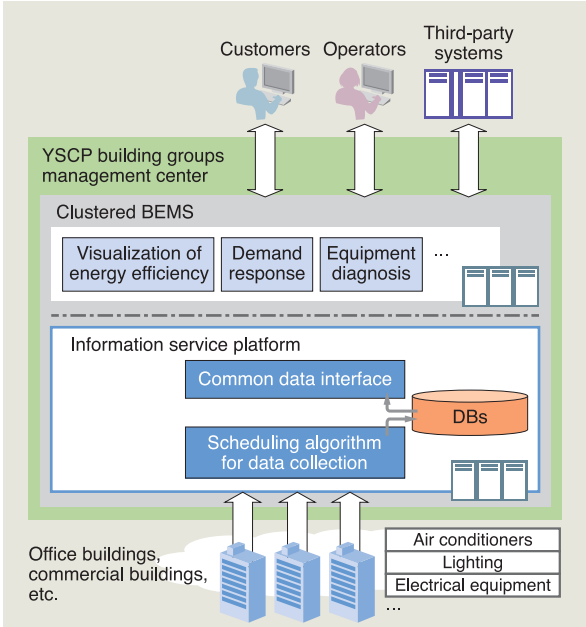
Information Service Platform for Clustered BEMS of Yokohama Smart City Project

A conventional building energy management system (BEMS) can acquire and process data from tens of thousands of points at a time, but lacks the capability to serve as a clustered BEMS that is required to monitor and control more than 10 times that number of data points in a group of buildings.

To address the needs of a clustered BEMS, Toshiba has developed a scheduling algorithm for collecting data from building facilities and a common data interface for using the collected data. The scheduling algorithm determines when to transmit data requests, considering response delays from facilities and network throughputs, thereby increasing the volume of data that can be processed in each sampling slot. The common data interface makes it possible to hide the database structure from applications when providing them with a Web application programming interface (API), eliminating the need to modify applications in order to extend the functionality of the database (DB).

We have employed these technologies to construct an information service platform for data collection, and integrated various BEMS applications onto this platform to create a clustered BEMS. The newly developed clustered BEMS has been deployed as an experimental system for the Yokohama Smart City Project (YSCP) to demonstrate its ability to integrate data from a group of buildings.

Our next step is to realize new community services, including automated demand response and equipment diagnosis.



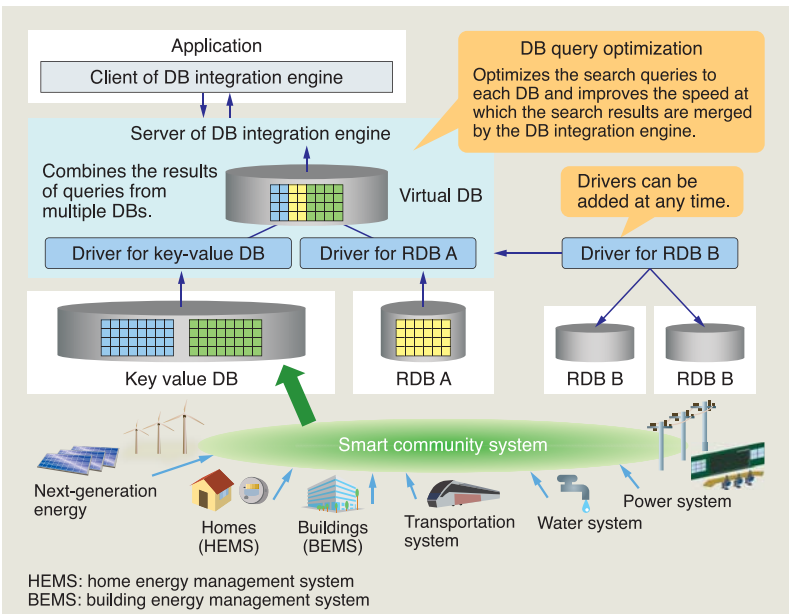
Outline of information service platform for clustered BEMS of Yokohama Smart City Project (YSCP)

Distributed DB Technology for Smart Community Systems

Smart community systems use not only conventional relational DBs (RDBs) but also new types of DBs, including key-value DBs and in-memory DBs, in order to process large volumes of data at high speed.

Toshiba has developed a distributed DB technology to process the large volumes of data generated by various controllers in smart community systems. The newly developed technology incorporates two engines: a Structured Query Language (SQL) processing engine and a DB integration engine. The SQL processing engine provides high-speed search capability for key-value DBs. It accepts complex queries similar to those available with conventional RDBs. The DB integration engine provides cross-searching of multiple disparate DBs, which gives users the impression that they are searching a single DB.

