HITACHI TECHNOLOGY
2008-2009

Infrastructure Technology/Products

Hard Disk Drives

Semiconductors

Displays

Materials

Next-generation Insulating Resin Materials that Enable High Performance Electrical Appliances

The Hitachi Group has developed an insulating resin material that has a TC of 10 W/m·K, significantly outperforming the TC of existing materials. This new material dramatically improves heat dissipation of all electric appliances and electric parts including semiconductor devices, circuit boards, motors, inverters and finished products using them, enabling high performance and compact size products that are a key to promoting our ubiquitous information society.

Eiji Omori (left), Head and Department Manager, Advanced Performance Materials Strategy Department, Advanced Performance Materials Business Sector, Hitachi Chemical Co., Ltd.; Dr. Yoshitaka Takezawa (right), Senior Researcher, Unit Leader, High Performance Polymer Unit, Department of Electronic Materials and Devices Research, Materials Research Laboratory, Hitachi Research Laboratory, Hitachi, Ltd.

New Concept Taking Advantage of an Existing Blind Spot in Research

All sorts of electrical appliances in the world use insulating resin and it is, so to speak, an unsung hero that supports our technology behind the scenes. On the other hand, insulating resin's low TC (thermal conductivity) has been an obstacle to improved products that are smaller in size and with higher performance. Although ceramic powders have been used as a filler to form a composite material with increased TC, improvement of resin itself has not been focused upon, and as a result the improvement of fillers in resins has been limited. We focused on this "blind spot" and studied the possibility of increasing the TC of resin itself. If possible, this should be a key for increasing heat dissipation.

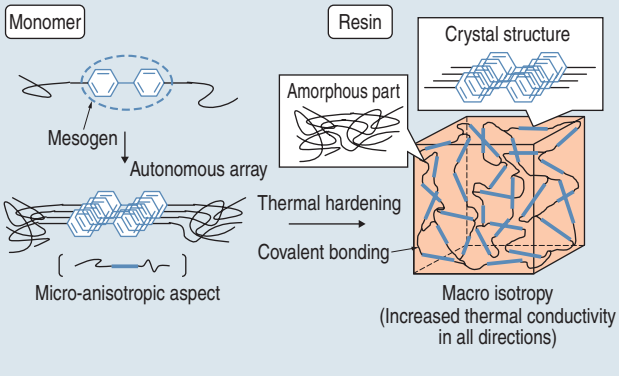
Steady 10-year Research until Commercialization

We started research around 1997. The TC increases under a crystalline condition where the regular array of molecules is demonstrated. We designed a new resin structure where such crystalline conditions are mixed with chains of molecules that play an important role to maintain flexibility of resins. We finally discovered a resin with maximum 0.96 W/m·K TC, about five times of those of general-purpose resins and the news of this was released in December 2001. Composition of fillers plays an important role in a resin. Through partnership with the Hitachi Chemical group who were interested in such a big opportunity, we were committed to commercializing composite materials. In the course of this process, we faced a challenge of mass production of raw materials for resins. We worked together with experts of resin composition to identify resins suitable for mass production among a huge number of molecule patterns that meet our design. We actually composed resins and evaluated them. After years and years of these processes, we finally identified the ideal resin. At last, we successfully developed a composite material that has a TC of 10 W/m·K, which was impossible with existing composite materials. Now our customers are evaluating our samples. It took more than 10 years to bring it to the market, but it is natural that it takes quite a long period of time to develop new materials.

New Material to Open up Opportunities for Innovation

In the automotive field the number of electrical parts is increasing in order to respond to environmental issues and improvement of performance, while in the power electronics field, further integration and higher performance are the issues. This composite material will be a key to a breakthrough in various fields including those automotive and power electronics.

When we first announced our concept, many made a negative comments against the idea, saying, "It is impossible." We were not discouraged but continued our efforts based on our firm belief. As a result, we pioneered the next-generation insulating resin material and will open up opportunities for further innovation. Our success attracted attention from researchers to this field. We continue to commit ourselves to the development of insulating materials with better properties by promoting commercialization of this composite material, in order to further our lead and to develop this field.



Concept to increase thermal conductivity of resins through super-molecular structure control

High Capacity HDDs Improving Materials and Energy Savings

After five decades of HDD (hard disk drive) technology innovation, areal densities have continued their double-digit growth. Hitachi introduced the Travelstar 5K160 in May 2006, which was the company's first 2.5-inch HDD with PMR (perpendicular magnetic recording) technology. Since that time, Hitachi has expanded the use of PMR and applied it across its product line.

Hitachi introduced the Deskstar 7K500 in 2005. The 3.5-inch drive used five disk platters to achieve a 500-Gbyte capacity. Hitachi would later introduce two additional 500-Gbyte drives, one with three disk platters (Deskstar T7K500) and another using two disks (Deskstar P7K500). Ultimately, the 500-Gbyte capacity could be realized with fewer disk platters in succeeding generations because of areal density advancements.

