

Toshiba continues to produce innovative technology and further enhance competitiveness aiming at sustainable growth under the technological slogan of “creating anti-commoditization technology”. The R&D division will promote the creation of new technology that will form the engine for growth in the future such as super-fast rechargeable batteries, enhancement of fundamental technologies and research & development contributing to existing business.

## New Rechargeable Lithium-Ion Battery Recharges in Only One Minute

Toshiba Corporation has achieved a breakthrough in lithium-ion batteries that makes long recharge times a thing of the past. The new battery can recharge 80% of its energy capacity in only one minute, approximately 60 times faster than the typical lithium-ion batteries in wide use today, and this fast recharge time is also combined with performance-boosting improvements in energy density.



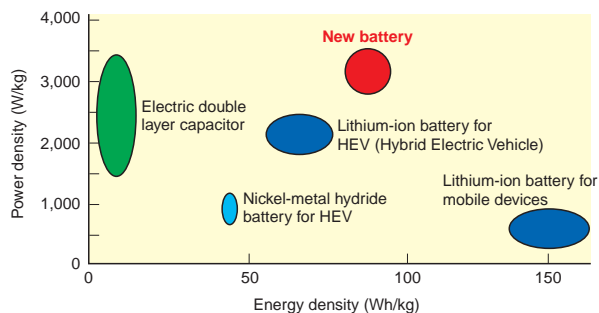
New battery for high-power use (prototype) (cell capacity: 3 Ah)

The new battery fuses Toshiba’s latest advances in nano-material technology for the electric devices sector with cumulative know-how in manufacturing lithium-ion battery cells. A breakthrough technology applied to the negative electrode uses new nano-particles to prevent organic liquid electrolytes from reducing while the battery is recharging. The nano-particles quickly absorb and store vast amounts of lithium ions, without causing any deterioration in the electrode.

The excellent recharging characteristics of the new battery are not its only performance advantages. The battery has a long life cycle, losing only 1% of capacity after 1,000 discharging and recharging cycles, and can operate at very low temperatures. At minus 40°C, the battery can discharge 80% of its capacity, against 100% in an ambient temperature (25°C).

The speedy and highly effective recharge characteristics of the battery will support CO<sub>2</sub> reduction, as the battery can save and re-use energy that was simply wasted before.

Toshiba expects that the high energy density and excellent recharge performance of the new battery will assure its successful application as a new energy solution in many areas of society.



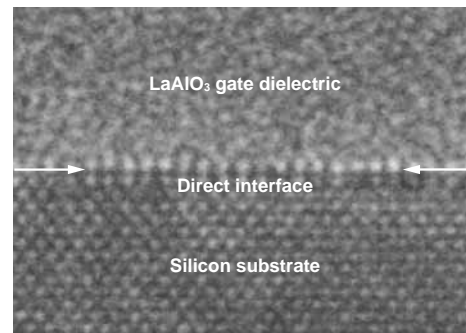
Comparison with other batteries

## LaAlO<sub>3</sub> Gate Dielectric without Any Interface Layer for Advanced CMOS Technology

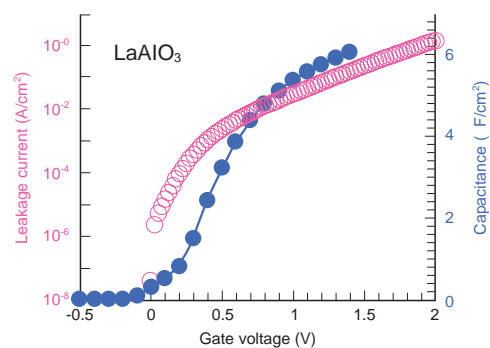
Toshiba has developed a LaAlO<sub>3</sub> gate dielectric with ultra-thin equivalent oxide thickness (EOT) and low leakage current.

The ultimate miniaturization of CMOS (Complementary Metal-Oxide Semiconductor) devices has required the replacement of conventional silicon oxide (SiO<sub>2</sub>) gate dielectric with a higher dielectric permittivity (high-k) material to suppress the gate leakage current.