The newly developed distributed DB technology makes it possible to easily combine, sort, and aggregate data of multiple DBs using SQL queries.



System architecture of DB integration engine for smart community system

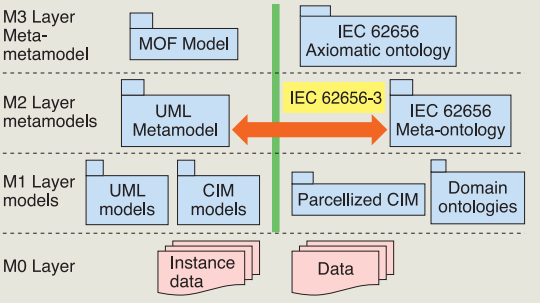
New IEC 62656-3 Standard for DB Maintenance of CIM Used in Smart Grids

The Common Information Model (CIM) defined in the IEC (International Electrotechnical Commission) 61970/61968 series of standards is used to exchange data and information among electric energy systems. However, the current CIM defined in the Unified Modeling Language (UML) has issues of data compatibility and sustainable model maintenance in a DB.

In order to improve the weaknesses of the CIM UML model, Toshiba has proposed the IEC 62656-3 standard, which defines an interface between the CIM and the tabular modeling methodology of IEC 62656. In IEC 62656-3, transformation rules between the metamodels of IEC 62656 and the CIM UML are defined. This standard makes it possible to derive a CIM in a tabular format called "Parcellized CIM" from a CIM UML model. Parcellized CIM has the following advantages:

- Each entity can be identified with a globally unique identifier (ID), including a version number, so that version management of each entity defined in the CIM model can be implemented. The version control mechanism of IEC 62656 ensures data compatibility among different versions of CIM models.
- Online model maintenance of the CIM through the IEC Common Data Dictionary (CDD) (http://std.iec.ch/iec61360) can be easily realized with the IEC 62656 format of Parcellized CIM. Additionally, the CIM can be complemented by other domain ontologies available in the IEC CDD.
  IEC 62656-3 has been submitted to IEC for FDIS circulation as of April 2014.

FDIS: Final Draft for International Standard



Mapping between metamodels of CIM UML and IEC 62656

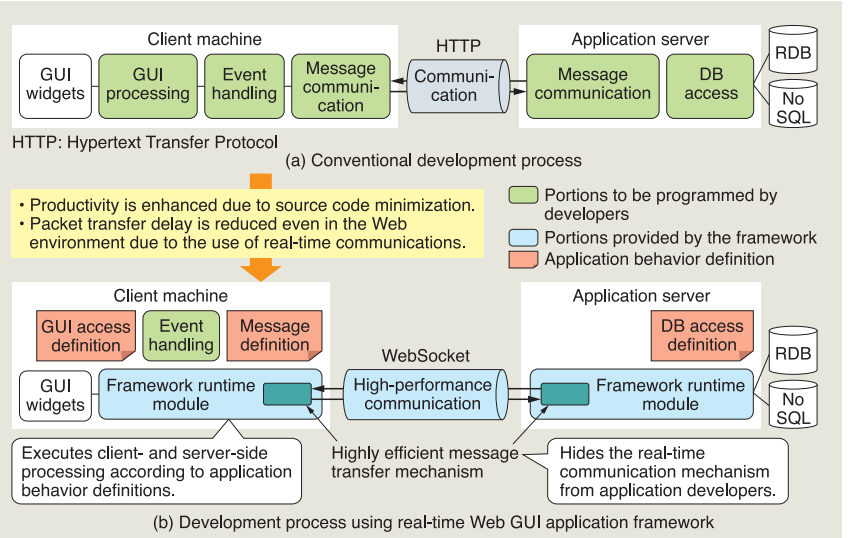
Real-Time Web GUI Application Framework

Toshiba has developed a new graphical user interface (GUI) framework for building Web applications for real-time social infrastructure systems including supervisory control and data acquisition (SCADA) systems.

Various real-time social infrastructure systems are being rebuilt as Web applications using cloud computing and Hypertext Markup Language 5 (HTML5) technologies. Although many HTML5 software libraries are available on the Internet, only a few of them provide a consistent framework for the development of client-server applications.

The newly developed GUI framework provides full functionality for the development of complete Web applications. In order to retrieve information from a server DB at high speed and automatically display the information on a client as GUI widgets, programmers need only to define a simple sequence of DB accesses, message communications, and GUI accesses. This GUI framework helps to minimize the code size of user programs, increasing the productivity of Web application development. Furthermore, the use of the WebSocket Protocol and a newly developed highly efficient message transfer mechanism allows real-time client-server communications.

