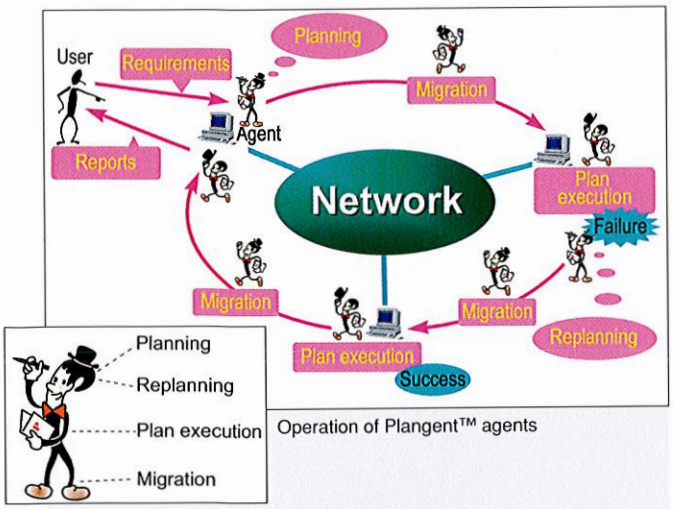
Research and Development

In its research and development activities, Toshiba employs its strengths as an integrated electronics manufacturer and its network of researchers in areas ranging from materials and devices to systems. The R&D process involves accurately forecasting future needs, developing the new products to meet those needs and quickly introducing them in the market. Consequently, Toshiba places importance on fostering the creativity of its researchers to develop key innovative technologies.

Plangent™ Intelligent Network Agent System

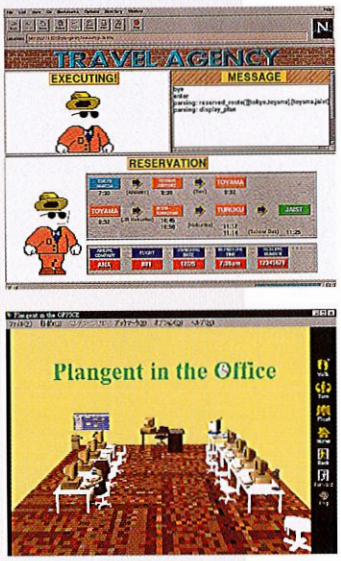


Operation of Plangent™ agents

Plangent™ is an intelligent agent system for use within computer networks that expands user abilities in fields such as information retrieval, remote machine control and ticket reservation on the Internet. As new services emerge through the widespread use of networks, especially the Internet, Plangent™ provides an effective framework for implementing these services by means of mobile agent technology.

Plangent™ agents interpret the user's requirements and autonomously migrate to computers in the network to find relevant information and services, returning to the user with the results. Individual Plangent™ agents have a planning function that produces action sequences to satisfy user requirements. When agents fail to execute original plans, they can produce alternatives adaptively.

Plangent™ is expected to reduce requirements on users for complicated network operations and knowledge, such as the exact nature and location of and means of accessing the information and services they require.



Sample Plangent™ screen displays

Wireless DAN

Wireless Desk Area Network (DAN) is a novel networking technology developed by Toshiba with applications as a support system for face-to-face meetings.

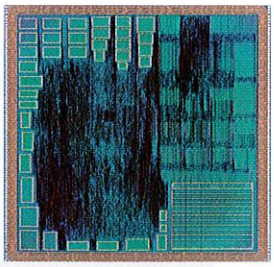
Wireless DAN discovers neighboring devices and autonomously creates a self-organized network of terminals in the same area without a network server. When machines enter or leave the area, it automatically and dynamically rebuilds an *ad hoc* network environment to reconstruct groupings and maintain communication routes. Electronic data stored on notebook PCs can be simply and instantly shared and processed, giving Wireless DAN numerous applications at meetings and brainstorming sessions.

This technology has been commercialized as a software system supported by notebook PCs with wireless LAN (RF, infrared), wired LAN devices or IrDA* port. Business development is being handled by a joint venture established by Toshiba in the United States.

