Devices/Materials

Hard Disk Drives
Semiconductors
Displays
Materials

Horizontal Assistance Enables Vertically-integrated Hitachi GST to Achieve Practical Perpendicular Recording

In the year the hard disk drive turns a half-century old, the industry begins a wide-scale conversion to a new recording technology method called PMR (perpendicular magnetic recording). PMR will enable hard disk drives to meet the continuing demand for increased storage capacities by increasing the areal density of the drive by as much as 10-fold.

The 50 Year Evolution of the HDD

The HDD industry has experienced 50 years of continuous innovation since the first commercial product debuted in 1956. International Business Machines Corp. (IBM) shipped the RAMAC (random access method of accounting and control) on September 13, 1956. It weighed nearly 1,000 kg and stored 5 million characters on fifty 24-inch diameter magnetic disks. The RAMAC featured a recording density of 2,000 bits per square inch. It could be leased for US $50,000 per year, which at the time was equivalent to the purchase price of 17 new automobiles.

HDDs have evolved rapidly since the RAMAC, thanks to the application of new magnetic, electronic and mechanical technologies. These developments have produced HDDs that provide more capacity in smaller footprints with higher performance and greater reliability with each new product generation.

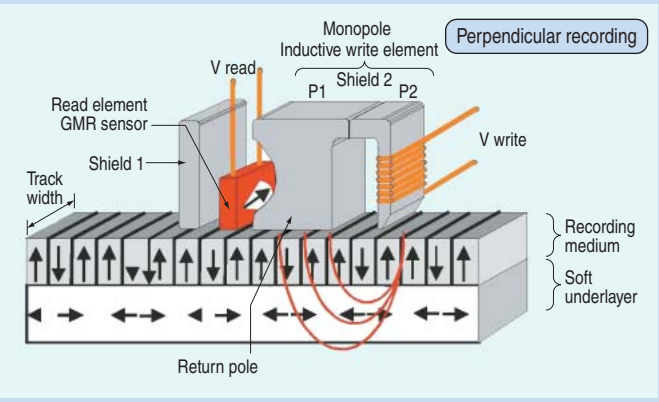
The HDD industry is celebrating its 50th anniversary in 2006 and the future has never looked better. IDC (International Data Corp.) predicts that the industry will ship more HDDs over the next five years than it did in the previous 50. Hitachi's efforts alone over the next five years will be marked by significant manufacturing and market expansion that could triple current annual shipments by decade-end—approaching 200 million drives per year.

In the year the HDD turns a half-century old, the industry begins a wide-scale conversion to a new recording technology method called perpendicular magnetic recording. Perpendicular recording will enable HDDs to meet the continuing demand for increased storage capacities by increasing the drive's recording density by as much as 40% per year.

Technical Strategy at the 50th Anniversary

Hitachi GST (previously as IBM) invented the HDD in 1956 and has been at the forefront of HDD technology advancement ever since. Our strategy is to use the full breadth and depth of Hitachi's research, development and manufacturing expertise to continue this leadership in HDD technology. Some of our major focus areas are perpendicular recording, development of new recording technologies such as patterned media and thermally-assisted recording, and other innovations in design and manufacturing technologies to improve HDD performance, cost and reliability. To expand into new consumer electronics applications for HDDs, we are investing new functions, such as security, digital rights management and multimedia data streaming performance.

Dr. John Best, Chief Technologist, Hitachi Global Storage Technologies



Recording technologies

What is Perpendicular Recording?

Perpendicular recording is a form of magnetic recording in which the magnetization of each data bit is aligned perpendicular to the disk surface. This is in contrast to current magnetic recording technology, called longitudinal recording, where the magnetization of each bit is aligned end-to-end in the plane of the disk. With perpendicular recording, hard drive manufacturers are able to squeeze more bits of data onto a disk, and thus can increase the storage capacity of HDDs.

After many years of concentrated effort to develop, test and bring to market perpendicular recording technology that equals or exceeds the reliability expectations of current longitudinal recording technology, Hitachi GST recently began shipping the Travelstar 5K160. The new HDD is the industry's most reliable and technically-advanced 2.5-inch product.

As a vertically-integrated company, Hitachi GST has the internal resources necessary for the development, optimization and verification of the dramatic changes required for perpendicular recording. Hitachi, Ltd. provided additional support, horizontally, from across its engineering practices to help deliver the new Travelstar 5K160.

Hitachi's Future Vision of HDDs

Hitachi researchers are already working on extensions to perpendicular recording—patterned media and thermally assisted recording—which are expected to deliver data densities beyond 1 Tbit per square inch. These data densities would enable multi-Tbyte mobile drives and microdrive solutions exceeding 80 Gbytes.