We are planning to build various social infrastructure systems as Web or cloud systems using this new GUI framework.



Development of Web applications using real-time Web GUI application framework

Quantum Access Network Technology

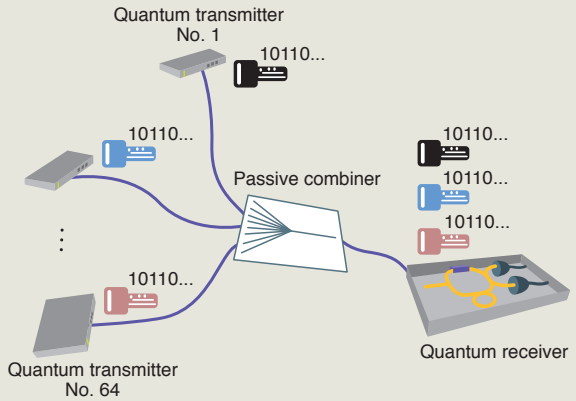
Toshiba has developed a new scalable approach to building a secure quantum access network that uses a new technology called quantum cryptography to detect eavesdropping of optical fiber with 100% certainty.

The quantum network uses standard passive optical network (PON) technology to connect multiple users in a tree-based architecture so as to allow the sharing of a single-photon (light particle) detector, one of the most complex components necessary for quantum transmission. We have demonstrated that our world-leading single-photon detector can be shared by up to 64 users(*). Our active stabilization technique provides continuous and stable network operation, allowing, for example, the transfer of approximately two hundred 256-bit secret encryption keys per second per user in an eight-user network. This new approach has shown a path for the first time toward implementing quantum cryptography technology in smart grid, smart city, and other networking applications.

The newly developed quantum access network is essential to make quantum cryptography more practical and cost-effective. In the future, we will further improve the speed and robustness of the quantum access network and develop more compact hardware.

This research is partly supported by the "Research and Development of Secure Photonic Network Technologies" commissioned research project of the National Institute of Information and Communications Technology (NICT), Japan.

(*) Fröhlich, B. et al. 2013. "A quantum access network." *Nature* 501: 69–72. (as researched by Toshiba)



Overview of quantum access network

Automatic Production Line for Elevator Metal Panels

Toshiba has developed a new production line and equipment for the metal panels that make up elevator parts, including cars, doors, and frames. This production line is designed to automatically attach reinforcement structures onto panels. The automatic equipment was codeveloped by the product design production sections.

We have improved the manufacturing processes and optimized the configurations of parts in order to automate parts assembly, and standardized elevator designs without compromising the rigidity and strength of panels and their assembly precision. Consequently, the variety of panels and reinforcement structures produced has been reduced.

The newly developed assembly technology uses vertical articulated robots, thus helping to improve productivity, shorten lead times, and reduce the number of operators.

The new production line and equipment are now operating at the Fuchu Factory of Toshiba Elevator and Building Systems Corporation.

Parts assembly equipment for automatic elevator production line

CIGS Solar Cell with World's Highest Level Energy Conversion Efficiency

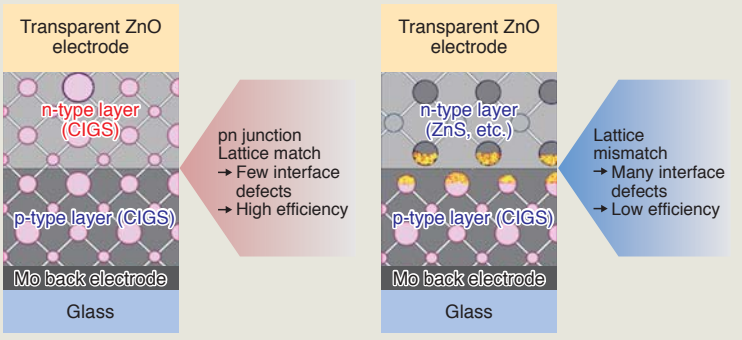
Toshiba has developed a small homojunction copper indium gallium diselenide (CIGS) solar cell with the world's highest level energy conversion efficiency of 20.7%(*).

Although the conventional heterojunction CIGS solar cell, which consists of an n-type zinc sulfide (ZnS) layer on top of a p-type CIGS layer, can be manufactured at lower cost and with less usage of resources, its efficiency is insufficient because it tends to have a high interface defect density due to lattice mismatch at the heterojunction interface.

To solve this problem, we have used our original liquid-phase doping technique to create a homojunction CIGS pn junction structure with few interface defects. In this technique, a thin CIGS film is dipped into a liquid containing a dissolved n-type dopant in order to form an n-type region on top of the p-type CIGS layer.