In addition to material savings, reducing the number of disk platters contributes to lower power consumption. The generational reductions in power consumption are significant. For example, the Deskstar 7K500 in the read/write mode used 13.6 W, the Deskstar T7K500 is 11.3 W and the Deskstar P7K500 is 8.2 W. Overall, power consumption was reduced 40% over three product generations.

The 2.5-inch Travelstar 5K500 was introduced in January 2008, delivering 500 Gbyte on three disk platters. While the storage capacity is equivalent to the 3.5-inch Deskstar P7K500, its read/write power consumption is quite different (8.2 W, reduced to 1.9 W, a reduction of 77% down, and its weight was reduced from 550 g to 148 g, a reduction of 76%). In conclusion, increasing areal density is a key measure of advancements in performance and capacity, and it also contributes to material and energy savings. (Hitachi Global Storage Technologies)

3.5-inch HDD (left) and 2.5-inch HDD (right)

Analog/mixed-signal IC Platform for Medical, Consumer, and Industry Applications with Low Noise and High-voltage Features

Applications for telecommunication devices have led the performance of analog ICs (integrated circuits). Recently, these analog circuits have been applied to other areas, such as medical, consumer and industrial products, because of the necessity for system-level integration. This change of trend is accelerated by the maturity of mixed-signal IC design and fabrication capabilities, which makes it possible to integrate not only analog but digital and high-voltage devices on the same die.

Hitachi, Ltd. has developed IC design platform that is suitable for this purpose. The following describes typical examples of use of this IC design platform.

(1) A high energy and time resolution amplifier for PET (positron emission tomography)

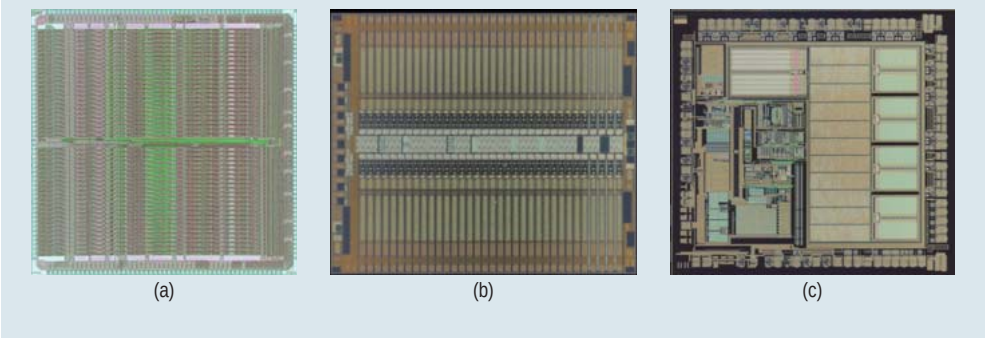
This IC is targeted for medical imaging fields such as PET, which integrate 48 channels of low noise amplifiers. A charge-sensitive amplifier is adopted for the input circuits, which achieved the lowest level of 220-electron equivalent noise. In addition, 0.35-µm SOI (silicon on insulator) BiCMOS (bipolar complementary metal-oxide semiconductor) technology has been applied.

(2) A scan driver IC for PDP (plasma display panel)

A high-voltage IGBT (insulated gate bipolar transistor) is used for the output circuits with 68 channels integrated. This IC is fabricated in 250-V SOI MOS (metal-oxide semiconductor) and IGBT technology.

(3) A high-sensitive battery monitor IC for industry use

This IC integrates voltage-follower, ADC (analog to digital converter), and MPU (micro processing unit) for voltage sampling and analysis of the inner state of the battery. A 40-V with fine-pitch CMOS technology is applied.



Low-noise amplifier IC for PET application (a), scan driver IC for PDP (b), and high-sensitive battery monitor IC (c)

Viewablity for Outdoor Use of LCDs Improved

LCD (liquid crystal display) applications are increasing for products such as mobile phones and digital still cameras that are frequently used outdoors. A new technology improving viewablity for such outdoor uses was developed.

(1) Hybrid IPS (in-plane switching) LCD module

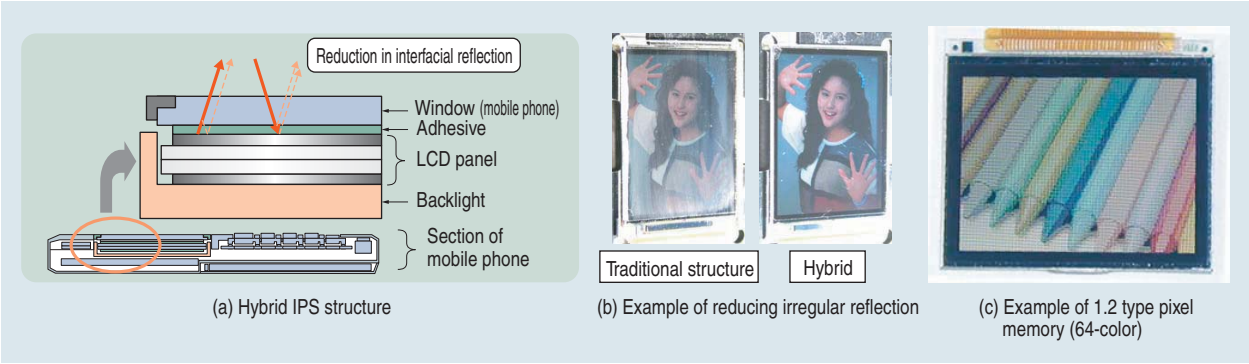
A technology was developed and applied to applications for mobile phones and digital still cameras that would eliminate interfacial irregular reflection and improve outdoor visibility (e.g. to be easily viewable bright sunlight). For mobile phones, adhering this product's window is incorporated into a transparent cover and glued together with the LCD using an impact-absorbing adhesive.

