Independent Administrative Institution
Japan Science and Technology Agency

Promoting business using advanced technology
Development of Creative Technology Seeds

# Contract Development since 1958

## Collection of Products developed by collaboration with Industries and Universities

# Contents

## Production, Processing



## Building, Transportation



## Chemistry, Materials, Metals

## Environment, Energies



## Agriculture, Bio Technology, Foods



## Civil Life, Welfare



## Health Care, Life Science

# 1 Promoting business using advanced technology

## Technology Transfer :"Development of Creative Technology Seeds"

JST aims to transfer important research results (new technology) achieved at universities, national and other public research institutes to companies, allowing this research to be put to practical use.

The purpose of "Development of Creative Technology Seeds" is to support the practical application of innovative research results obtained by universities and public research institutes etc.(*)

This project is composed of the following four programs in correspondence to the developmental phase.

(*) Universities etc. include universities, higher professional schools, public research institutes, as well as government-affiliated corporations, independent administrative institutions, and public corporations that are engaging in R&D activities.


### ■Modeling of innovative research results

For the purpose of supporting the practical application of new technological concept owned by R&D-oriented middle- or small-sized enterprises and based on the research results of universities etc., this program promotes R&D related to trial manufacturing and possibility verification.


### ■Promotion of creation of university-initiated venture businesses

This program promotes R&D required for starting and developing the businesses based on the research results of universities etc.


### ■Development of the utilization of innovative venture businesses

This program promotes business establishment promotion, regarding the themes among R&D results of universities etc., for which innovation can be expected by the use of R&D-oriented venture businesses.


### ■Contract development

This program promotes business establishment promotion regarding new technologies that are significantly difficult for business establishment, among new technologies important for national economy.

# 2 Contract Development since 1958

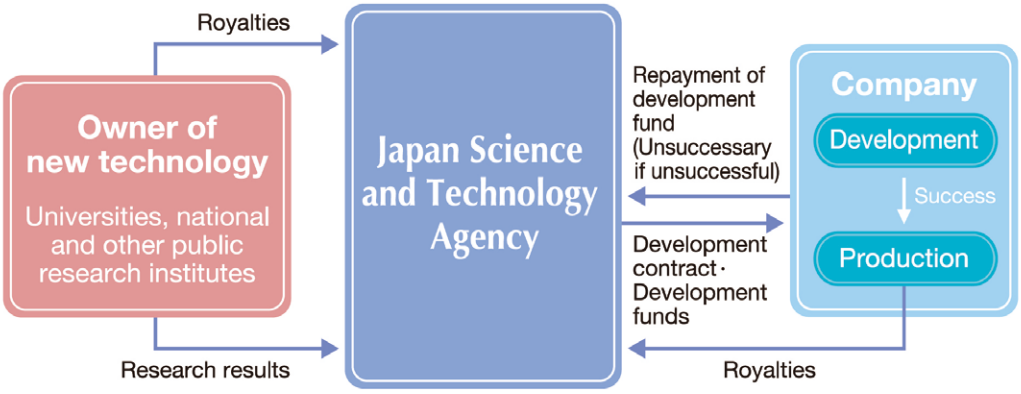
## JST provides Risk-Taking Funds for the commercial development of new technologies that can contribute to the advancement of society and improvement of people's lives.

For the development of new technologies considered important for society and likely to involve high risk, JST assists companies developing applications for practical use by providing Risk-Taking Funds. If development is successful, the companies repay JST. If it is unsuccessful, there is no requirement for repayment.

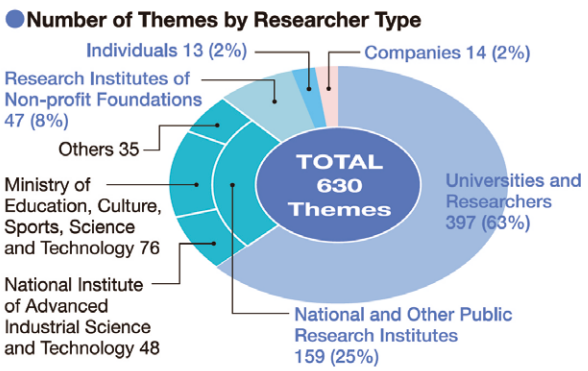
This project publicly solicits a wide range of subjects from researchers and companies. Among the submitted ideas, JST adopts new technologies considered to be important for national economy and difficult to develop on a commercial scale through the process of evaluation and screening. As the enterprises, those with appropriate R&D power and management infrastructure are selected.