Toshiba has proposed LaAlO<sub>3</sub> as a high-k gate dielectric material with both a large bandgap and good thermal stability. The direct bonding of LaAlO<sub>3</sub> film and Si substrate without any interface layer was successfully formed by developing a high temperature deposition technique, resulting in the achievement of an ultra-thin EOT of 0.31 nm. Furthermore, a dramatic reduction in defects present in the LaAlO<sub>3</sub> film was achieved at the same time, leading to a remarkably low leakage current under 10<sup>-6</sup> of that for a conventional SiO<sub>2</sub> gate dielectric.



Cross-sectional TEM image of LaAlO<sub>3</sub> film directly deposited on silicon substrate



Capacitance and leakage current characteristics of LaAlO<sub>3</sub> gate dielectric

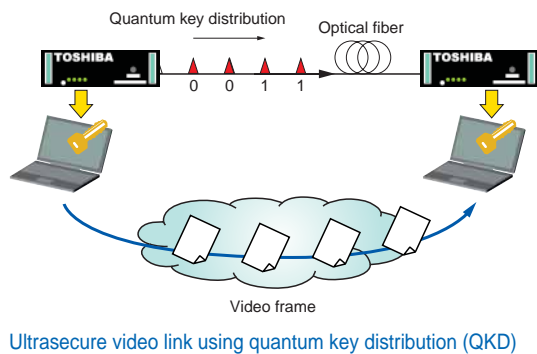
## High Bit Rate Quantum Key Distribution System

Recent developments at Toshiba Research Europe Ltd. (TREL) in Cambridge, UK have resulted in much higher bit rates for quantum key distribution (QKD) than previously available. This allows encryption keys to be formed at a rate of up to 100 per second.

QKD is a technique for distributing secret digital keys over optical fiber with guaranteed secrecy. The inherent secrecy of QKD, together with the practical and security advantages of real-time key delivery, will lead to their increasing adoption in corporate networks over the next five years.

The Toshiba system achieves a key distribution bit rate of more than 25 kbps for 15 km of fiber. This is thanks to the active stabilization technology that allows continuous one-way propagation of the photons with minimal loss and error signal. Another important advance has been a five-fold increase in the clock rate of the system. Not only does the TREL system have a high key bit rate, but it also works over 120 km optical fibers and it has been rigorously proven secure.

A secure video link system was developed on top of the above QKD. The quantum video link uses a unique 256-bit digital key to encrypt each frame of the video. Each key is formed by QKD and is completely uncorrelated with any other key. This ensures that even if a hacker deciphers any frame of data, they gain no information about the remaining data. TREL organized a demonstration of the video link system for UK financial and government organizations at the Bank of England in London in April 2005 and successfully showed the effectiveness of QKD for a high data bandwidth link.



## Development of Daily Life Support Robots

It is expected that robots will be used increasingly in our daily life in the future due to such factors as the growth of the aging society. In order to perform a service, it is essential for the robot to communicate with the user, ascertain his/her location, and accompany him/her. So we have developed two kinds of prototype robot that coexist in harmony with people and also support us in our daily life. (\*)

### ■ ApriAlpha™ V3 Sharp Ear Robot

In our home life, we are surrounded by many kinds of sound, like talking voices or TV noise. Our newly developed high performance auditory function enables the robot to detect the direction from which voices are coming, and recognize the content to provide many services. The robot is equipped with six microphones in order to support verbal orders from plural users and it detects the direction of each voice, and recognizes each item of content to carry them out.

### ■ ApriAttenda™ Person-Following Robot

To find a specified person without fail, it is necessary to detect and extract the region representing the person from an image containing a complicated scene. Our new algorithm has realized a person-following function. The distance from each feature point is measured by a stereo vision system, and then the area representing the person is detected using the distribution of the distance and the history of the feature points, and then information on the color and texture of the clothes the target person is wearing is combined.

These two robots were exhibited at the NEDO Prototype Robot Exhibition at Aichi EXPO 2005 and successfully demonstrated top level performance in each of their developed function areas. Also the robots were selected as the most amazing inventions of 2005 by TIME magazine.