* *IrDA: Infrared Data Association*

Face-to-face meeting support system

Single-Chip MPEG2 Encoder LSI



MPEG2 encoder LSI

Moving Picture Experts Group 2 (MPEG2) is an international standard set by ISO for moving picture compression that is used for digital versatile disk (DVD) systems and digital TV broadcasts. Toshiba has developed a single-chip MPEG2 video encoder LSI based on main profile at main level (MP@ML), which is the core specification of the MPEG2 standard. This LSI offers the same high performance and advanced functions as the company's previous MPEG2 encoder for DVD authoring.

Reduction of the enormous computation power required for motion detection is a key requirement for realizing a single-chip LSI, and Toshiba's original algorithm, called hierarchical multi-field telescopic search, reduces computation power to 1/144, compared to a direct search algorithm. In spite of the major reduction in computation power, the algorithm maintains wide, precise and high-performance motion detection. Replacing the firmware of an external reduced instruction set computer (RISC) enables functions required for DVD encoding, such as variable bit-rate encoding and multi-angle encoding, and communications, such as low-delay encoding.

MPEG2 encoder board

The development of this LSI will contribute to significantly lower costs for encoders, with applications in a wide range of fields, including a low-cost, PC-based DVD authoring system and a CODEC (encoder/decoder) communication system.

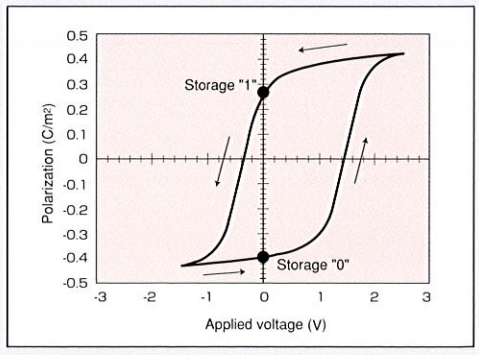
LSI specifications

Process	0.3μm CMOS 3-layer metal embedded array
Chip size	14.17mm x 14.17mm
Transistor count	4.2 million
Package	391-pin PGA
Power consumption	2.3W (3.3V)
Motion detection area (Max.)	Horizontal : -144 to +144 Vertical : -96 to +96

Epitaxial Capacitor for Gigabit-Scale Semiconductor Memory Applications

Toshiba has developed a thin film capacitor that represents an entirely new concept. The capacitor has an epitaxial structure that consists of dielectric and electrode films having the same crystal structure and the same orientation. The capacitor is free from degradation of dielectric properties, because the interface of dielectric and electrode is so smooth and aligned that it cannot be distinguished using a high-magnification electron microscope. In addition, different ferroelectric properties are obtained by varying the levels of lattice strain in dielectric film, which is done by adjusting lattice mismatch between the dielectric (barium strontium titanate) and the electrode (strontium ruthenate).

Even with a film thickness of 20nm, film for DRAM applications has a dielectric constant of 1,000, or three times higher than previous films, and exhibits extremely low current leakage and high reliability. The ferroelectric film for non-volatile ferroelectric RAM (FRAM) applications shows high remanent polarization of 50μC/cm² at low operation voltage. These dielectric films could be used to realize simple planar capacitors for gigabit-scale DRAM or FRAM, and hold promise for applications in semiconductor memories for portable electronic devices such as hand-held computers.



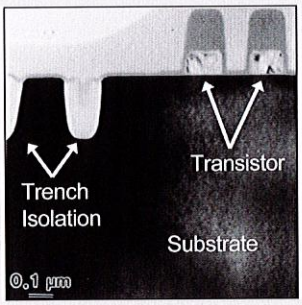
Polarization hysterisis of ferroelectric epitaxial capacitor

Sub-0.1μm LSI Technology with Substrate Over-Biasing Technique

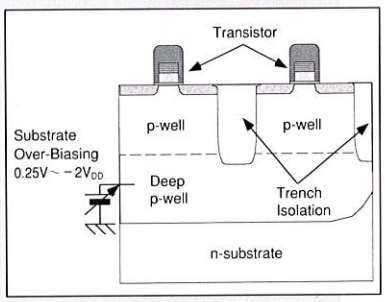
A new substrate over-biasing technique developed by Toshiba realizes ultra-low power consumption and high-speed operation in a sub-0.1μm transistor, thus enabling test production of LSIs that are among the world's smallest.