The future holds promising new opportunities for HDDs, but it requires a deep understanding of head, disk, read channel, controller design and manufacturing engineering. This comprehensive approach to vertical integration clearly differentiates Hitachi from other HDD suppliers.

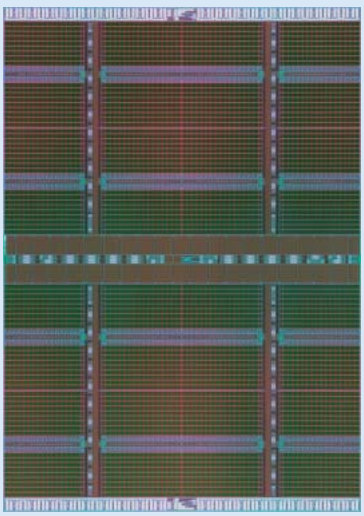
144-Mbit Broadband RAM for G-bits to T-bits Communication and Network Systems

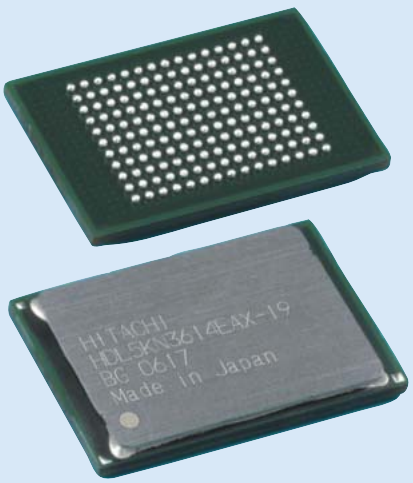
As the ubiquitous information society develops, vast amounts of data including audio and video streams are transferred through networks connecting numerous nodes, such as PCs and cell phones. For the ubiquitous information society to further evolve, communication and network equipment as typified by routers and switches must have even higher performance and lower cost. In the case of routers and switches, since high-speed memory is heavily used for various applications, the quality (in terms of cost performance) of memory products governs the competitiveness of devices.

SRAMs (static random access memories) have been widely used as packet buffers and table memories in routers and switches. A packet is a unit of data transferred through a network, and a packet buffer is a temporal memory device of a packet. A table memory holds the target address for each packet.

In terms of both bandwidth and memory capacity, HDL5KN brings a huge improvement in performance compared to solutions based on conventional SRAMs, and is the world-leading high-performance network memory, with embedded 144-Mbit high-speed DRAM (dynamic random access memory), which is four times as large as an SRAM. The maximum memory-core frequency is 500 MHz, and the interface circuit can send and receive 36-bit-wide data simultaneously at 1.0 Gbit/s. The data bandwidth is wide, i.e. 8 Gbyte/s, which exceeds that of SRAMs, i.e. 4.8 Gbyte/s. This LSI was manufactured by using Hitachi's high-performance embedded DRAM process, and is packaged in a standard 165-pin FCBGA (flip-chip ball-grid array) package. Moreover, 16 memory banks are mounted in the chip, and while read/write commands can be received at a pitch of 2 ns (two nanoseconds), maximum utilization of data bit-width is possible. To promptly meet the various requirements of users, we are offering a broad line-up of, for example, data bandwidth, operating frequency, and memory-latency and input-and-output voltage levels.

Hitachi will promote this device globally and will contribute to the continuing evolution of the ubiquitous information society by enhancing the performance and reducing the cost of network equipment.





Access time: 10 ns
Operating frequency: 500 MHz
Data bandwidth: 8 Gbyte/s

144-Mbit broadband RAM for G-bits to T-bits communication and network systems

Hard Disk Drive

The hard disk drive industry will celebrate its 50th anniversary on September 13th of this year. In 1956, the first hard disk drive—the 5-Mbyte RAMAC (random access method of accounting and control)—made random access to information possible using computer systems. Now, hard disk drives are used in various consumer electronic devices in the home and in computer network systems supporting social infrastructures. Today, Hitachi offers a full line-up of products from the one-inch Microdrive to a 3.5-inch hard disk drive for servers.

In April 2006, Hitachi announced new 3.5-inch ATA/SATA hard disk drives—the Deskstar T7K500 and 7K160 for desktop PC applications and the new brand CinemaStar 7K500 and 7K160 for digital video applications. Moreover, a new 2.5-inch drive (Travelstar 5K160) using perpendicular recording technology was recently introduced. The use of perpendicular recording represents one of the most pivotal technology transitions for the hard disk drive industry, allowing the continued growth of areal density and storage capacity. Travelstar 5K160 has a 160-Gbyte storage capacity and a 5,400-rpm rotational speed.
(Hitachi Global Storage Technologies)

Product line-up

High-performance IPS Provectus Technology for Large-screen LCD-TVs

IPS (in-plane switching) is a horizontal electric field liquid crystal mode with super-wide viewing angle performance. IPS technology was announced by Hitachi in 1995, and the following year, the company applied it in an actual product. The transmittance and contrast ratio of IPS Provectus (the word *provectus* in Latin means “innovation”) have been improved by 1.6 and 3 times respectively, since the technology was originally developed. As a result, IPS LCDs (liquid crystal displays) for TV applications have the highest performance in the world. LCDs using the advanced IPS Provectus technology will be produced in IPS Alpha Technology’s new plant.
(Hitachi Displays, Ltd.)
(IPS Alpha Technology, Ltd.)