(2) Pixel memory display

A pixel memory display was developed by making each pixel contain an SRAM (static random access memory) to eliminate the necessity of writing display data externally when continuing the display of the same information. As a result, in the displays of information such as the time and e-mail that mainly display an unchanged image, power consumption is reduced to $\frac{1}{100}$ or lower compared with ordinary products. By combining pixel memory display with previously mentioned anti-reflection feature for outdoor use, battery power consumption is greatly reduced and long-time continuous use of mobile products mounting this panel is enabled.

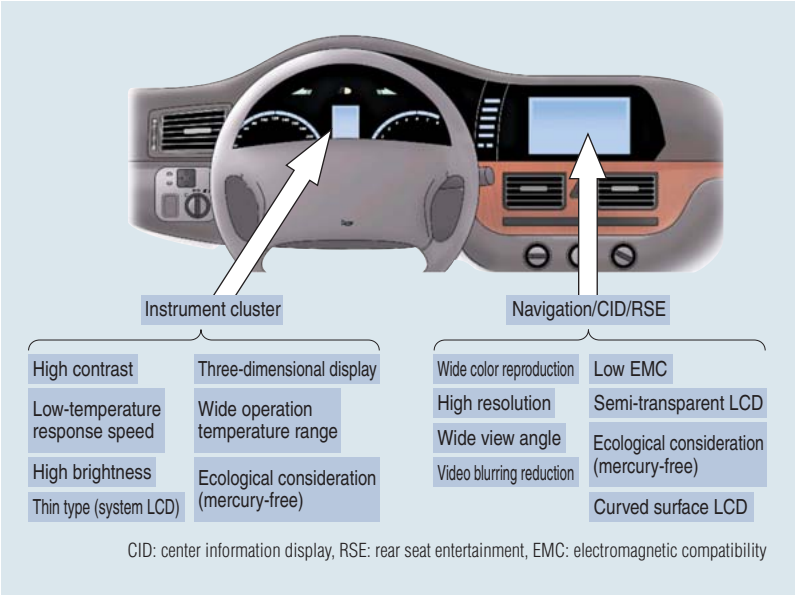
At this time, Hitachi also placed into production a 64-color pixel memory display with each color containing a 2-bit memory for application of a wristwatch display linked to a mobile phone via short-distance communication.

(Hitachi Displays, Ltd.)



Hybrid IPS LCD modules (a) and (b), and pixel memory display (c)

TFT Displays for Vehicles



TFT technology for vehicle applications

In recent years, vehicles have been using many LCDs (liquid crystal displays) such as STN (super-twisted nematic) and TFT (thin film transistor) as display units, typically for car navigation. New models will have several LCDs such as in the instrument cluster, and in the future the rear seat area will have displays with LCDs too.

To accommodate this growing market, Hitachi is enhancing the TFT field for vehicles and has developed new technologies as important factors of the next-generation displays for vehicles including:

(1) IPS (in-plane switching) for vehicles achieving high contrast and wide view angles

(2) LED (light emitting diode) backlights enabling high brightness and compact design and well as ecological considerations

(3) Three-dimensional display for the next-generation of products achieving improvements in visibility and functionality

Adoption of these technologies for the next new models has been determined and their use on specific products is being planned.

(Hitachi Displays, Ltd.)

Three-dimensional Displays for Vehicles

Hitachi developed a 3D (three-dimensional) TFT (thin film transistor) display mainly for instrument clusters as a next-generation display for vehicles. In cooperation with Nippon Telegraph and Telephone Corporation, this product uses two TFT LCDs (liquid crystal displays) to dramatically improve visibility without causing eyestrain.