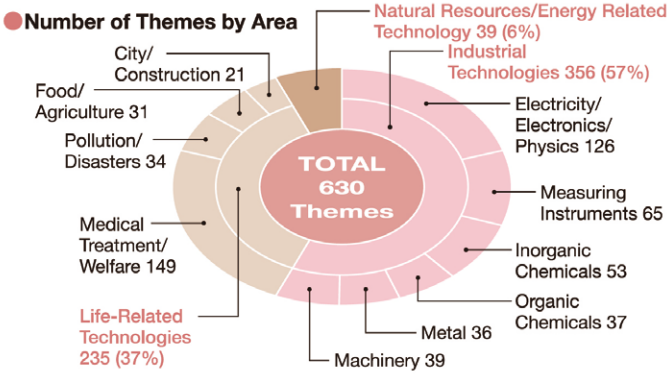
- Development fund : 100 million to 2 billion yen per project, without interest
- Development period : 2 to 7 years
- Repayment when successful : If the development is successful, companies shall repay development expense to JST by annual installments within 10 years. Meanwhile, if it is unsuccessful, 90% of the expense would be exempted at the JST's risk.

### Scheme




### Number of Themes (1958-2008)



# Continuous manufacturing technology of red light emitting diode (GaAlAs)

| | |
|---|---|
| Researcher | NISHIZAWA Junichi (Semiconductor Research Institute), SUTO Ken (Tohoku University) |
| Company | STANLEY ELECTRIC CO., LTD. |
| Development Period | October 1972 – April 1976 |
| Development Fund | Approx. 200 million yen |
| Abstract | Although red light emitting diodes made of GaAsP and GaP came into use, there were problems such as low emission efficiency due to crystal defect as well as a low productivity.<br>This technology allows the liquid-phase growth of GaAlAs, with a crystal lattice gap close to GaAs, on a GaAs substrate continuously and in multilayer form. Thus, this technology improved light emitting efficiency due to the reduction of crystal fault, and reduced power consumption to tens of percentage of the conventional method. In addition, the productivity was improved due to continuous manufacturing, and cost reduction became possible. |
| Use and Application | (1) electronic billboards, (2) display element of household appliance, and (3) automobiles |

Figure

Appearance of the light emitting of diode

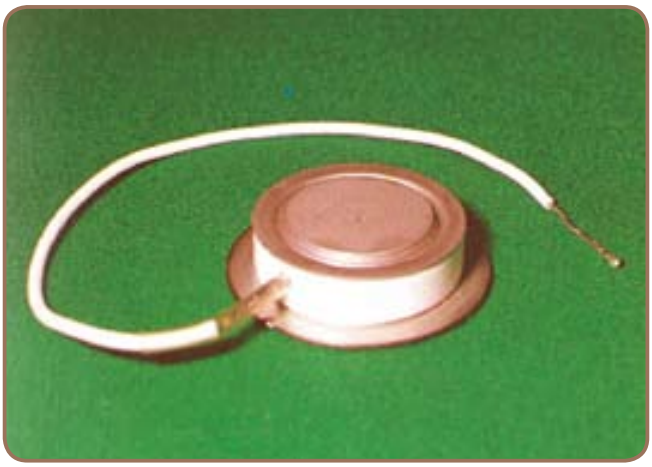
Example of application to display

Example of application to car tail lamp

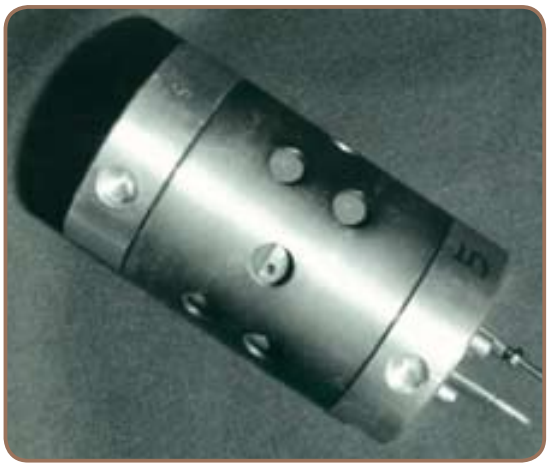
# Manufacturing technology for high-power ultrasonic wave generator

| | |
|---|---|
| Researcher | NISHIZAWA Junichi, TERASAKI Takeshi (Semiconductor Reseach Institute) |
| Company | NEC TOKIN Corporation |
| Development Period | February 1975 – September 1978 |
| Development Fund | Approx. 280 million yen |
| Abstract | Static induction type transistor (SIT) is a semiconductor element having superior characteristics, such as high-speed action/low loss and high-fidelity amplification of signal waves. In this technology, the manufacturing technology has been established for high-power SIT corresponding to high voltage, large current, and high-frequency through the high-concentration diffusion technology and the crystal growth technology of lesser defect and strain.<br>Ultrasonic waves have been used in many fields, such as processing and cleaning, thanks to ultasonic waves' characteristics. As application expanded, however, high power and high efficiency were demanded. In this technology, therefore, a compact and light-weight, high-power ultrasonic cleaner of higher efficiency with no need for frequency adjustment has been commercialized using high-power SIT and integrating the conformity with various oscillators and control of oscillation amplitude. |
| Use and Application | Ultrasonic oscillators, high-frequency generators, wideband power amplifiers, power units (switching regulators), broadcast transmissions, etc. |