Our next step will be to improve the homojunction technology so as to realize a CIGS solar cell with even higher efficiency (25%, equivalent to that of a single-crystal silicon (Si) solar cell).

(*) As of September 2013 (as researched by Toshiba)

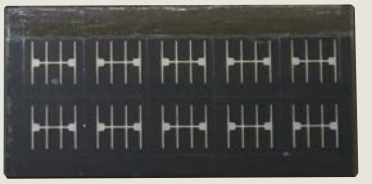


New device structure (homojunction)

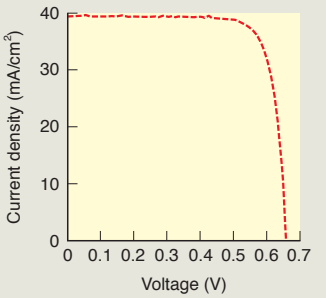
Conventional device structure (heterojunction)

ZnO: zinc oxide Mo: molybdenum

New device structure of high-efficiency CIGS solar cell



Newly developed CIGS solar cell



Current density-voltage characteristics

Organic Photovoltaic Cells with High Conversion Efficiency

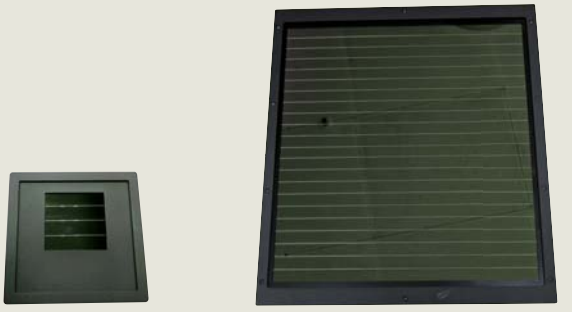
Organic photovoltaic (OPV) cells are light in weight and flexible and can be printed in various forms.

Toshiba has developed OPVs with the world's highest conversion efficiency(*) by using an original p-type polymer and a high-precision patterning film formation method called meniscus coating. Our newly developed 20 × 20 cm OPV submodule has an efficiency of 6.8%, while our 5 × 5 cm OPV minimodule has an efficiency of 8.5%. Furthermore, we have developed a 30 × 30 cm OPV module and verified its power generation capability.

OPVs offer higher efficiency in indoor lighting environments. We have confirmed that their efficiencies under light-emitting diode (LED) illumination are higher than those of crystal- and amorphous-Si photovoltaics.

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

(*) Green, M.A. et al 2014. "Solar cell efficiency tables (version 43)." *Progress in Photovoltaics: Research and Applications* 22 (1): 1–9. (as researched by Toshiba)



5 × 5 cm OPV minimodule

30 × 30 cm OPV module

5 × 5 cm OPV minimodule with world's highest conversion efficiency and 30 x 30 cm OPV module

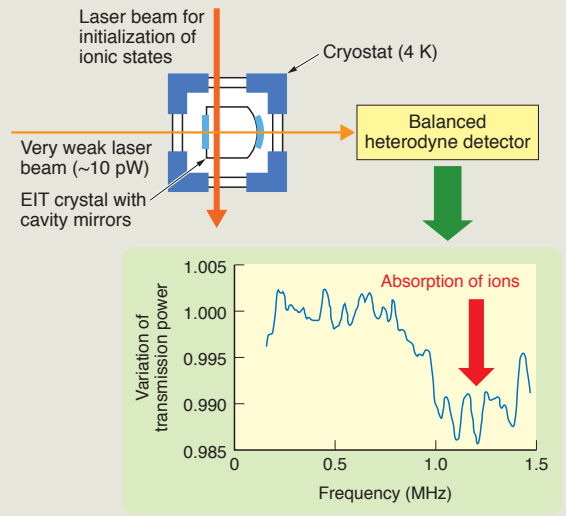
Ultraprecise Spectroscopy of EIT Crystal toward Realization of Quantum Computer

A quantum computer uses quantum superposition of physical states to deliver ultrahigh-speed computation. Ions in a crystal that exhibits electromagnetically induced transparency (EIT), such as Pr^{3+}:Y_2SiO_5(*), retain their quantum superposition states for a very long time, and are therefore suitable for quantum computer applications. However, it is difficult to observe individual ions in a crystal. This is the current challenge to be solved in order to realize a quantum computer using an EIT crystal.

To address this issue, Toshiba has established a novel spectroscopic technique to measure the absorption of ions in a crystal enhanced by an optical cavity by detecting a very weak light transmitted through the cavity at a high level of precision. Using this technique, we have succeeded in observing an unprecedentedly small number of ions. Furthermore, by analyzing the results of detailed experiments, we have also discovered a new law governing the distribution of ion energy levels in an EIT crystal.