[Product theory]

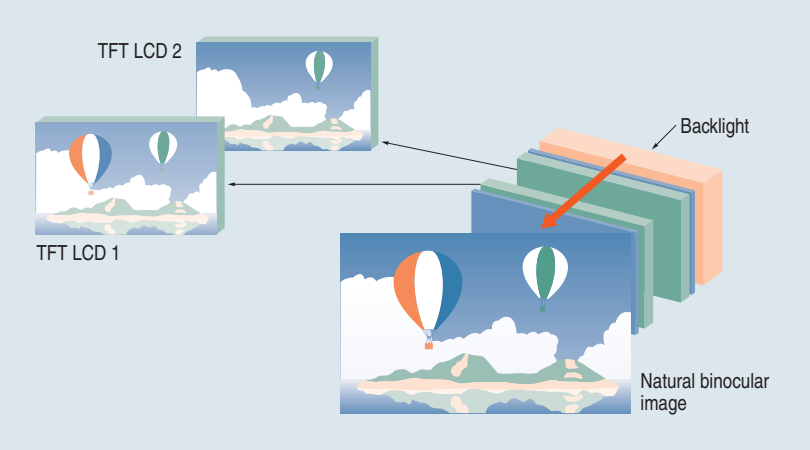
(1) This 3D TFT display uses two currently-available TFTs arranged from each other at a slight angle of a few millimeters.

(2) In a simple configuration, a backlight is positioned on the rear side and an interface circuit board attached.

(3) In the figure, the eye determines the relationship of the balloon, island, and sky positions from the brightness of two TFT placed on the front and rear. With the naked eye, binocular vision overlaps these two TFT images to achieve the perception of a 3D image.

The superiority of this 3D TFT display to other 3D displays is that special eyeglasses are unnecessary and eyestrain is much less because image recognized in the binocular illusion is about same position as the focal distance for viewing TFT.

(Hitachi Displays, Ltd.)



3D display theory

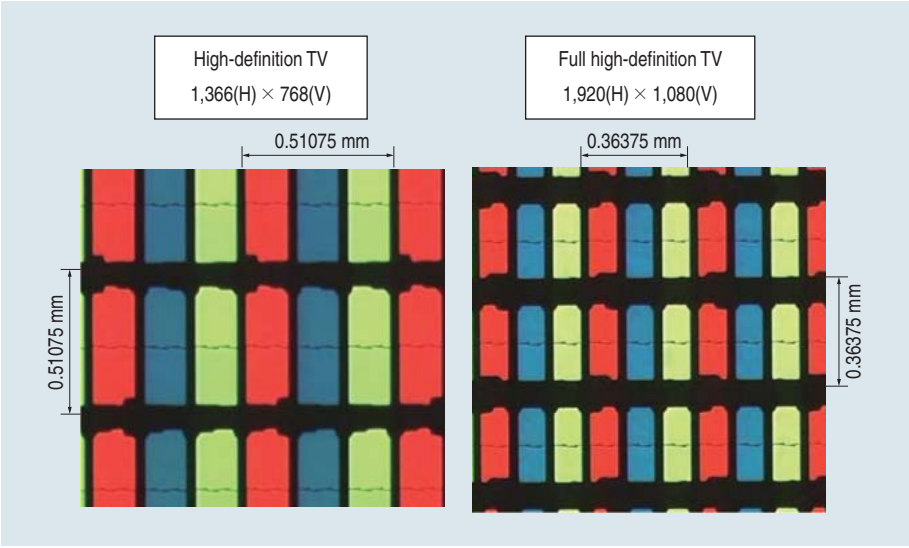
32-inch Type LCD Module Supporting Full High-definition TV

Hitachi developed an IPS LCD (in-plane switching liquid crystal display) module (IPS Alpha panel) for 32-inch type full high-definition TV (television) to support the high image quality of LCD TVs. Mass production started in April 2008. The developed module doubles the precision [number of pixels: 1,920 (horizontal)×1,080 (vertical)] compared with traditional high vision panels [1,366 (horizontal)×768 (vertical)] and holds the video blurring response speed to only 8 ms in 120 Hz video model.

For the LCD panel, the front contrast ratio is improved by 20% from traditional products by reducing scattering on panel. In addition, the high-transmission design suppresses the backlight power needs that would increase along with the increasing high precision to 105 W that is approximately equivalent to that of traditional high-definition panels and thus achieves low power consumption.

This time, the lineup is enriched with a wide viewing angle that is already appreciated domestically and internationally as a solid benefit along with the IPS Alpha panel for 37-inch type full high-definition TVs which have been in mass production since April 2007, according to the rise of need for full high-definition TVs.

(IPS Alpha Technology, Ltd.)



Enlarged photograph of 32-inch type IPS Alpha panel pixel lighting for full high-definition TV

Photo-nanoimprint System for Nano-fabrication

Photo-nanoimprint is one of the next-generation methods of lithography for nano-scale fabrication. Hitachi, Ltd., in cooperation with Hitachi Chemical Co., Ltd. and Hitachi High-Technologies Corporation developed the photo-nanoimprint system. This system uses an original photo-curable polymer that has quite low viscosity like water. This polymer is suitable to form the nano-scale size structures with ultra-thin residual layer. The unique pressure method called HiDAF (high pressure direct air flow) forms the air cushion between the press stage and substrate with dynamic pressure controllability. The HiDAF makes it possible to use the large wafer with an uneven wavy backside surface. High resolution such as 25 nm pillar structure was formed by this new system. The system is expected to be useful as a production tool for next generation of IT (information technology) devices.