Figure



High-power static induction type transistor (SIT)



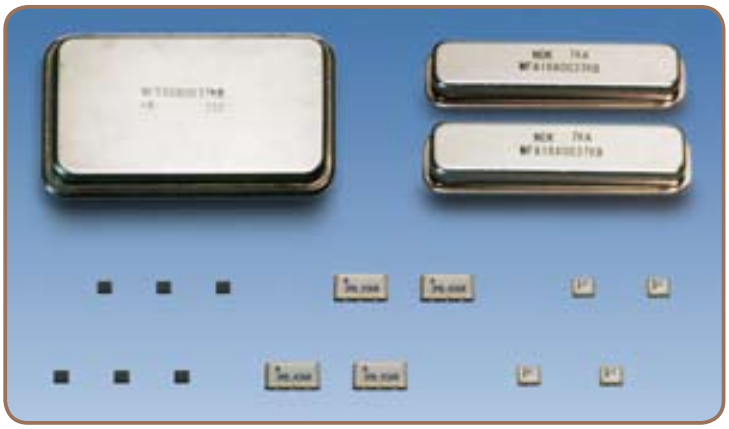
1 kW composite resonance oscillator

# Manufacturing technology of elastic surface wave element

| | |
|---|---|
| Researcher | SHIBAYAMA Kimio (Tohoku University) |
| Company | NIHON DEMPA KOGYO CO., LTD. |
| Development Period | December 1974 – November 1977 |
| Development Fund | Approx. 190 million yen |
| Abstract | As radio wave usage increased rapidly and interference among different communication systems became a problem, measures were taken, such as transfer from lower to higher frequency zones or reduction of adjacent frequency intervals. This technology utilizes the surface wave that is propagated as surface vibration of a piezoelectric substrate to develop an element that selectively passes electric signals within a required frequency zone.<br>Although the crystal filter conventionally used is highly stable and reliable, the available frequency is limited to 150-200 MHz. Manufacturing of elements capable of high frequency zones that can never be reached with a crystal filter was realized using this new technology.<br>The original element manufactured with this technology was a 400 MHz zone filter for mobile communication devices. Since then, this technology has evolved to allow a high-frequency zone of 2 GHz and now utilizes an RF filter for optical communication (e.g., radar, satellite communication, consumer devices, cellular phones, and filters and resonators for duplexers). |
| Use and Application | RF filter and IF filter or resonator for mobile communications; optical communications; radar; satellite communications; cellular phones; various consumer devices; intermediate frequency filter for television tuners, etc. |

Figure

Electronic beam-exposure instrument draws a micro-electrode pattern up to 0.2 μm on a piezoelectric crystal wafer or dry glass plate. Also serves as an electron microscope.