(\*) ApriAlpha™ V3 and ApriAttenda™ have been developed as part of the next generation robot project of the New Energy and Industrial Technology Development Organization (NEDO). The development of ApriAttenda™ was collaborated with Tokyo University of Science.



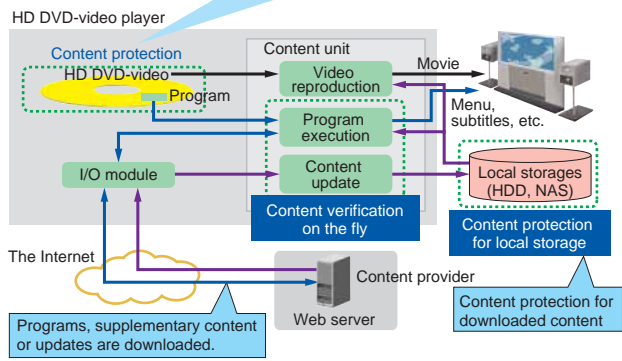
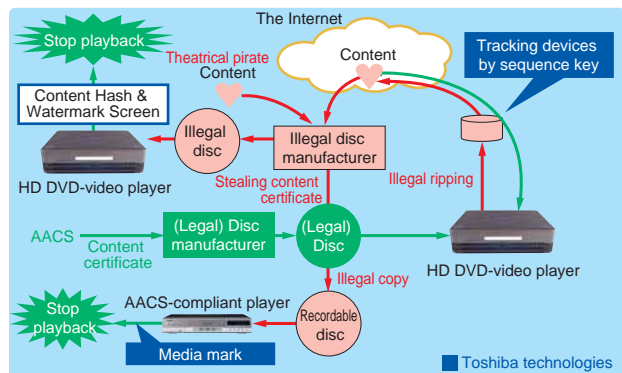
The demonstration at the NEDO Prototype Robot Exhibition  
ApriAlpha™ V3 sharp ear robot (left) and ApriAttenda™ person-following robot (right)

## Content Protection for HD DVD-Video

As one of the leading companies in the creation and promotion of the next generation DVD specifications, Toshiba plays a key role in the creation of the AACS (Advanced Access Content System) specification for protection of HD DVD-video content, in which programmability/interactivity as well as Internet connectivity is supported.

Toshiba has developed new technologies, which provide solutions for new challenges such as the technology of sequence key implementation for tracking source devices that illegally distribute content, the technology for the protection of content in local storage.

The AACS specification for HD DVD-video makes it possible for content providers to feel secure in providing high quality content while users feel free to enjoy the excellent features of the content.



HDD: Hard Disk Drive  
NAS: Network Attached Storage

Overview of content protection for HD DVD-video players

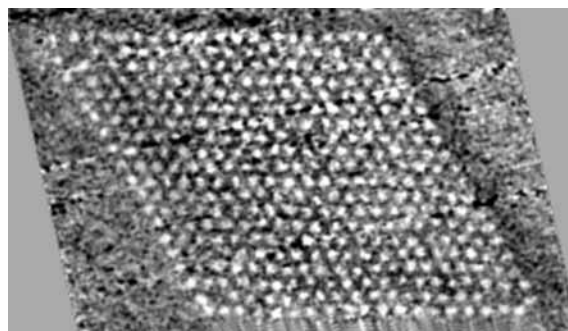
## Defect-Free Template for XY-Type Nano-Patterned Media Using Self-Assembled Dot Arrays

Toshiba has aimed to realize an XY-type magnetic recording technique that makes it possible to achieve a density of over 1Tbps (Terabit/in<sup>2</sup> = 10<sup>12</sup> bit/in<sup>2</sup>) with magnetic recordings.

Toshiba has developed a nano processing template for separating neighboring magnetic dots for preparing patterned media. Self-assembled polymer materials were used for large-area nano patterning with 20 nm-size nano dots. The polymer materials were assembled in the guides for positional control. The figure shows 20×20 defect-free self-assembled dot structures, which are arranged in the diamond-shaped guides. These polymer dots will be replaced with magnetic dots in the following process.