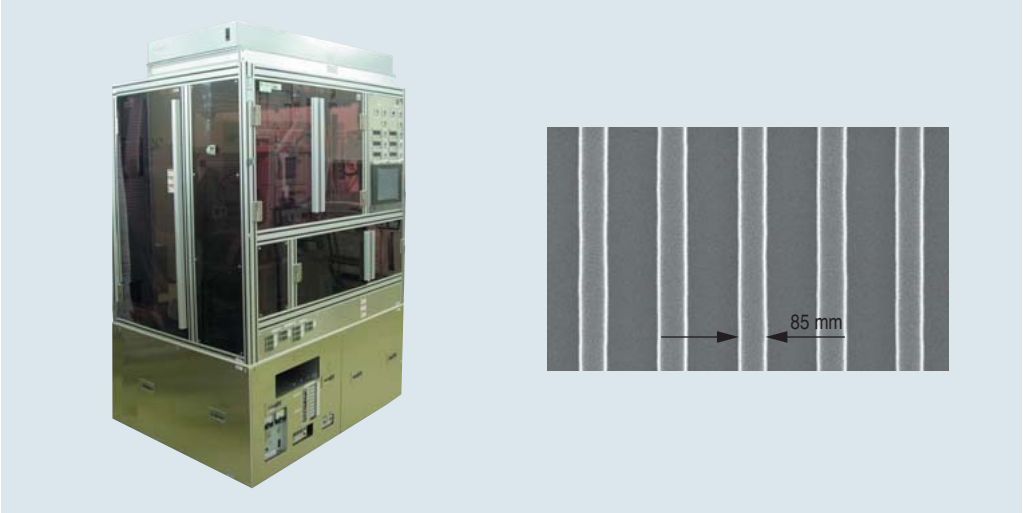
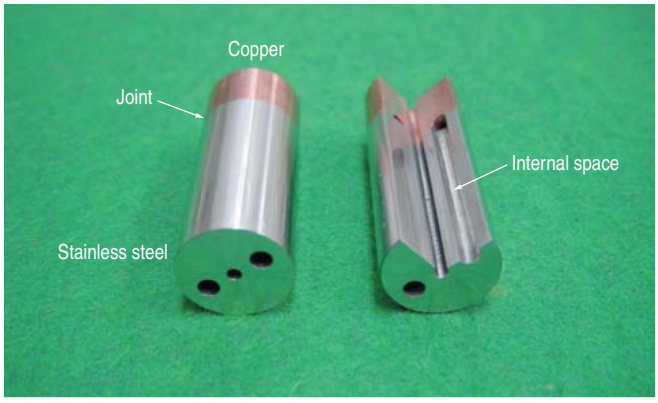


Photo-nanoimprint system (left) and the example of patterned polymer (right)

Metal Bonding Technique for Precision Internal Space Formation



Dissimilar metal joint of stainless steel and copper with internal cavity

New solid-state bonding technique using resistive heating has been developed to allow metal-to-metal planar joining with only minor deformation. Efficient resistive heating by pulsed electric current and adaptive control of bonding pressure reduces bonding time and deformation to 10–30% of conventional process. In this new process, metals are joined without any adhesion or brazing filler metal, which leads to high bonding strength of the joints. Bonding of dissimilar metals is also possible. This new technique allows producing metal components with complicated internal structure such as channels for coolant or lubricant. As Hitachi, Ltd. continues to reduce bonding time and realize higher precision, methods such as this new bonding technique will contribute to size reduction, weight savings, and functionalization of metal components in many industrial fields.

Super-size Plastic Mold Steel CENA1

CENA1, a new concept tool steel for injection mold, breaks through with excellent machinability and rust resistance. Though it was believed that the relationship between superior rust resistance and excellent machinability was a tradeoff in conventional plastic mold steels, conquest of this tradeoff has been achieved by the implementation of a new microstructure design and combination of alloying elements. In addition, CENA1 has excellent mirror polishability, crepability and EDM (electrical discharge machine) finishability. CENA1 is a prehardened mold steel with higher hardness, 40 HRC.

