

TOSHIBA REVIEW

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Special Reports

Nanotechnology

Beyond Feynman's Dreams

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Frontiers of Nanotechnology

ISHIUCHI Hidemi / ITOH Yoshiyasu / INABA Michihiko

A wide variety of applications have been developed as outcomes of the nanotechnology revolution. Examples in the energy engineering field include nanostructure ceramics, power generation systems using nanocrystals, while examples in the electronics field include the development of semiconductor integrated circuits with a feature size in the sub-hundred nm range, and nanosize semiconductor devices such as quantum dots and single-electron transistors, and so on. Measurement techniques are progressing as well. In addition to physical and chemical methods, biochemical methods using DNA molecules as probes have also been developed.

Nanotechnology is expected to become a major driver of innovation in the near future.

Thermoelectric Generating System for Effective Use of Unutilized Energy

SHINDO Takahiko / NAKATANI Yujiro / OISHI Takashi

Exhaust heat with a low temperature of 150°C or less exists in large quantities. However, the thermal energy cannot be used efficiently from both the economic and technical points of view. For efficient collection of this thermal energy, Toshiba has developed a thermoelectric module with a bismuth-tellurium composition, a thermoelectric system using the module, and long-term reliability evaluation technology for the module. The thermoelectric module with a nanocrystalline structure showed a conversion efficiency of 3.6% at 130°C, exceeding that of conventional materials. In addition, we confirmed the high reliability of the thermoelectric module through a study conducted at a geothermal generation system in the Kusatsu hot springs area as well as by a heat-cycle evaluation study.

Nanostructured Joining Technology for High-Strength Reaction-Sintered Silicon Carbide

SUYAMA Shoko / ITOH Yoshiyasu

High-strength reaction-sintered silicon carbide (SiC) developed by Toshiba has the world's highest strength, exceeding 1,000 MPa, and properties such as no pores, almost no sintering shrinkage, and low sintering temperature. However, joining technology is indispensable for this material in order to apply it to components of large size and complex shape.

We have therefore developed a nanostructured joining technology for high-strength reaction-sintered SiC that realizes excellent thermal stability and high joining strength. We are now in the process of applying this technology to hydrogen production systems and space optics.

Nanosensing Technique Using X-ray Color Image Intensifier

NITTOH Koichi / MIYABE Keisuke / NAKAYAMA Kunihiko

Nondestructive photography of high-speed phenomena is required in a broad range of leading-edge technologies such as the analysis of collision phenomena of solids and liquids and the inspection of vibration and distortion under high-speed operation. In addition, minute observation at the nanometer scale is essential for many basic technologies such as the microfabrication of electronic parts and machines, crack inspection of materials, and development of functional materials.

The Color I.I.TM (UltimageTM) color image intensifier, originally developed as an X-ray real-time imaging device, has various advantages in terms of high-speed and precise imaging compared with other devices. The Color I.I.TM system can take high-speed X-ray transmission images in the range of tens of nanoseconds, which is not possible using film- or imaging plate (IP)-based systems. Furthermore, a spatial resolution as small as 400 nm can be attained by the combination of the image-magnifying function of the Color I.I.TM system, a high-resolution camera, and an X-ray source of 400 nm focus size.

25 nm SONOS Type Memory Device Using Double Tunnel Junction

OHBA Ryuji

A 25 nm gate length bulk-planar silicon oxide nitride oxide semiconductor (SONOS) type memory, which has a Si nanocrystalline layer between double tunnel oxides, shows excellent memory characteristics due to the Coulomb blockade and quantum confinement functions of Si nanocrystals.

Toshiba has experimentally shown direct evidence of the great advantage in trade-off between charge retention and write/erase (w/e) speed using this device, suggesting that further device scaling and improvement are possible by Si nanocrystal size scaling. We have been developing the double tunnel junction SONOS type memory as a strong candidate for use in the smaller than 25 nm region.

New Nanoarchitectures for Post-CMOS Era

FUJITA Shinobu / ABE Keiko / YASUDA Shinichi

The complementary metal-oxide semiconductor (CMOS) based on the silicon metal-oxide semiconductor field-effect transistor (Si-MOSFET) may reach its limit within 10 years. However, no new solution has been proposed yet for the post-CMOS era. Toshiba has been working on building new nanoarchitectures for the post-CMOS era using the most realistic methods possible. For this purpose, we have developed new circuitry using post-silicon memory and transistors, three-dimensional (3D) circuitry, fault-tolerant circuitry, network circuitry, and so on. Among these, the design of high-bandwidth 3D memory and fault-tolerant circuitry is the most important.