This technique enables the manufacture of high-density magnetic recording media at low cost and with high throughput.

This work was supported by the IT-programs of Research Revolution 2002 of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan.

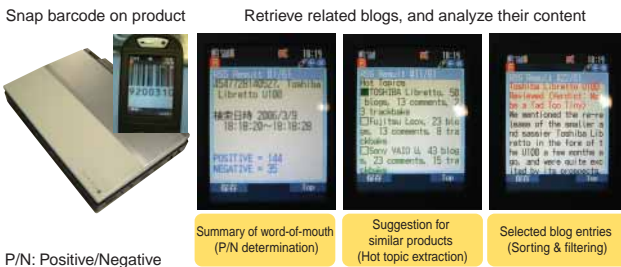


Defect-free self-assembled dot structures in diamond-shaped guide

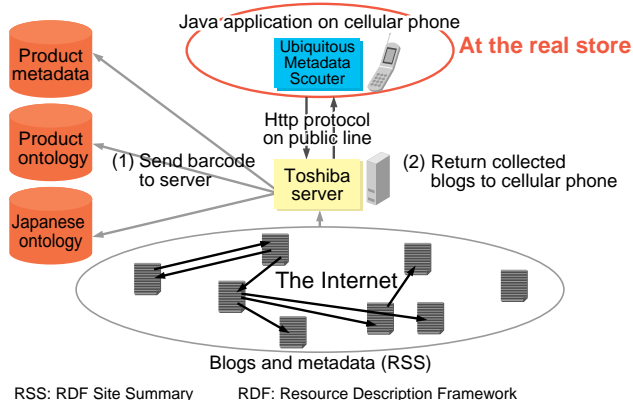
## Ubiquitous Metadata Scouter - Ontology Brings Blogs Outside

Toshiba has developed a mobile service, which summarizes blogs for use in real stores. In a ubiquitous computing environment, it would be desirable for users to connect their real world situation with useful information available on the Internet. However, the current typical device for ubiquitous computing such as a cellular phone has a small display, limited operability, and narrow-band network. Therefore, a technique for extracting only the necessary information based on its meaning is required for ubiquitous computing.

With the Ubiquitous Metadata Scouter, a user scans a product bar-code using a cellular phone camera. It then acquires the corresponding metadata for the product (data describing the product like the name and manufacturer) from the Internet, and collects the related blogs. Furthermore, the point is to analyze the content of each blog using ontology, and indicate a total rating. Ontology means the specification of a conceptualization to classify concepts relating to a certain area. It also shows other related products, which are much talked about. We have performed public trials for this service at the real consumer electronics store and a bookstore in Tokyo, March 2006.



### Service use case



### System architecture

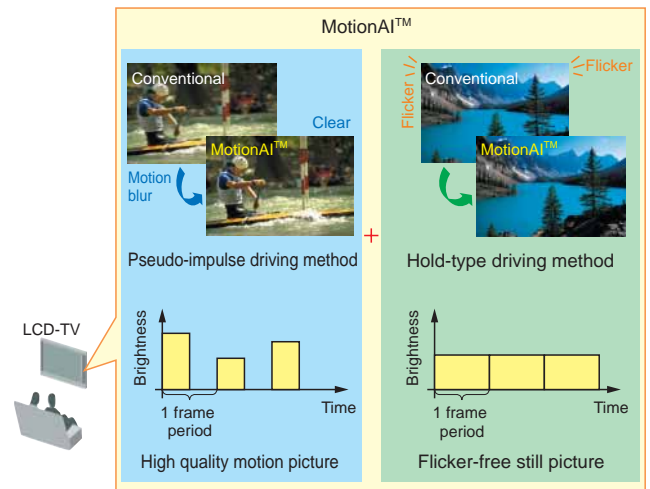
## MotionAI™ Display System for High Quality Motion Pictures on LCD-TVs

Toshiba has developed a novel display system, MotionAI™, for high quality motion pictures on LCD (Liquid Crystal Display) -TVs.