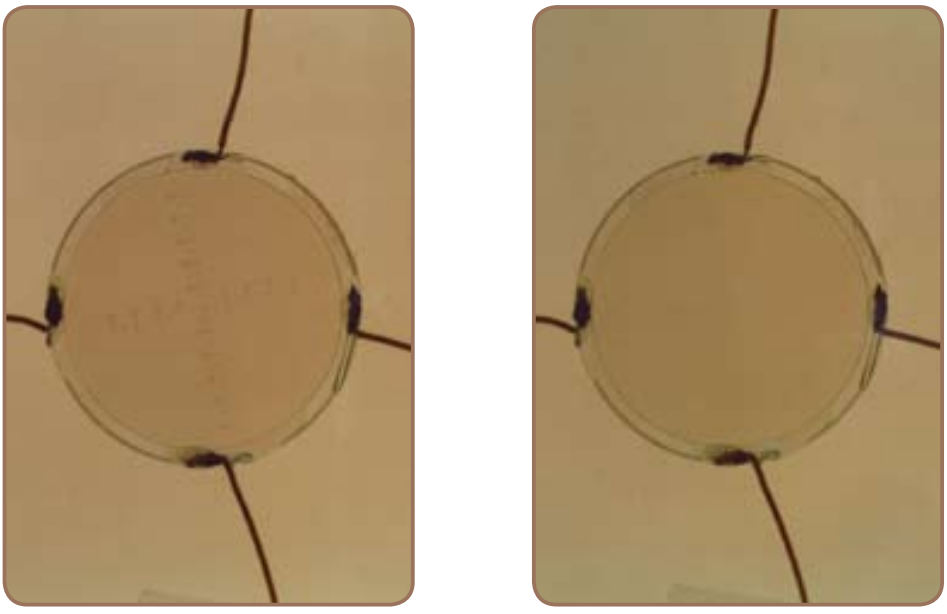


Top : SAW filter for terrestrial digital broadcasting (two types)
Bottom left : Duplexer for cellular phone
Bottom center : SAW filter for optical communications
Bottom right : SAW filter for RFID

# Forming technology of functional optical thin film

| | |
|---|---|
| Researcher | MURAYAMA Yoichi (Toyo University) |
| Company | NIKON CORPORATION |
| Development Period | October 1977 – October 1980 |
| Development Fund | Approx. 190 million yen |
| Abstract | This technology is one of the application developments for the electrochromic thin film that is now expected to realize electronic paper, a next-generation display material.<br>This technology combines the conventional vacuum evaporation method with the characteristic of the high-frequency excitation thin film forming method that forms a thin film by actively ionizing particles evaporated from an evaporation source, to establish a manufacturing technology for a full-solid electrochromic thin film.<br>An optical element using this thin film provides both characteristics of a transparent display element and reflection protection film, and can be used for the view-field display element of optical devices such as cameras or measuring instruments. For example, when shooting an image or measuring with an optical instrument, the scale for focusing can be displayed within the optical view field only when necessary. |
| Use and Application | View-field display element of optical devices such as cameras |

Figure



Colored scale　　Non-colored scale

Electrochromic thin film (when developed)

# Manufacturing technology of thermo electron irradiation negative electrode using lanthanum boride single crystal

| | |
|---|---|
| Researcher | KAWAI Shichio, TANAKA Takaho (National Institute for Materials Science), SHIMIZU Ryuichi (Osaka University) |
| Company | DENKI KAGAKU KOGYO KABUSHIKI KAISHA |
| Development Period | March 1978 – March 1981 |
| Development Fund | Approx. 160 million yen |
| Abstract | Tungsten has been used normally for the thermal negative electrode of instruments using electronic beams (e.g., scanning or transmission electron microscopes or electronic beam exposure devices for semiconductor manufacturing); however, the tungsten negative electrode does not provide enough current with a narrow electronic beam, and its life is short. Furthermore, a sintered lanthanum boride negative electrode has the disadvantage that a stable electronic beam can hardly be produced due to many holes on the surface, and its life is not as long as expected.<br>In this research (i.e., a technology to grow highly pure and even single crystal), a fine processing technology to produce an efficient negative electrode chip and a negative electrode structure with high mechanical stability were developed, and now a highly pure single crystal can be grown.<br>The single crystal lanthanum boride negative electrode produced by this technology provides 10x brightness and 5x life of the tungsten negative electrode and low potential barrier of 2.66 eV compared with 4.7 eV of tungsten, allowing electrons to be emitted over the barrier easily and ensuring high stability at a high temperature due to the high melting point. |
| Use and Application | Thermal negative electrode of scanning or transmission electron microscopes or electronic beam exposure devices for semiconductor manufacturing |