Bit-Cost Scalable Technology for Low-Cost and Ultrahigh-Density Flash Memory

TANAKA Hiroyasu / AOCHI Hideaki / NITAYAMA Akihiro

Toshiba has been developing bit-cost scalable (BICS) technology to realize low-cost and ultrahigh-density flash memory. A feature of BICS technology is that a whole stack of electrode plates is punched through and plugged by another material to form a three-dimensional memory cell array. This fabrication process is expected to achieve a continuous reduction in bit-cost, since the number of processes will not significantly rise against increases in the number of layers for future ultrahigh-density memories.

Technologies for RF MEMS Tunable Capacitors

OHGURO Tatsuya / IKEHASHI Tamio / SUGIZAKI Yoshiaki

In recent years, cellular phones have become capable of handling not only wideband code division multiple access (W-CDMA) but also one-segment TV broadcast reception, the Suica card payment system, and FM radio. Furthermore, many functions are being added for better communication such as Bluetooth®, ultra-wideband (UWB), worldwide interoperability for microwave access (WiMAX), wireless LAN (WLAN), and so on. In order to balance the increase of components for broadband and miniaturization of terminals, radio-frequency microelectromechanical system (RFMEMS) variable capacitors have been attracting considerable attention. However, it is necessary to overcome the problems of stiction of the MEMS actuator and the fact that MEMS packaging technology has not yet been fully established.

In response to these problems, Toshiba has developed an intelligent driver integrated circuit (IC) realizing stable operation of the MEMS actuator and an in-line wafer level package (WLP) technology with high reliability and low cost.

Electrochemical DNA Chip for Personalized Medicine

GEMMA Nobuhiro / HASHIMOTO Koji / NIKAIDO Masaru

Toshiba has developed an electrochemical DNA chip that makes simple and low-cost DNA testing possible due to the realization of a compact detection system and elimination of the need for dye labeling. The electrochemical DNA chip is expected to become a platform in the medical diagnostic field in place of the conventional fluorescent DNA chip.

For personalized medical care, we have established a highly accurate system using electrochemical DNA chips to predict response to interferon in patients with the hepatitis C virus (HCV) and to detect single nucleotide polymorphisms (SNPs) in drug metabolizing enzyme genes. We have also been developing future technologies such as a fully automated DNA detection system and a complementary metal-oxide semiconductor (CMOS) type DNA chip.

Bioassay for Detecting Neurotoxicity of Environmental Contaminants

SUGANO Mitsuko / AKAHOSHI Eiichi / URUNO Saeko

Various environmental chemicals are suspected to damage human health. An adequate method of assessing the toxicity of such chemicals has not yet been established, however, because they affect different organs such as the liver, reproductive organs, immune tissues, nervous tissues, and so on.

Toshiba has developed a tyrosine hydroxylase (TH) assay method for detecting the neurotoxicity of environmental contaminants. This is an in vitro bioassay method using TH gene expression, which is a functional marker of the dopamine system in the brain, together with evaluation metrics. TH assay provides a simple screening method with high throughput for a large number of environmental contaminants.

Feature Articles

W55T CDMA2000 1xEV-DO Cellular Phone

KATAYANAGI Masanori / IKEDA Katsuhiko / TANIMOTO Fumihiko

The CDMA2000 1xEV-DO (code division multiple access 2000 1x evolution data only) service was launched in November 2003 by Japanese cellular phone service provider au, and since the end of 2006 au's cellular phone service has supported the 800 MHz frequency band reorganization. As a result, the size of the radio circuit system of cellular phones has been increasing to accommodate the triple bands with the new frequency added to the conventional dual bands. Moreover, the size of cellular phones is growing larger as additional functions for new services and enhanced performance are incorporated into them. In response to these developments, Toshiba has released the latest CDMA2000 1xEV-DO cellular phone, model W55T, for the Japanese market. The W55T is capable of handling substantial functions in a slim chassis of only 9.9 mm in thickness.

D4 Advanced Protection Relay for Reduction of Operative Burden

ISHIHARA Yuji / KAGAMI Toshiro / MINAMI Yuji

A protection relay is used for detection of faults that occur in electric power systems such as transmission lines and substation facilities. For example, a protection relay must detect a lightning strike fault within several tens of milliseconds and instantaneously issue a trip command to isolate the faulty part of the network or facility from other normally operating parts, in order to maintain the stability of the electric power system.