Motion picture quality on LCD-TVs is degraded by hold-type motion blur. The hold-type motion blur can be improved by a pseudo-impulse driving method like a CRT (Cathode Ray Tube) display method. However, the pseudo-impulse driving method causes a perceptible flicker on LCD-TVs, especially when displaying still pictures on LCD-TV.

MotionAI™ is a technology that allows the display method to be switched between the pseudo-impulse driving method like a CRT and the hold-type driving method like a conventional LCD according to the input picture on LCD-TV. MotionAI™ detects whether the input picture is a motion picture or a still picture using an original algorithm that has low processing cost acceptable for HDTV. When the input picture is a motion picture, which would cause a hold-type motion blur on LCD-TVs, the display method of the LCD-TVs is switched to the pseudo-impulse driving method to eliminate the hold-type motion blur. On the other hand, when the input picture is a still picture, the display method is switched to the hold-type driving method to prevent flicker on the LCD-TV.

MotionAI™ allows the realization of novel LCD-TVs, which have the features of both high quality motion pictures and flicker-free still pictures.



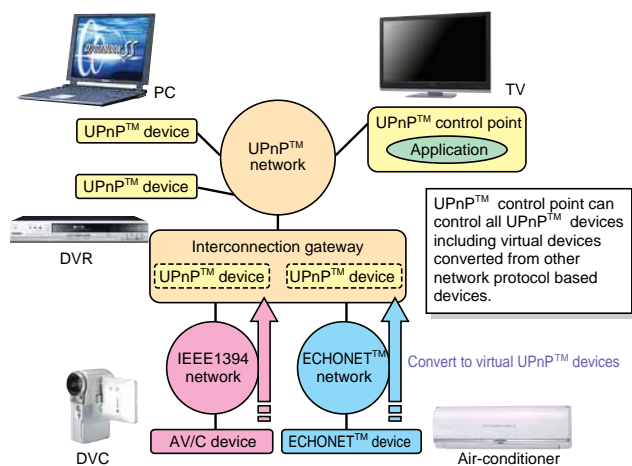
### Concept of MotionAI™

## Interconnection Gateway Architecture for Networked Home Appliances

Heterogeneous networking protocols are used in home networks. Consumer electronics devices such as PCs, TVs and VCRs are connected via the UPnP™ protocol, while household appliances such as air-conditioners and refrigerators are connected via other specific networking protocols.

Toshiba has developed an interconnection gateway to connect these heterogeneous home appliances. The gateway device enables a UPnP™ Control Point, e.g., a TV, to control appliances running other networking protocols. Programmers can easily build control applications for a variety of devices including those that are non-UPnP™ in a UPnP™ manner.

This development represents one of the results of the “Digital Information Device Interoperability Infrastructure” project by the New Energy and Industrial Technology Development Organization (NEDO).



AV/C: Audio Video Control  
DVR: Digital Video Recorder  
DVC: Digital Video Camera

Home network supported by interconnection gateway

## A Real-Time Scheduling Technology for Multi-Core Processors

Toshiba has developed a real-time scheduling technology realizing simultaneous processing of plural multimedia applications on Cell Broadband Engine™, a multi-core processor.

Multimedia processing like viewing and recording digital broadcasting includes many kinds of software modules such as video decoders. To execute plural types of multimedia processing simultaneously, the software engineer must determine the execution timing of every software module guaranteeing the real-time constraints attributed to each type of multimedia processing.

Our real-time scheduler offers a comprehensible method for specifying real-time constraints instead of traditional methods such as specifying priorities. The engineer can specify real-time constraints with a processing flow form including parameters such as the number of threads, processing ratio, memory bandwidth, and precedence constraints between software modules.

In addition, an extended scheduling algorithm based on the critical path method embedded in the scheduler guarantees the real-time constraints of all multimedia processing and automatically determines the execution timing of the software modules.

These features reduce the workload of the software engineer drastically and simplify the development of digital consumer electronics using multi-core processors.