Our next step is the observation of a single ion in an EIT crystal, which is crucial in realizing an EIT-crystal-based quantum computer.

(*) Pr^{3+}:Y_2SiO_5: praseodymium-doped yttrium orthosilicate. Pr: praseodymium, Y: yttrium, O: oxygen.



p: pico (10^{-12})

Cavity-enhanced absorption spectroscopy of EIT crystal for quantum computers

Experimental Verification of Direct Correlation between Hydrogen in Gate Oxide and Its Reliability Degradation Using Nuclear Reaction Analysis

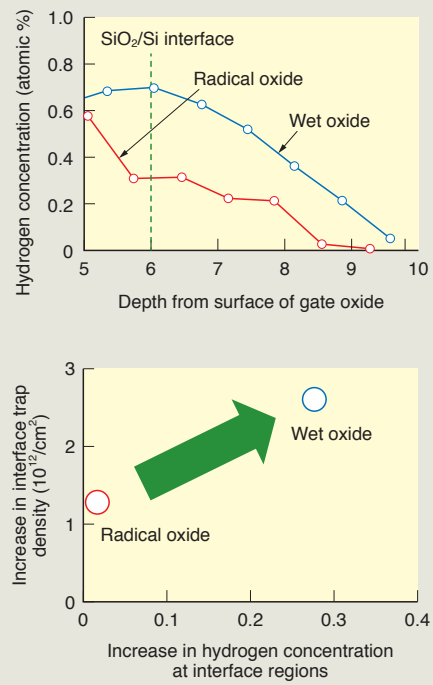
Based on a first-principle calculation, it had been reported that hydrogen migration onto the SiO_2/Si interface degrades the reliability of the gate oxide in a MOS transistor, a basic building unit of an LSI. However, this phenomenon had not been experimentally proven.

Toshiba has conducted a study in which nuclear reaction analysis (NRA) was performed to obtain hydrogen concentration distributions around the SiO_2/Si interface regions for two types of MOS transistors with different types of gate oxide (SiO_2) and the interface trap density was electrically measured.

Based on the results of this study, we have quantitatively verified for the first time in the world(*) that the concentration of hydrogen around the SiO_2/Si interface is directly correlated to the interface trap density and plays a crucial role in the degradation of gate oxide reliability.

(*) Suzuki, M. et al 2013. "Experimental proof of direct correlation between hydrogen migrated to SiO_2/Si interface and MOSFET characteristics using high energy $^{15}N^{2+}$ ion beam." International Conference on Solid State Devices and Materials. Fukuoka, Japan, September 2013. (as researched by Toshiba)

SiO_2: silicon dioxide
MOS: metal-oxide semiconductor
LSI: large-scale integration



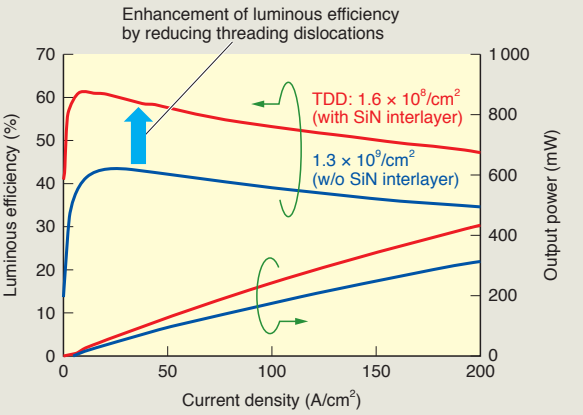
Depth profiles of accumulated hydrogen at interface regions estimated by NRA (upper) and correlation of increments of hydrogen concentration and interface trap density (lower)

Enhancement of Luminous Efficiency of GaN-on-Si-Based Blue LEDs by Reducing Threading Dislocations

White LEDs are widely used in various applications, including general lighting and LCD TV backlighting. Gallium nitride (GaN)-based blue LEDs fabricated using large-diameter Si substrates are expected to serve as high-efficiency and low-cost light sources for LED lighting. However, because of the large lattice mismatch between the GaN crystal and the Si substrate, the GaN layer of an LED has a high threading dislocation density (TDD) on the order of 10^9 to 10^{10}/cm^2. The threading dislocations act as nonradiative recombination centers and limit the light-emitting efficiency of an LED.

To resolve this problem, Toshiba has developed a novel technology that uses a silicon nitride (SiN) interlayer to reduce threading dislocations. The newly developed technology provides a GaN layer on the Si substrate with a TDD as low as 1.6×10^8/cm^2, which is comparable to that of a GaN layer formed on a conventional sapphire substrate. We have verified that GaN-on-Si-based blue LEDs fabricated using this TDD reduction technology exhibit enhanced luminous efficiency.