Name (Year)	S-TFT (1996)	S-IPS (1998)	AS-IPS (2002)	IPS Provectus (2004–)
Advantage	Wide viewing angle	Color-shift free	High transmittance	High contrast ratio
Transmittance	100	100	130	160
Contrast ratio	100	137	250	300
Plane view electrode structure and LC molecule operation	Electrode LC molecule (left rotation) single domain	Electrode LC molecule (L/R rotation) two domains	Transparent electrode Shield signal line by common electrode	Transparent electrodes Inter digital pixel and plane common electrodes
Front photograph of a pixel				

S-IPS: super-IPS AS-IPS: advanced super-IPS

Advances in IPS liquid crystal

IPS Low-temperature Polysilicon TFT-LCD with 16:9 Aspect Ratio for Digital Cameras

HDTV (high definition TV) screens typically employ a 16:9 aspect ratio that matches the human field of view, so now there is growing demand for LCDs (liquid crystal displays) with the same aspect ratio for high-end digital cameras. This prompted Hitachi Displays to develop a 3.1-inch (7.9-cm) low-temperature polysilicon TFT (thin-film transistor) LCD with an aspect ratio of 16:9. The display features an IPS (in-plane switching) display mode that produces superior color reproducibility in all directions and a fine-reflection function that ensures excellent outdoor visibility.

[Main features]

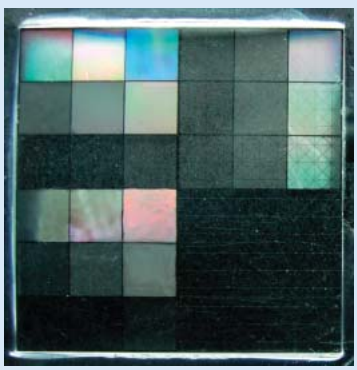
(1) Dots: 960 (H) × 240 (V)
(2) Display size: 3.1 inches (7.9 cm)
(3) Viewing angle: 170° or more horizontal/vertical directions
(4) Color reproducibility: 50% (NTSC ratio)
(5) Contrast ratio: 8-bit digital (RGB series input)

(Hitachi Displays, Ltd.)

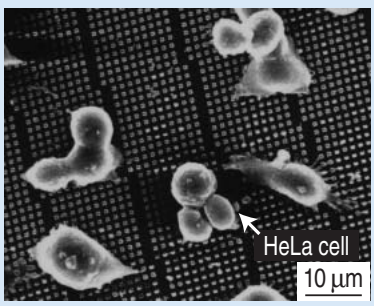
3.1-inch (7.9-cm) IPS low-temperature polysilicon TFT-LCD with 16:9 aspect ratio

Nano-structured Cell Culture Sheet Developed Using Nanoimprint Technology

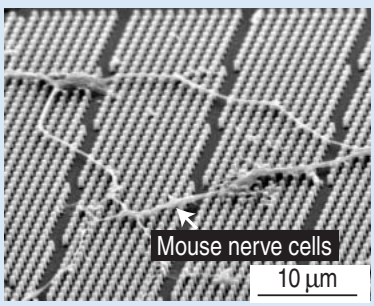
A cell culture sheet with high-density nanopillar structures has been developed using nanoimprint technology. Cultivated cells stick strongly to conventional flat dishes. Trypsin is usually applied to remove the cells, but it damages them. On the other hand, the contact area between nanopillar sheets and cells is reduced because the cells grow on the nanopillar structures. Therefore, the cultivated cells can be collected without trypsin treatment. Furthermore, unique growth behaviors have been observed on the nanopillar structures. Nanopillar sheets are expected to be a new research tool in the regeneration field.



