Research and Development

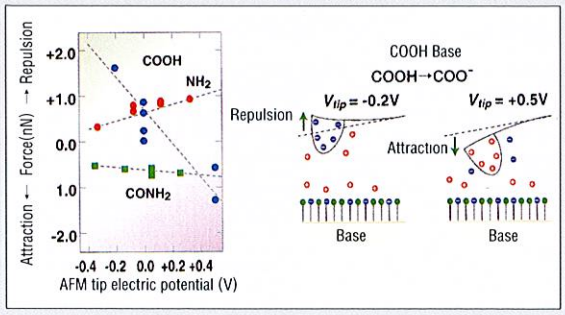
In its research and development activities, Toshiba employs its strengths as an integrated electronics manufacturer and its network of researchers in areas ranging from materials and devices to systems. The R&D process involves accurately forecasting future needs, developing the new products to meet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

Identification of Chemical Functional Groups in Aqueous Solutions by AFM

By controlling the potential of an atomic force microscope (AFM) tip in aqueous solutions, Toshiba has developed technology for identifying the species of chemical functional groups distributed on the surface. This technology is indispensable for evaluation and control of biomolecular functions on a molecular level.

Functional groups have specific charged states in aqueous solutions. The charge distributions on the surface of biomolecules ascribed to the distributions of the functional groups play an essential role in biomolecular functions such as molecular recognition and enzyme reaction. Until now, the charge distributions on the surface of aqueous solutions could not be evaluated directly.

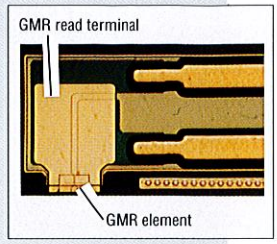
By electrochemically controlling AFM tip potential by potentiostat, Toshiba researchers succeeded in detecting the molecular force corresponding to the charged states of the functional groups, which in turn verifies that the functional groups can be identified by their observed force characteristics. Furthermore, the researchers were able to visualize the two-dimensional distribution of functional groups on the surface of aqueous solutions by developing the force mapping system.



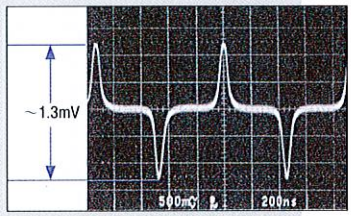
Electrostatic force between AFM tip and functional groups in aqueous solution

Giant Magnetoresistive Magnetic Head

Toshiba has developed a giant magnetoresistive (GMR) head that can read and write multiple megabits of data into a one millimeter square space on a magnetic disc. This advance was made possible by the development of cobalt-based alloy GMR multilayered film, using double magnetic underlayer film, that allows great resistance changes even in a weak magnetic field and almost eliminates hysteresis.

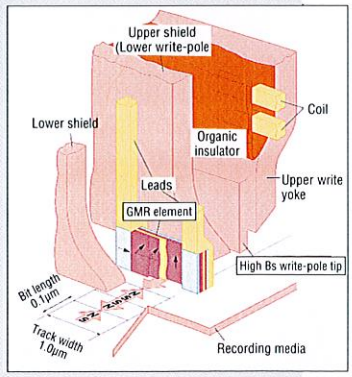


Giant magnetoresistive read element



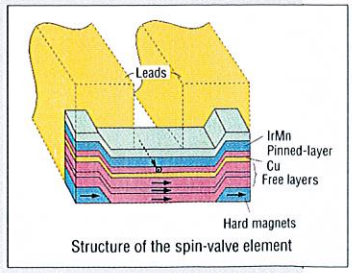
Read-back waveform

The new GMR heads are the first in the world with both a thermal stability at over 300°C (which had been a major obstacle in practical applications) and high sensitivity. Furthermore, the corrosion and poor thermal stability problems of anti-ferromagnetic film, which is necessary to realize good linear response to a signal magnetic field, were alleviated by developing a new anti-ferromagnetic film. The new GMR heads are over three times more sensitive than MR heads currently in use.



Conceptual cutaway view of GMR Head

In a promising development for very high-density magnetic recording with a track width of less than one micron, the newly developed GMR heads demonstrate a high output level of greater than 1mV for a 1μm track width. The new GMR will make the dream of small, 100Gbyte storage capacity hard disc drives a reality.