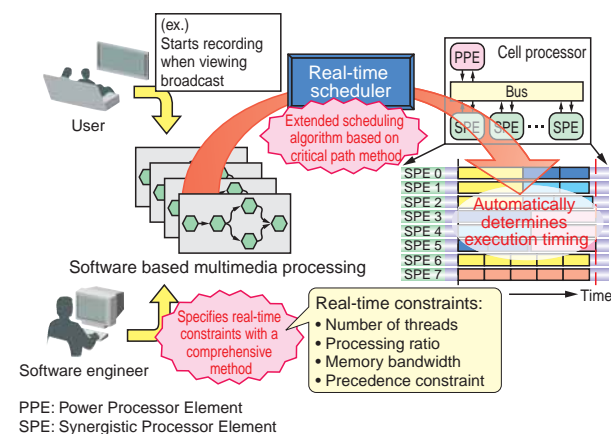


Image of operation of scheduler for multi-core processors

“Cell Broadband Engine” is a trademark of Sony Computer Entertainment Inc.

## Improvements to Meet Organizational Needs Using CMMI Continuous Representation

The purpose of software process improvement activities is to achieve a business goal, and not to achieve a target maturity level.

This is the first time the Toshiba group has adopted CMMI (Capability Maturity Model Integration) continuous representation. Using this representation, we were able to conduct software process improvement activities to meet organizational needs and avoid targeting an unreasonable maturity level.

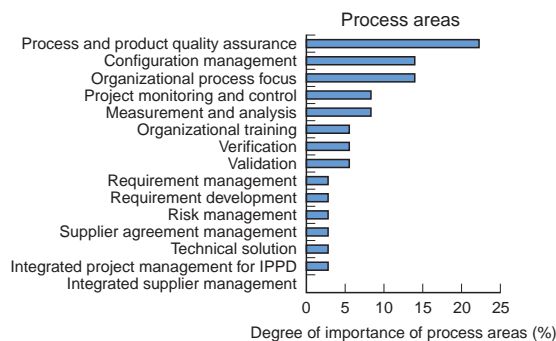
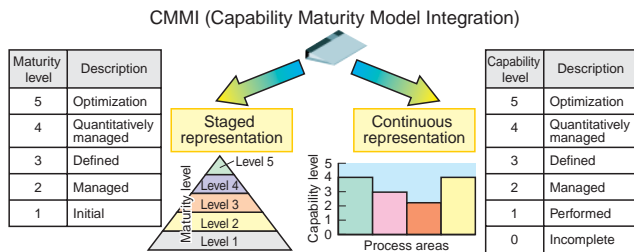
By analyzing business goals, items to be improved and lessons learned from past projects, we were able to select and improve the process areas that are important for organizational needs.

We were also able to avoid any slowdown in software process improvement activities since the goal of software process improvement was not to achieve any given maturity level.

CMMI continuous representation is useful for organizations that are unable to achieve further improvement benefits or continue process improvement after achieving a target maturity level.

*"Capability Maturity Model"* is a registered trademark of Carnegie Mellon University in the U.S.

*"CMM Integration"* and *"CMMI"* are service marks of Carnegie Mellon University in the U.S.

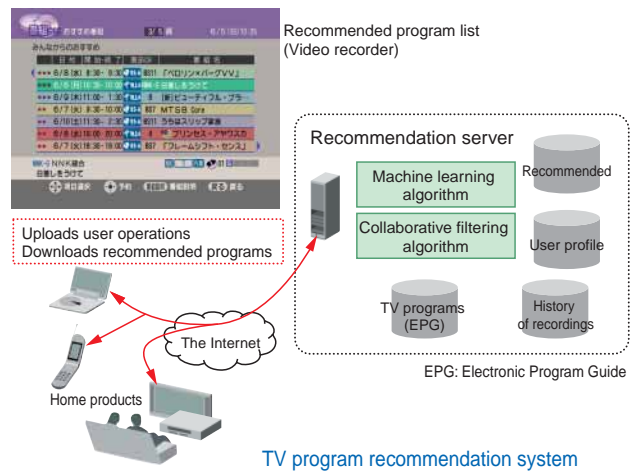


CMMI continuous representation and selection process areas to meet organizational needs

## Recommendation Technology by Analyzing Action History on Home Audiovisual Products

Toshiba has developed a TV program recommendation system for home audiovisual products, which can be connected to an Internet service for residents of Japan. The system is an application of a machine learning algorithm, which can determine a user's preferences from the history of operations performed on home appliances such as personal video recorders. The system also contains a collaborative filtering algorithm, which can look for similar users, and can look for their favorite items.