(a)



HeLa cell (human epithelial-like cell line, grown from tumor)
(Joint research with National Institute of Advanced Industrial Science and Technology)



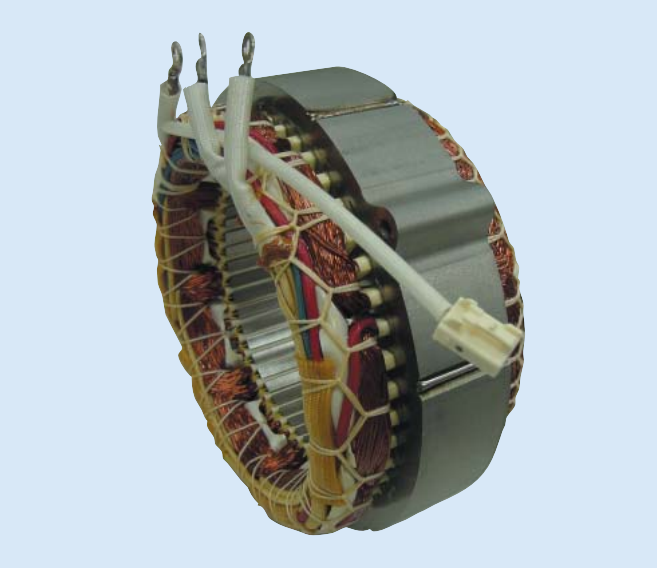
Mouse nerve cells (fetal mouse cerebral cortex)
(joint research with Hokkaido University)

(b)

Cell culture sheet (a) and cultured cells (b)

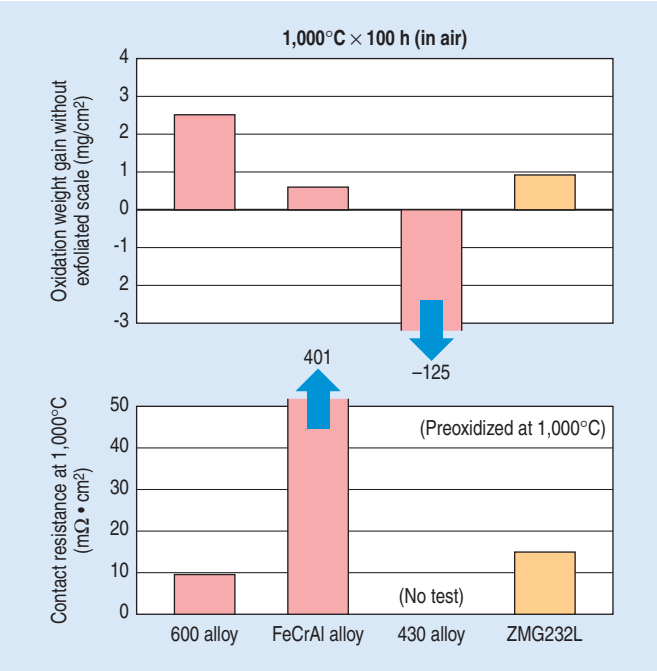
Development of a Method of Evaluating and Analyzing the Insulation of a Motor Fed by an Adjustable Speed Drive in a Hybrid Electric Vehicle

To decrease the fuel consumption and increase the mileage of HEVs (hybrid electric vehicles), their motors need to be smaller and more efficient. One way to do this is to increase the drive voltage of the motor fed by the ASDs (adjustable speed drives) in HEVs. However, designing and constructing the motor insulation for the high and steep-fronted voltage pulses generated by an ASD is very difficult without increasing the insulation thickness because the higher voltage distribution and the resulting electrical insulation aging between turns of the motor windings are very complicated for that voltage compared with conventional sine voltage drive. Toward solving these problems, we have developed methods of evaluating and analyzing the related phenomena and consequently, found design and construction methods for decreasing the voltage distribution and optimizing the electrical insulation materials of the motor fed by the ASD. In addition, we have developed a method of testing in-line electrical insulation to assure the quality of products. As a result, we have decreased the insulation thickness of an HEV motor winding by 30% compared with the conventional method. We will apply these methods not only to HEVs but also various industrial machines.



Stator windings of HEV motor

Ferritic Fe-Cr Alloy for SOFC Interconnects



Comparison of oxidation resistance and electrical conductivity of ZMG232L and conventional heat-resistant alloys

The ferritic Fe-Cr alloy ZMG232L has been developed as an interconnect material for SOFCs (solid oxide fuel cells). Interconnect materials are key components of SOFCs. The properties required for the materials are as follows:

(1) Low contact resistance at operating temperatures in the range of about 600 to 1,000˚C

(2) Good oxidation resistance at the operating temperatures for a long time

(3) A coefficient of thermal expansion close to that of the electrolyte material YSZ (a zirconia ceramic)

Some problems with conventional heat-resistant alloys are as follows:

(1) 430 alloy does not have sufficient oxidation resistance.

(2) Austenitic alloys with good oxidation resistance (e.g. 600 alloy) have much larger coefficients of thermal expansion than YSZ.

(3) Al-containing ferritic alloys with better oxidation resistance than austenitic alloys have low electrical conductivity of their oxide layers.

The new ZMG232L is an Fe-22%Cr ferritic alloy with a small addition of special elements for SOFC interconnects, and it is designed to have all of the required properties.

(Hitachi Metals, Ltd.)