LCD: liquid crystal display



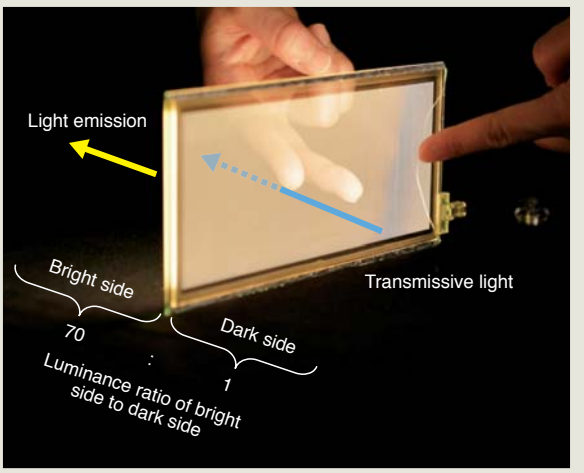
Luminous efficiency and light output power of GaN-on-Si-based blue LEDs

Transmissive One-Side-Emission OLED Lighting

Organic LEDs (OLEDs) emit gentle light in a plane and can be fabricated in transparent form. Because of these advantages, OLEDs are expected to be next-generation light sources as the successors to LEDs. However, the conventional transparent OLED panel using a semitransparent cathode loses transparency when it is lit up. This is because visibility through the panel from one side to the other is obstructed by the light emitted from both sides of the panel.

To solve this problem, Toshiba has developed a transmissive one-side-emission OLED panel using a microfabricated cathode with a width of approximately 100 µm, narrow enough to be invisible to the naked eye. In the newly developed OLED panel the bright side achieves 70 times the luminance compared with the dark side. Because it emits light from only one side of the panel, the illuminated objects can be seen from the dark side through the panel. Furthermore, we have adopted a solid transparent encapsulant to improve the transmittance of the OLED panel. This structure reduces reflection due to the differences in the refractive index at each interface among the sealing glass, internal gas, and organic layers. As a result, the newly developed OLED panel has a transmittance 18% higher than the conventional type.

We will continue to develop new applications, taking advantage of the unique features of OLEDs.



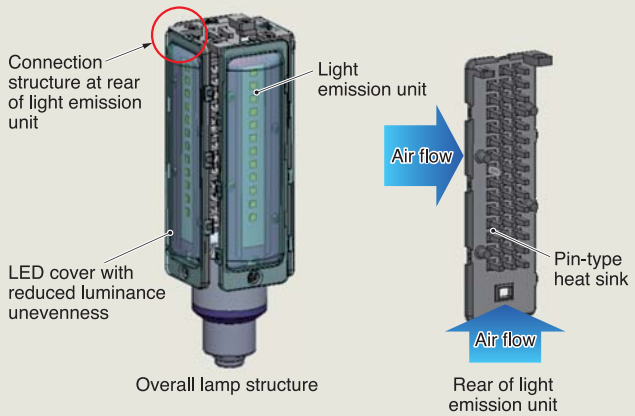
Transmissive one-side-emission OLED panel

Design Method for LED Lamps to Replace 100-Watt Mercury Lamps

In order to replace mercury lamps, LED lamps must be sufficiently small to be attached to existing lighting fixtures. Other requirements include an optical housing that provides spherical light distribution equivalent to that of mercury lamps and a cooling structure designed to suppress the temperature rise of LEDs irrespective of the orientation in which they are mounted.

Toshiba has developed a design method for evaluating the optical and cooling performance of LED lamps using simulation. The newly developed design method helps to reduce the number of trial manufacturing runs. An LED lamp developed using this method has a pin-type heat sink with high cooling performance, an LED cover with reduced luminance unevenness, and a connection structure at the rear of the light emission unit to allow air flow inside the lamp housing.

A trial product has exhibited a luminous flux of 4 200 lumens, which is as bright as a 32-watt mercury lamp. This LED lamp is not only mercury-free but will also contribute to energy saving.



Structure of newly developed LED lamp to replace mercury lamps

Short-Span Seek Control Technology for HDDs for Enterprise Use

In order to improve the data access performance of hard disk drives (HDDs), it is important to speed up seek control so that the read/write head moves rapidly to the target data track. Speeding up short-span seeking is particularly effective in improving the data access performance because short-span seek control(*1) is executed frequently in read/write operations. However, fast seeking tends to cause motion-induced residual vibration of the head after it arrives at the target data track. Conventionally, this residual vibration has been a major cause of read/write latency.