For instance, users of a Toshiba DVD video recorder connected to the Internet service could find TV programs that they are likely to enjoy, just by following their normal recording habits. They might also find potentially enjoyable TV programs, which they do not normally watch, but that are often recorded by users with interests or favorites common to their own.



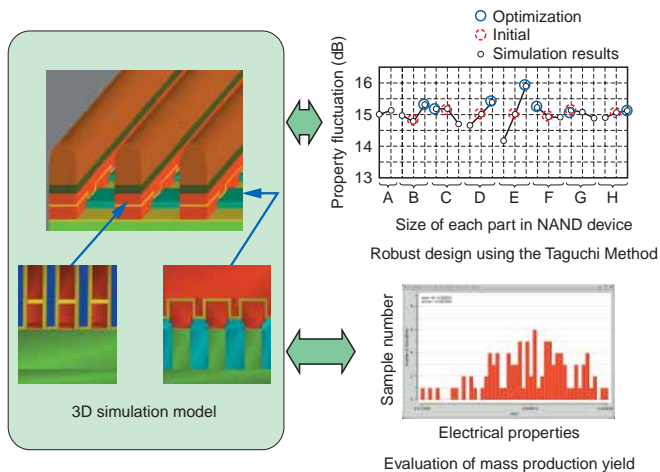
## Robust Design for NAND Device Through Simulation

Toshiba has developed a device structure design simulation technology for NAND flash memory, which takes full account of the influence from manufacturing process changes.

The electrical properties of the cell can be calculated with an error accuracy of not more than 7%, using a three-dimensional (3D) model for the device structure. The sensitivity of these electrical properties to any process changes is evaluated by utilizing methodologies such as the Taguchi Method and Monte Carlo method.

This simulation technology was applied to NAND flash memory with a design rule of not more than 100 nm, allowing the design of NAND element device structures having less fluctuation in electrical characteristics despite manufacturing variation.

NAND: Negative AND circuit



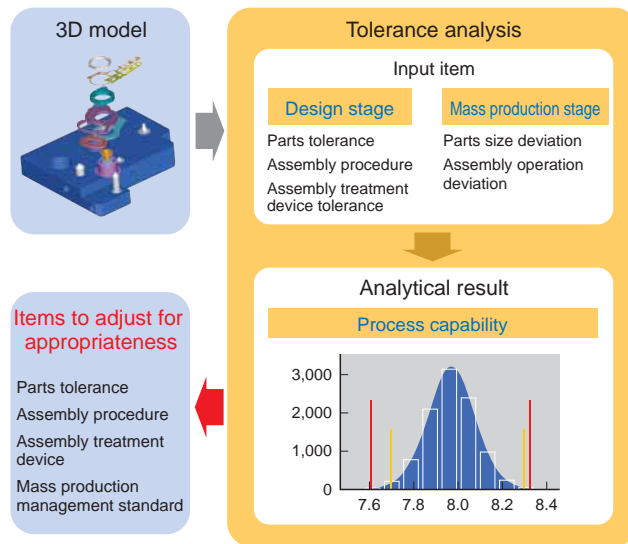
Robust design for NAND flash memory

## Tolerance Analysis Technology

Design for manufacturing, which means that products are designed and developed with due consideration given to their manufacturability, is one of the key approaches for the timely supply of high quality and low price products to the market.

Toshiba has developed a tolerance analysis technology, which can statistically analyze and forecast the influence of dimensional tolerances and assembly procedures for mechanical parts and manufacturing equipment on the final assembly accuracy of products, and can give appropriate guidelines for realizing a product design in consideration of manufacturing processes.

This technology was applied in the development of a 0.85- type HDD (Hard Disk Drive) and contributed to high quality mass production.



Tolerance analysis technology