Toshiba launched the world's first microprocessor-based digital protection relay in 1980. Since then, we have been continuously improving protection relays and contributing to power system stability throughout the world. In the development of our new D4 protection relay platform, we employed state-of-the-art hardware and software technologies to improve reliability and maintainability as well as upgraded human interface and analysis tools.

Newly Developed SCiBTM High-Safety Rechargeable Battery

KOSUGI Shinichiro / INAGAKI Hiroki / TAKAMI Norio

Toshiba has developed the SCiBTM high-safety rechargeable battery and is ready to produce it in commercial quantities. The SCiBTM battery has three major features. First, it is designed to have intrinsic safety and will not thermally run out of control even when an internal short-circuit is formed due to an external impact. This is because an inactive oxide is applied to the anode in place of carbon, which is more active and combustible. Second, the SCiBTM battery has a superior lifetime. Its performance degradation has been confirmed to be negligibly small after 3,000 charge-discharge cycles. This is comparable to other electronic devices such as electrolytic condensers, which means that new types of electronic equipment will be marketed that require no replacement batteries. It is therefore an environmentally friendly product due to the reduction in waste batteries. Third, the SCiBTM battery can be recharged in only five minutes.

It will be applied to a wide variety of electric appliances such as electric bicycles, electric forklifts, automatic guided vehicles (AGVs), multifunctional peripherals (MFPs), and so on.

GaN Solid State Power Amplifier for X-band Weather Radar Systems

ASAHI Yasuaki / SATOMI Akihiro / KANTO Kazuhiro

Toshiba has developed a 200 W (at 9 GHz) solid-state power amplifier (SSPA) for X-band (8-12 GHz) weather radar systems utilizing a 4-way combiner of new gallium nitride high electron mobility transistors (GaN HEMTs) of over 50 W. Compared with conventional power amplifiers such as klystrons and magnetrons, the newly developed SSPA is smaller in volume, offers higher reliability, and allows the occupied frequency bandwidth to be narrower due to suppression of the spurious level.

Web Service Technology for Facility Networks

MAEGAWA Tomonori / HANADA Yuuichi

Building automation is a major field of application for current facility networks, allowing facility management personnel to monitor and control facilities. In the building automation industry, Web services are one of the most important technologies for access to facility data from various user's applications. The interface specifications have been published, but the technology has not yet been applied to actual products.

Toshiba has developed a prototype software for realizing integrative systems cooperating with enterprise systems and/or Internet services. We have confirmed the interoperability of the system by an interconnection test with another company. This system enables users to develop various integrative systems to optimize the use of facility data.

Data Management System Standard for Product Ontology with Spreadsheets

MINAMINO Noriko / MURAYAMA Hiroshi

ISO/TS13584-35, a Spreadsheet interface for parts library, was approved as a technical specification (TS) by the International Organization for Standardization (ISO) in 2007. The standardization was led by Toshiba in dialogue with Paradine GmbH in Austria, and is based on the spreadsheet formats used in parts library (PLIB) servers developed and marketed by our company. The standard also permits interface with other standards, such as the German DIN 4002 standard and the ISO 15926 reference data library (RDL) standards promoted by the Scandinavian countries. The uniqueness of Part 35 lies in the fact that both data and metadata are represented in basically the same structure.

Contextual Checking System for Numerical Inconsistencies in Business Documents

TANIGUCHI Yuko / ZU Guowei / KANO Toshiyuki

Business documents such as weekly sales reports, financial reports, and social surveys contain many types of numerical information. In the event that such a document contains a numerical inconsistency that is not discovered and corrected before publication, the company's reputation will suffer negative consequences. The proofreading of documents is therefore indispensable to avoid such risks. However, the proofreading of large volumes of business documents generated by a company using human efforts alone involves a great deal of labor and high costs.

Toshiba Solutions Corporation is developing a contextual checking system for numerical inconsistencies in business documents, which will help persons responsible for such documents to eliminate numerical inconsistencies in them. This technology will result in considerable savings in labor and facilitate the publication of documents with a low risk of mistakes.

Frontiers of Research & Development

Paraphrase Generation for Document Retrieval

2D Carrier Profiling Technology Realizing World's Highest Resolution of 1 nm