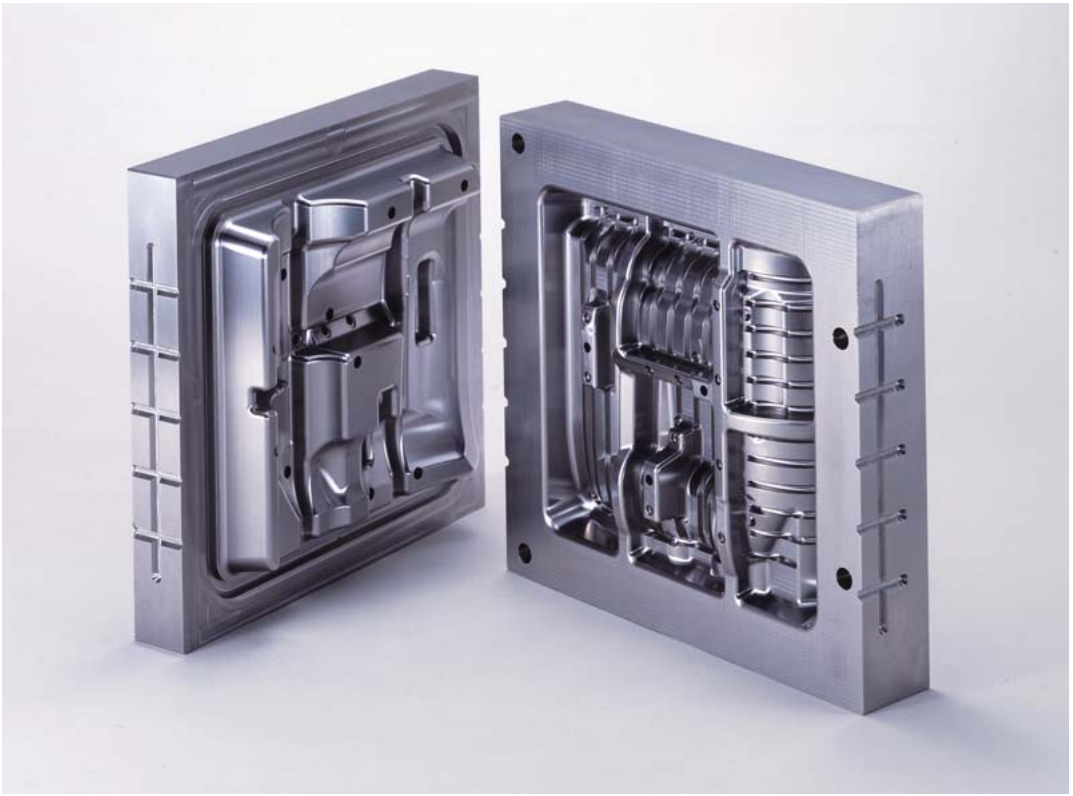
The combination of these properties provides a steel with outstanding production performance. The practical benefits of good rust resistance in a plastic mold can be summarized as follows: The surface of cavity impressions retains their original finish over an extended service life, because CENA1 increases mold durability against corrosion by gas generated from resin. As well, since water-cooling channels are less like to be affected by corrosion (unlike conventional mold steels), heat transfer characteristics, and therefore cooling efficiency, are constant throughout the mold life, ensuring consistent cycle times. So, these benefits, coupled with the high hardness of CENA1, offer the molder low maintenance, long-life molds for the greatest overall tooling economy.

Therefore, CENA1 is increasing popularity in compliance with advanced plastic molding technology. Specifically, CENA1 is most suitable for weldless molds for which temperature control is required, because surface condition of heating and cooling holes comes to be less corrosive and more stable. CENA1 is widely used for molds applied for the products such as PDP (plasma display panel) and video and digital camera devices for which better surface condition is indispensable.

In recent years, trends of flat panel television sizes have become increasingly large. Therefore, very large-scale weldless molds are necessary. But large-sized materials of more than 1 m in width for making the weldless mold could not be manufactured so far, because these materials manufactured from large ingots have low toughness. So, Hitachi has earnestly investigated the cause of low toughness in large ingots. As a consequence, the new super-size plastic mold steel, CENA1α which has higher toughness and much better machinability than conventional steels, has been developed. Although conventional steels such as AISI P21 improved are under the tradeoff relationship between toughness and machinability, both of these properties are improved in the case of CENA1α by the microstructure controlling with thermomechanical treatment. CENA1α is most suitable for large-scale weldless molds, and widely used for molds applied for the products such as large-scale FPD (flat panel display) unit bezels and the exterior component of automobiles. Consequently, CENA1α has received the “50th Nikkan Kogyo Shimbun’s 2007 Best 10 New Products Prize.”