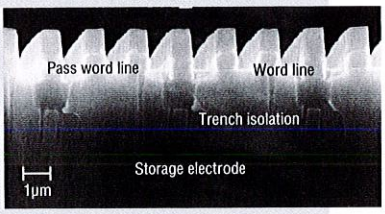
Structure of the spin-valve element

Structure of giant magnetoresistive element

Basic Technology of 4Gbit DRAM

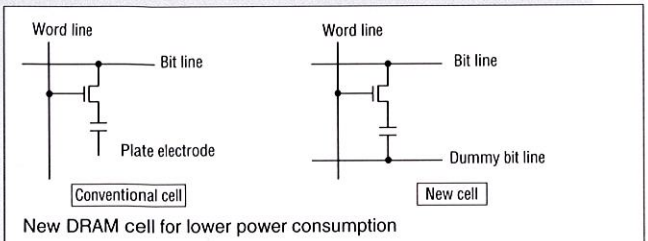
Meeting the demand for moving picture applications, Toshiba has developed a novel cell technology for the realization of a low-power, low-cost 4 gigabit DRAM.

By introducing the new DRAM cell, which uses a dummy bit line (the complementary signal of the bit line) as the plate electrode, the signal from the memory cell can be doubled compared with that of conventional DRAM cells. This new cell also enables a small bit line swing, reducing power consumption to a quarter of conventional cells.

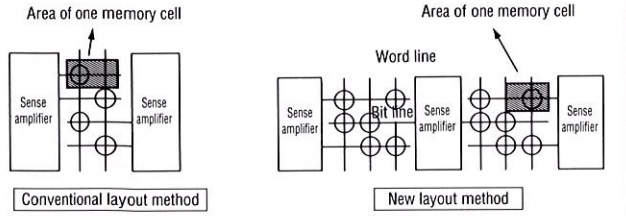


SEM cross-section of memory cell

The new technology makes possible significant size reductions as well. Using the new memory cell layout method, which enables sharing of the adjacent word line, the cell size has been reduced to 75 percent of that of conventional cells. At 0.29μm², it is the world's smallest cell, an achievement made possible by 0.2μm CMOS technology and the trench capacitor structure.



New DRAM cell for lower power consumption



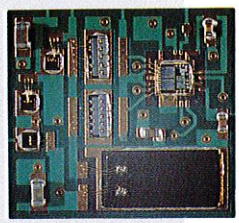
Layout of newly developed memory cell

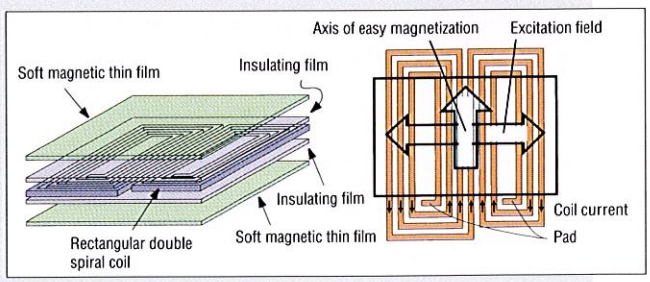
Micro DC/DC Converter for Portable Electronic Devices

Toshiba has developed a micro DC/DC converter for portable electronic devices such as "handy" telephones and notebook-type personal computers. The new product converts input battery voltages to the various voltages necessary for equipment, such as CPUs, HDDs and LCDs, used in those systems. Among the major technological features of the new converter:

- Switching frequency is over 1MHz, ten times that of conventional DC/DC converters. A high-speed PWM control IC has been developed for this purpose. The switching device uses lateral-type Nch-MOSFET with gate capacitance (Ciss) of about 70pF to suppress the increase of switching loss in the MHz range;
- The newly developed thin film inductor is thinner and has better electromagnetic shielding characteristics than the conventional coil-winding inductor. A double spiral coil is sandwiched between two sheets of soft magnetic thin film with uniaxial magnetic anisotropy. This structure allows the thin film inductor to operate in the MHz frequency and conduct electric currents above 1A; and
- In contrast to conventional DC/DC converters, all devices are mounted on a resin substrate in the bare-chip state and connected by wire bonding technology.

As a result of the above features, the micro DC/DC converter, with 3.6V input voltage to 5V/3W output power, offers thickness of only 2mm; permitted output power density of 10W/cc; and conversion efficiency of about 80 percent.


Micro DC/DC converter



Structure of thin film inductor

Miniaturization Technologies for PHS Terminals

Toshiba has developed a miniature terminal for the 1.9GHz band personal handy phone system (PHS), a digital cordless telephone system used in Japan. Features of the new terminal include passive components reduction for both transmitter and receiver chains through adoption of direct conversion architecture; size and cost reduction using a module configuration with high-density mounting technology for the RF functional circuits; and battery volume reduction through the low-power RF circuit design technique that employs the high-frequency Si and GaAs process, and through use of a high-capacity lithium ion rechargeable battery.