In the sub-0.1μm generation of transistors, because the source and drain electrodes are extremely close, their electric fields affect each other and may cause a malfunction. In conventional technology, ionized impurities are introduced to suppress the interference between the electric fields. However, the resulting high operation voltage of the transistor was a critical obstacle to realizing low-power, high-speed operation. With Toshiba's new substrate over-biasing technique, the electric field of the over-biased substrate repels the interfering electric fields of the two electrodes back to their sources. Using this technique, Toshiba was first to realize high-speed operation of a sub-0.1μm transistor with ultra-low power supply.

To verify the new technique, Toshiba used state-of-the-art process technology to fabricate a test chip with a wiring pitch of 0.24μm and transistor gate length of 0.08μm. The chip operates at 2GHz with a power supply of only 0.5V. The new technique reduces power consumption to 1/400 that of a 0.3μm LSI operating at 3V.



Cross section photograph of a test chip

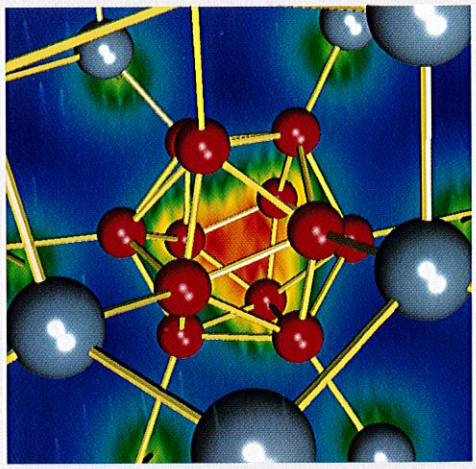


Substrate over-biasing technique

Synthesis of B_{12} Cluster in Si

Toshiba has found that when heavy-dose B ions are implanted into silicon (Si), icosahedral B_{12} clusters are formed and function as acceptors, generating two holes.

As LSI devices become increasingly integrated, the dopant concentration in Si must also increase. It was previously thought that carriers are generated in semiconductor devices because dopant impurities take the place of lattice Si atoms. However, as a result of simulations of the cluster structure that reproduce the experimentally obtained infrared absorption spectra, Toshiba has found that the optimized icosahedral B_{12} clusters stably exist and are electrically active in heavily doped Si.


Icosahedral B_{12} cluster existing in Si crystal

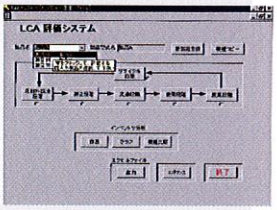
Practical Support Tool for Environmental Assessment of Products

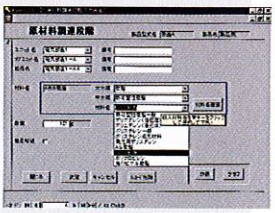
Life cycle assessment (LCA) has attracted interest as a technique for evaluating the environmental impact of a given product throughout its life cycle, and the results of the evaluation can be used as a basis for product improvement. LCA consists of four phases: goal and scope definition; inventory analysis, which involves scientific and quantitative analysis of the input and output of a given product throughout its life cycle; impact assessment; and interpretation of the results of the assessment.

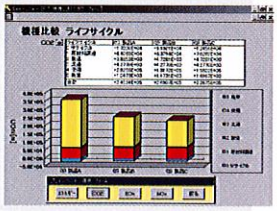
Toshiba has developed Japanese-language software that simplifies inventory analysis. Features of this software include modeling of the life cycles of products in five stages from procurement of materials to the recycling and/or disposal process. In addition, the software includes a database of emission values corresponding to such factors as materials or electricity used. As a result, the user can input the quantities of materials and energy to be utilized for a given product for automatic calculation of the amounts of CO_2, NOx and SOx emissions.

Commercialized in October 1997, the software is a support tool for creating environmentally conscious products (ECPs) at the design stage, a capability that is becoming increasingly important.