To overcome this problem, Toshiba has developed a new short-span seek control technology that suppresses residual vibration by gradually correcting the current waveform of the voice coil motor for each seek operation. As a result, the latest 2.5-inch enterprise HDD that incorporates the newly developed short-span seek control technology achieves 405/350 input/output operations per second (IOPS) for a 4 Kbyte random read/write, the world's highest data access performance(*2).

(*1) Control of a seek operation with a seek distance not exceeding about 30% of the maximum seek distance

(*2) As of October 2013, for HDDs for enterprise use with a rotation speed of 15 000 rpm (as researched by Toshiba)

2.5-inch HDD for enterprise use equipped with newly developed short-span seek control technology

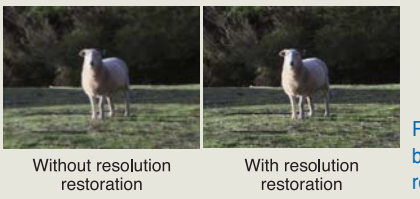
Signal Processing Technologies for CMOS Image Sensors

Toshiba has developed two technologies for complementary MOS (CMOS) image sensor applications: a resolution restoration technology that improves the resolution of a thin lens, and a digital focusing technology that allows users to change the focus point in photos after they have been taken by using the camera-to-subject depth information from two cameras.

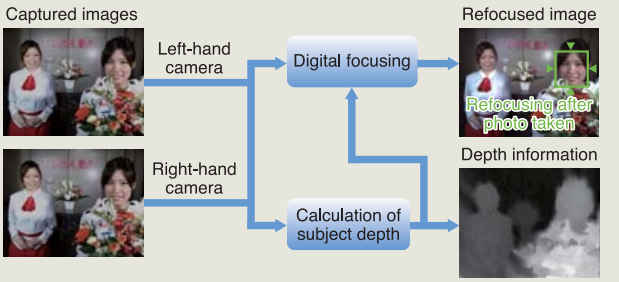
In order to reduce the thickness of smartphones, it is necessary to use a thin camera module (particularly with a thin-lens combination). However, reducing the number of lenses decreases the image resolution. To explore the optimal trade-off between the number of lenses and camera resolution, we analyzed how images become blurry when thin lenses are used. As a result, we developed the resolution restoration technology, which corrects image-blurring effects. This technology improves camera resolution, making it possible to develop thin camera modules without compromising resolution.

The digital focusing technology matches two images taken by left- and right-hand cameras to calculate the camera-to-subject depth. While the conventional technique gives false depth information for flat regions of an image, the newly developed hierarchical matching technique improves depth accuracy in flat regions. A conventional autofocus camera cannot adjust the focus after photos are taken, whereas the newly developed digital focusing technology allows users to refocus on any subject because it relies only on mathematical calculation.

We will incorporate these technologies into future products.



Result of processing by resolution restoration technology



Block diagram of digital focusing technology

Result of processing by digital focusing technology

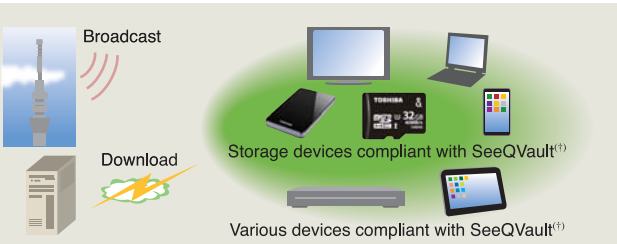
Compact, Secure ID Scheme for NAND Flash Memory and SeeQVault(†) Standard

In order to prevent unauthorized copying of commercial digital content, a unique ID is generally assigned to each medium to encrypt the content when it is recorded on it. Toshiba has developed a secure ID management scheme designed to prevent any third-party replication of such IDs. The newly developed scheme can be implemented in a compact controller of NAND flash memory.

In this scheme, electronic appliances must first obtain separately licensed secret information to execute an authentication protocol for the NAND flash memory. Upon the successful implementation of the authentication protocol, an electronic appliance is granted permission to use a unique, secure ID assigned to each NAND flash memory.

This scheme has been adopted in the SeeQVault(†) content protection technology licensed by NSM Initiatives LLC. SeeQVault(†)-compliant microSDHC memory cards have been on the market since October 2013, and SeeQVault(†)-compliant portable HDDs are expected to be released in the near future.

In Japan, SeeQVault(†) has already been authorized as a content protection technology to protect digital broadcast contents, and TVs and content players/recorders that support SeeQVault(†)-compliant media will be released in the near future. SeeQVault(†) will be used to protect a variety of digital contents, including audio contents, e-books, and games.