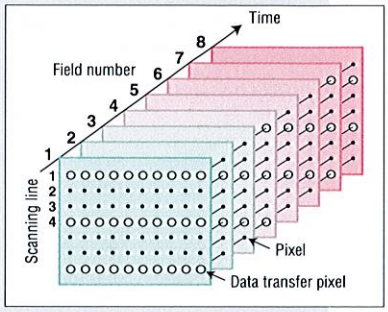
The terminal is 60cc in volume and weighs 85 grams. Tests of the terminal have included an air interface connection test using a PHS base station simulator, as well as practical confirmation of voice and data communications. The front-end design concepts and techniques of this terminal can be applied to the development of low-cost miniature terminals for other radio communication systems such as Digital European Cordless Telephone (DECT) and Personal Communications Service (PCS), as well as mobile multimedia terminals.

Ultracompact PHS terminal

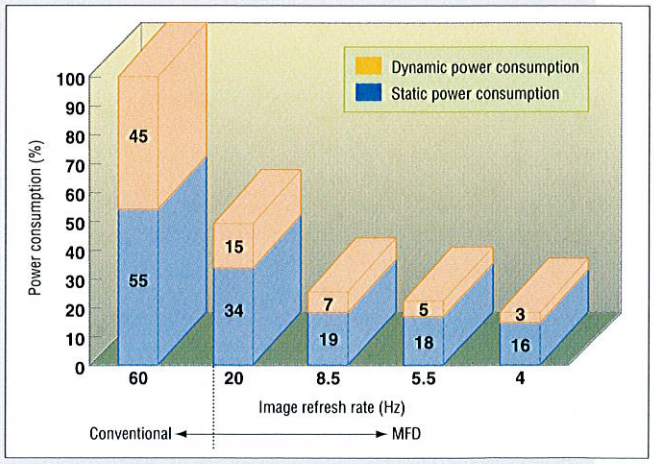
Energy-Saving Technology for TFT-LCDs

With a multi-field driving (MFD) method developed by Toshiba that uses the new approach of lowering the refresh rate, driving power consumption of both transmissive and reflective TFT-LCDs can be reduced to less than half of conventional levels.

Until now, although TFT-LCDs have a memory for each pixel, the refresh rate could not be reduced to less than 60Hz, the visible lower frequency limit against flicker visibility, because the flicker depends completely on the refresh rate. The MFD method decreases the refresh rate without causing a flicker problem by dividing a displayed image into not only odd plural images but also uniformly dispersed, interlaced images in both spatial and time domains. As a result, power consumption has been reduced to less than half that of conventional methods without image degradation of displayed images.

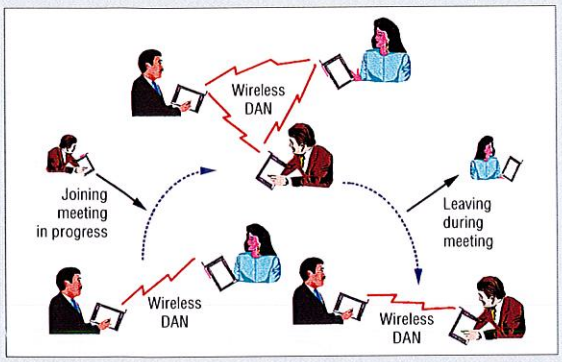


Principle of MFD method



Reduced power consumption of TFT-LCD using MFD

Wireless Networking Technology for Portable Computers



Wireless DAN system

Wireless Desk Area Network (DAN) is a new networking technology developed by Toshiba that allows portable computers to form autonomous wireless communications networks free of fixed facilities, such as a system server.

With this technology, networks can be easily and quickly constructed between two or more computers in proximity. The equipment consists of any AT-compatible portable computer, a 2Mbps wireless LAN card and newly developed dedicated communications software. The new networking software automatically identifies terminals with which it can communicate within the 50-meter service area of the LAN card, and allows users to select terminals to which data is to be transferred. An encryption function assures secure transfer of data.

Applications using wireless DAN technology include a face-to-face paperless meeting support system where all information, including multimedia data, can be distributed via the wireless network. A white board function is also available, simplifying joint writing and editing of documents. The absence of a system server makes it possible for any participant to leave the meeting while it is in progress.

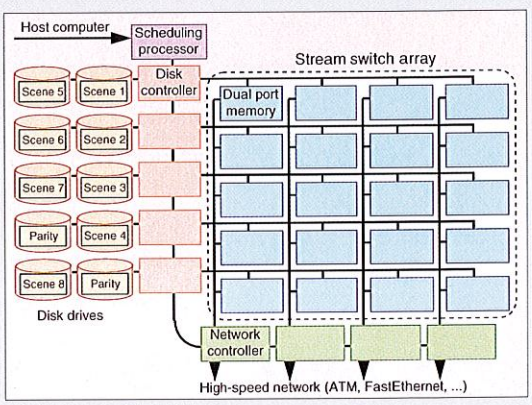

Face-to-face paperless meeting using wireless DAN

SmartStreamer Multimedia Server


SmartStreamer

SmartStreamer is a multimedia server computer that can provide highly efficient, cost-effective networked multimedia information services, such as video on demand or on-line shopping, to large numbers of consumers simultaneously.