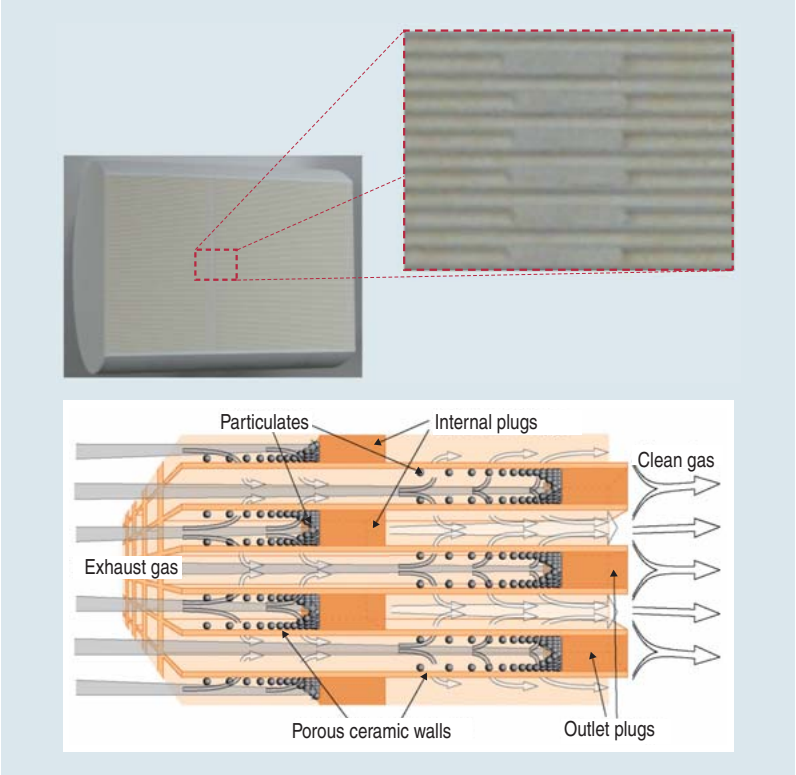
CENA1 is striving for the 21st century global standard which responds to customer demand.

(Hitachi Metals, Ltd.)



An example of weldless molds

IP Filter, Internal Plugged DPF

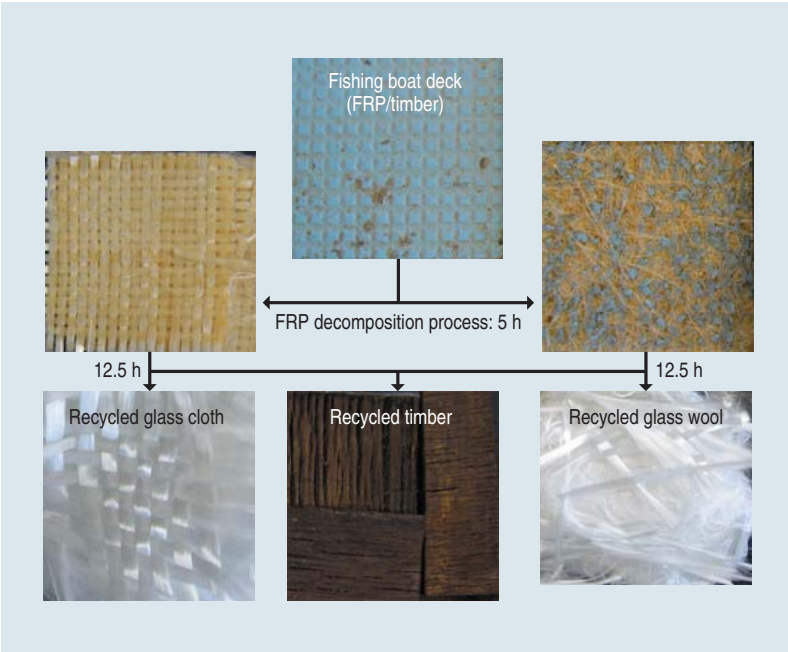


Magnified view of internal plugs (upper) and IP Filter structure (lower)

This newly-structured DPF (diesel particulate filter) "IP Filter," which has internal plugs, has been developed to improve the current DOC (diesel oxidation catalyst) + DPF system by reducing the size of the unit. Both the DOC and the DPF are integrated into one structure that includes open-ended cells on the front face unlike a conventional wall-flow DPF.
This filter successfully provides high soot filtration efficiency and suitable temperature response characteristics.
Furthermore, the filter provides low-pressure drop when accumulating particulate by the distribution characteristics of particulate on the filter. This distinct filter provides increased system design flexibility in order to meet upcoming emission regulations.
Specifications of the filter can be adjusted according to customers' requirements.
(Hitachi Metals, Ltd.)

Recycling Technology for FRP Using Atmospheric Decomposition

FRP (fiber reinforced plastics) has been used for a wide range of applications including bath tubs, vehicles, and vessels due to its light weight, strength, and weather resistance properties. However, current concerns have focused on the issue of the difficulty of recycling FRP.
Hitachi Chemical Co., Ltd. has successfully developed a recycling technology to decompose unsaturated polyester resin (thermoset resin) used for FRP under atmospheric pressure and temperature of 200°C or less into fiber, filler, and decomposed resin.
This technology does not require expensive equipment and facilities since powdering and pressurizing processes are not involved, and it is much more beneficial from health and safety standpoint. Fibers can be processed and recycled into nonwoven fabrics that can be used again for new FRP products as reinforcing fibers. Decomposed resin can be used as fuel, and its application to the FRP is also under development. As part of its commercialization, Hitachi Chemical has granted license to Kokudosha for fishing boat recycling.
(Hitachi Chemical Co., Ltd.)