Storage and other devices compliant with SeeQVault(†) content protection standards

ID: Identifier SDHC: SD High Capacity

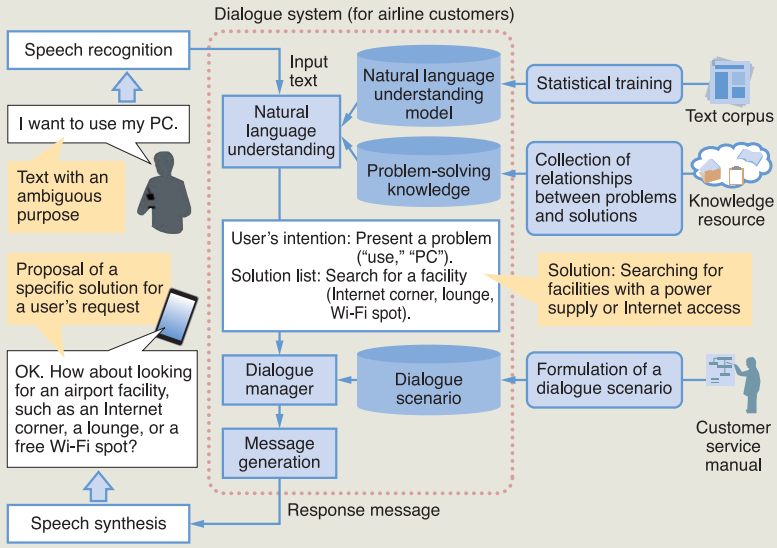
SeeQVault is a trademark of NSM Initiatives LLC.

Problem-Solving Dialogue Technology

Toshiba has developed an advanced spoken dialogue technology for human-machine dialogue systems designed to infer the intentions of users' utterances and assist in resolving their problems.

Problem-solving knowledge is one of the most important components of dialogue technology. We have constructed a knowledge base that consists of a set of three pieces of information—target, action, and reason—using a purpose information extraction technology. When a user speaks to a dialogue system about a problem, this technology steers the dialogue toward solving the problem presented.

We are now working to automate the acquisition of problem-solving knowledge, and aim to launch a dialogue system and services using the newly developed dialogue technology.



Outline of problem-solving spoken dialogue system

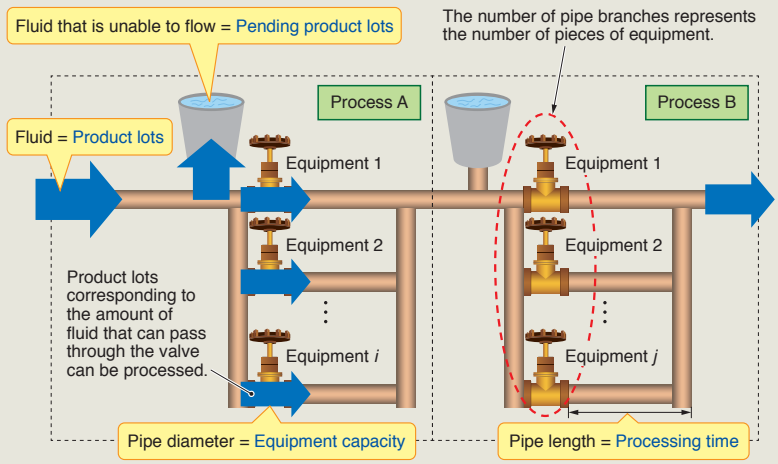
High-Speed Simulator for Semiconductor Manufacturing Control

Semiconductor manufacturing requires dynamic production volume control according to demand and factory capacity fluctuations. Production plans must be regularly updated, based on short-term demand forecasts.

To address this need, Toshiba has developed a high-speed simulator using fluid models. The newly developed fluid simulator treats production lots as a fluid, omitting lot-tracing calculations made by conventional simulators. As a result, the simulation speed has been improved owing to the use of approximate calculations.

In the fluid simulation, the equipment capacity and the turnaround time of each manufacturing process are represented as the diameter and length of a pipe. The fluid flow signifies production lots being processed, while a fluid that resists flowing indicates pending production lots. Unlike conventional discrete-event simulation, the speed of fluid simulation is not affected by the number of production lots simulated. Therefore, the fluid simulator can simulate the manufacturing of a large number of production lots at high speed.

The newly developed fluid simulator is 15 times faster than the conventional simulator for our production scale and thus allows even a long-term (monthly) simulation. It has been used to identify equipment bottlenecks and clarify manufacturing situations from a broad perspective.



Outline of high-speed fluid simulator applying fluid model