A newly developed stream switch array is the key to the high performance of SmartStreamer. The array provides a dedicated parallel data transfer route that facilitates the flow of data from hard disks to the network. Dual-port memory in the array works either as a routing switch or as a buffer, and guarantees continuous distribution of video and audio data. The sophisticated scheduling algorithm provides optimum control of disk and network controllers, and realizes efficient data transfer and quick response to user demands. Through the use of the hardware Redundant Arrays of Inexpensive Disks (RAID) function in the array, SmartStreamer can continue operation with no performance degradation even if a disk drive malfunctions. The new architecture creates a server system with a data transfer rate ten times faster than other systems. SmartStreamer is expected to reduce system cost to one-fifth that of conventional systems and paves the way for practical on-demand services.

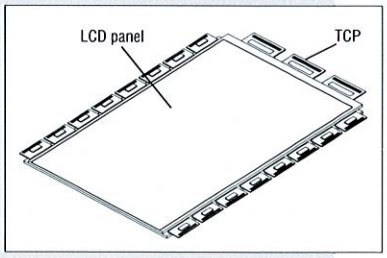


Architecture of SmartStreamer

Fastest Commercial Outer Lead Bonder for LCDs

Outer lead bonders are used to bond the tape carrier package (TCP) to the glass substrate of LCDs. Toshiba has produced the fastest commercial outer lead bonder, with a bonding tact time of two seconds.

As manufacturers strive to make larger, higher-resolution LCDs, the bonding pitch of the glass substrate and TCP has become progressively narrower and more pins have been added. To meet the burgeoning demand for low-cost LCDs, manufacturing productivity is becoming increasingly vital. The newly developed outer lead bonder is an essential part of the manufacturing process of LCD modules, and accurate, high-speed bonding is a key factor in production advances. The reduction of the bonding tact time to two seconds was achieved by developing a high-speed TCP supply system and a parallel recognition system for lead positions.



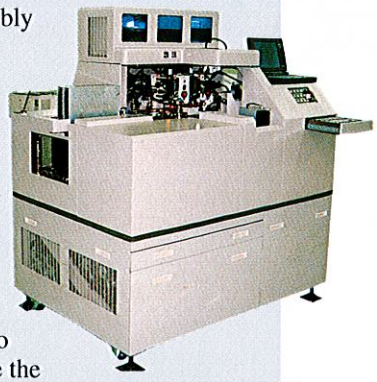
LCD panel after outer lead bonding

Productivity has increased markedly, while maintaining a bonding accuracy of ±5μm. In addition, the machine is now 24 percent smaller and requires a smaller floor area than previous models, due to improved parts design.


Commercial outer lead bonder for LCDs with a 2 second bonding tact time

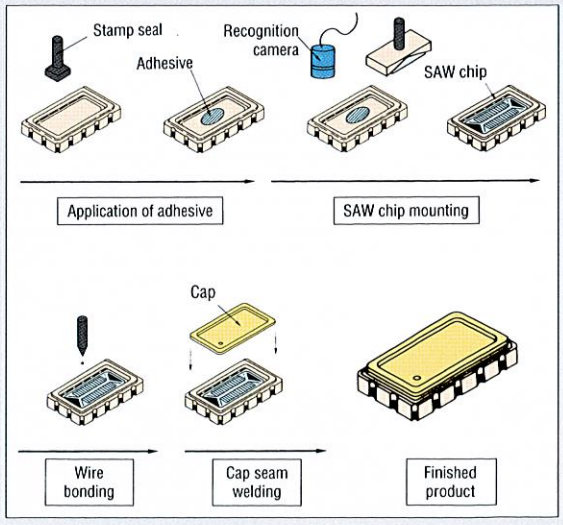
Assembly Technology for Ceramic Packaged SAW Filter

Toshiba has developed assembly technology for and begun production of a ceramic packaged surface acoustic wave (SAW) filter. The new assembly technology offers mounting accuracy within 100μm for the SAW chip in the box-type package.


External view of SAW mounter

Digital capability, compact size and the ability to handle high frequencies make the new SAW filter better suited for use in small mobile radio devices than the dielectric filter used previously. The market for mobile radio equipment is expected to expand along with growth in digital phones and services such as the personal handy phone system (PHS), which commenced service in Japan in July 1995.

Other features of the new technology include paste application at a thickness of 100μm±20μm; positioning of the vacuum nozzle within ±10μm on the XY axis and ±5μm on the Z axis; and recognition of package outline within ±10μm. This technology will be useful for future development of new SAW filters.



Assembly process of SAW filter