Cover of support tool for environmental assessment of products


Product life cycle menu


Input menu for material procurement stage

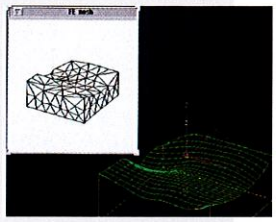

Comparison of life cycle emission results among three types of products

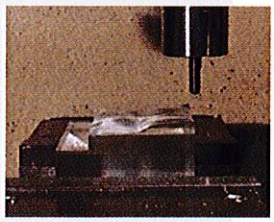
Next-Generation CAD Technology

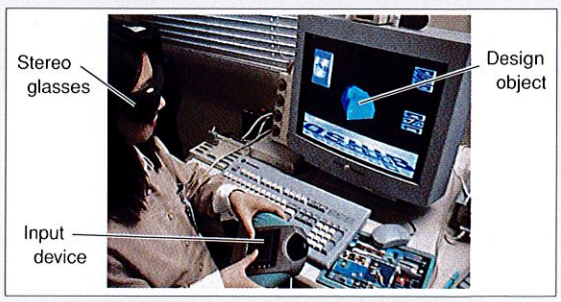
Three-dimensional data can be directly and intuitively created with Toshiba's new mechanical CAD system. Its modeling operations are so much easier to understand than conventional CAD systems that even industrial designers who are unfamiliar with computers can create 3-D solid model data and simulate its mechanical behavior from the product planning stage.

A newly developed input device equipped with spatial position and tactile sensors allows an object in the system to be manipulated as a virtual clay mockup on the stereoscopic display. The spatial position sensor controls the position and orientation of a design object and the tactile sensor controls object deformation. Behavior of the design object is in one-to-one correspondence with designer input, giving designers the feeling of actually holding and deforming the object. Data created in this process are internally converted to 3-D solid model data, enabling immediate mechanical simulation or mockup manufacture.

This technology has the potential to drastically improve the efficiency of the product development process from design to manufacturing.


Output solid data and finite element mesh creation for various simulations


Rapid mockup manufacture using high-speed machining system



Intuitive creation of shapes using next-generation CAD

High-Speed, High-Accuracy Flexible Liquid Crystal Cell Assembly Machine

A high-speed, high-accuracy liquid crystal cell assembly machine developed by Toshiba can assemble array substrate and color filter substrate with a tact time of 25 seconds and ±2μm alignment accuracy.

The rapid diffusion of LCDs in recent years has led to demand for higher display resolution and lower prices. At the same time, there is a growing need for high-accuracy, high-productivity manufacturing facilities.

This machine carries out substrate alignment as part of the cell assembly process. Alignment accuracy of color filter substrate and array substrate is a critical factor affecting display brightness. The machine uses a recognition algorithm device and a high-rigidity alignment mechanism to achieve a high level of alignment accuracy. High productivity is realized by reducing tact time through parallel operation of units carrying out separate functions of each process, such as adhesive supply, transfer and assembly of substrate, alignment and attachment. The machine can flexibly handle substrate sizes from 166x200mm to 430x315mm.

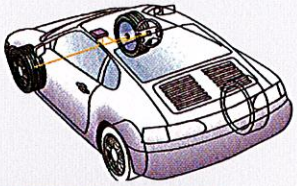
Liquid crystal cell assembly machine

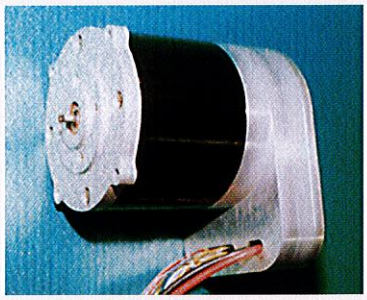
Electric Power Steering Drive System with Voltage Booster Circuit

Toshiba has developed a high-efficiency motor drive system for power steering of compact cars in cooperation with Shibaura Engineering Works Co., Ltd. Demand is strong for improved automobile energy efficiency to reduce environmental impact.

In conventional power steering, handling is assisted by oil pressure generated by a pump directly connected to the drive shaft of the internal combustion engine.

Toshiba proposed a method that employs a brushless DC motor drive with a voltage booster for the oil pump. The drive system regulates oil pressure with high efficiency when necessary to keep it at the appropriate level, which results in a reduction of about 3% in energy consumption.





External view and installation position of motor equipped with drive system