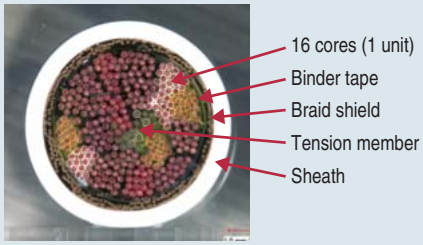
Decomposition process of FRP fishing boats

44AWG Micro-miniature Multi-coaxial Cable with High Impedance for Ultrasound Medical Equipment

Many customers demand higher impedance and lighter weight probe cable with more coaxial cores to make clearer imaging for ultrasound medical equipment.
44AWG (American Wire Gauge) high-impedance probe cable has been successfully developed with Hitachi's original technology about finer copper-alloy conductor and thinner insulation of cellular PFA (perfluoroalkoxy).
[Main features]
(1) Minimal increase of electrical resistance using a new copper-alloy conductor with high conductivity and strength
(2) Thinner insulation and lower dielectric constant with extruded cellular PFA to make smaller diameter and lower attenuation coaxial cable
(3) Light weight and excellent flex life for cable bending
(Hitachi Cable Finetech Co., Ltd.)

Item		Unit	Specified value	
Number of cores		–	200	300
Inner conductor	AWG size	–	44	
	Material	–	Silver plated copper alloy	
	Stranding	No./mm	7/0.02	
	Diameter	mm	0.06	
Insulation	Material	–	Cellular PFA	
	Thickness	mm	0.06	
Skin layer	Material	–	Polyester tape	
	Thickness	mm	0.01	
Outer conductor	Material	–	Silver plated copper alloy	
	Thickness	mm	0.02	
Jacket	Material	–	Polyester tape	
	Diameter	mm	0.27	
Assembly diameter		mm	4.9	6.1
Braid shield	Material	–	Tinned, spiral wrapped tinsel copper	
	Thickness	mm	0.25	
Sheath	Material	–	PVC	
	Thickness	mm	0.80	
	Diameter	mm	7.1	8.3

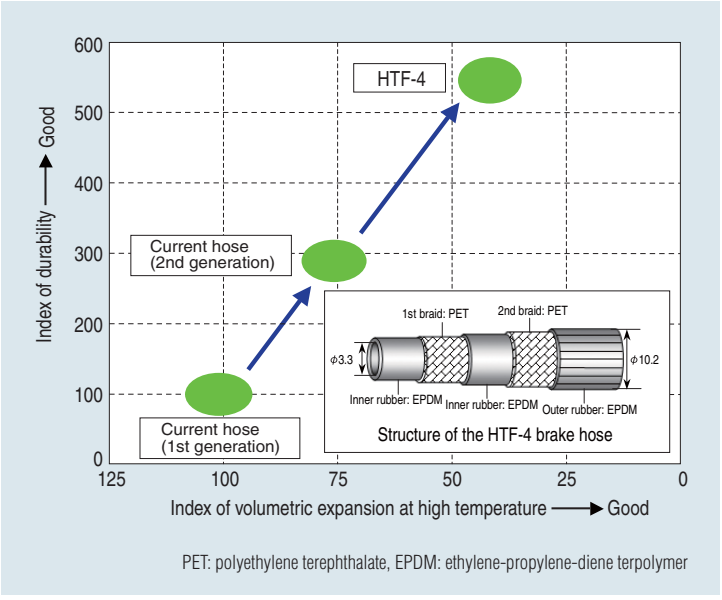
Item		Unit	Specified value
Inner conductor resistance (20°C)		Ω/km	Max. 10,500
Insulation resistance (20°C)		MΩ-km	Min. 1,000
Dielectric strength	Inner–outer conductor	–	To withstand AC 500 V for 1 min
	Shield–ground earth	–	To withstand AC 5,000 V for 1 min
Capacitance (1 KHz)		pF/m	Nom. 60
Characteristic impedance (10 MHz)		Ω	Nom. 75
Attenuation (10 MHz)		dB/m	Nom. 0.65



PVC: polyvinyl chloride

Construction and material (left), electrical properties (upper right), and cross-section of cable (300 cores) (lower right)

High Durability and Low Volumetric Expansion Brake Hose "HTF-4"



PET: polyethylene terephthalate, EPDM: ethylene-propylene-diene terpolymer

Position of HTF-4 compared with current hoses in hose performance

Brake hoses must have high durability to withstand the stress caused by the bouncing of the wheel assemblies, twisting caused by steering, and pressure generated by the pedal action. In recent years the space available for the brake hose layout has been getting tighter and this increases the stress on the hoses since the hose is routed in severe shape. This has further accelerated the need for highly durable brake hose. Furthermore, lower volumetric expansion has been also constantly sought in brake hoses in order to obtain more sensitive brake feeling.
For satisfying this demand, Hitachi Cable, Ltd. has developed the new "HTF-4" brake hose that has higher durability and lower volumetric expansion. HTF-4 has the top-level durability in the world that enables it to withstand more severe hose layouts. In addition, the HTF-4 hose has lower expansion over wide temperature range, which contributes to brakes that have sensitive and reliable feeling. The market has recognized these benefits and increasingly this hose has been adopted widely in Japan and internationally.
(Hitachi Cable, Ltd.)