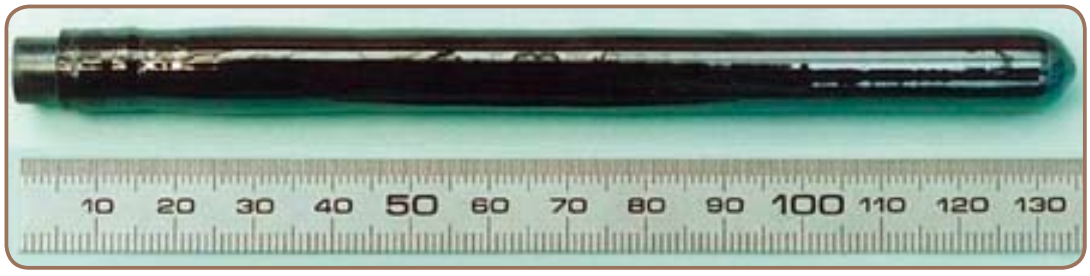
Figure


Lanthanum boride single crystal

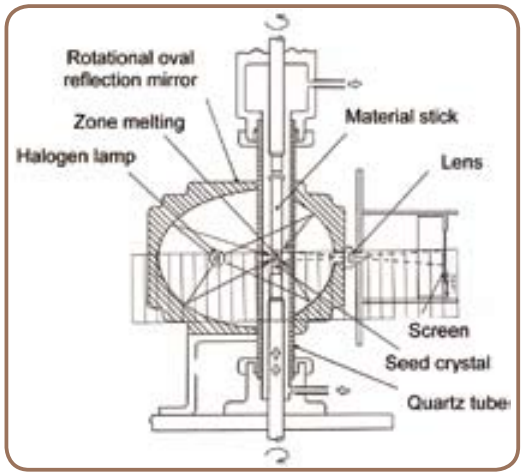
# Manufacturing technology of magnetic resonance element using garnet single crystal

| | |
|---|---|
| Researcher | KIMURA Shigeyuki, SHINDO Isamu, MORI Yasumichi, KITAMURA Kenji, IYI Nobuo (National Institute for Materials Science) |
| Company | FDK CORPORATION, ADVANTEST CORPORATION |
| Development Period | March 1978 – March 1981 |
| Development Fund | Approx. 220 million yen |
| Abstract | The single crystal of Yttrium Iron Garnet (YIG), an oxide magnetic material, is used in optical parts for optical communication, sweep oscillators, and high-frequency parts.<br>This technology established a method of producing a cylindrical YIG single crystal with high reproducibility within an infrared optical heating system using the traveling solvent floating zone (TSFZ) method, a proprietary method of growing a single crystal. A manufactured even-density, high-quality single crystal provides excellent features such as low-light absorption and low optical distortion. When used for a magnetic resonance element, it provides such features as low magnetic resonance FWHM (Full Width at Half Maximum:ΔH) and low thermal dependency.<br>The YIG single crystal produced from this technology was widely used as the magnetic optical crystal for the isolator of optical communications and other areas, and supported the early age of optical communication. |
| Use and Application | Magnetic optical crystal for optical communication, magnetic resonance elements |

Figure




YIG single crystal grown by TSFZ method




Z forge structure


Optical isolator using YIG

# Manufacturing technology of gallium nitride (GaN) blue light emitting diode

| | |
|---|---|
| Researcher | AKASAKI Isamu (Nagoya University) |
| Company | Toyoda Gosei Co., Ltd. |
| Development Period | March 1987 – September 1990 |
| Development Fund | Approx. 550 million yen |
| Abstract | For developing blue light emitting diode with high emitting efficiency and long life, a superior quality of gallium nitride crystal is required. In the past, it has been difficult to grow the crystal of superior gallium nitride crystal on a sapphire substrate. This technology has succeeded in preparing superior gallium nitride by installing an aluminum nitride buffer layer in between a sapphire substrate and gallium nitride crystal, and thus established the manufacturing technology of blue light emitting diode. |
| Use and Application | (1) display element for household appliance and measurement instruments, (2) backlight of cellular phones, and (3) large-scale full-color display on street and at athletic field |

Figure

Appearance of light emitting

Large-scale full color display
(National Kasumigaoka Sports Stadium)

Traffic signal (on Ginza street)

Backlight of cellular phone

# Manufacturing technology of large-scale full-color LCD

| | |
|---|---|
| Researcher | J. Duchamp (Commissariat à l'énergie atomique),<br>UCHIDA Tatsuo (Tohoku University) |
| Company | STANLEY ELECTRIC CO., LTD. |
| Development Period | March 1988 – April 1991 |
| Development Fund | Approx. 2.3 billion yen |
| Abstract | Two types of driving methods are available for the liquid crystal display: (1) the simple matrix method, which sequentially applies display data to pixels as voltages, and (2) the active matrix method, which uses active elements attached to the pixels. As the number of pixels increases, both methods exhibit disadvantages. With the simple matrix method, the effective voltage drops and contrast is lowered. With the active matrix method, the yield decreases.<br>For these reasons, the maximum LCD size available was considered around five or six inches. LCD allows color display by using color filters on transparent electrodes; however, this color filter causes decreases or unevenness in the driving voltage, resulting in deterioration of display contrast or uneven display image.<br>This technology uses a new display method referred to as SH (Super Homeotropic), which provides steeper electro-optic characteristics (i.e., the ratio between applied voltage and optical transparency), and by combining with the vertical alignment control technology, material design technology, optical compensation technology, and the color filter forming technology (which produces a double-layer electrode structure, which puts a color filter film between two layers of transparent electrodes electrically joined through contact holes) to enable manufacturing of a large-scale full-color LCD using the simple matrix method. |
| Use and Application | Large-scale full-color LCD |

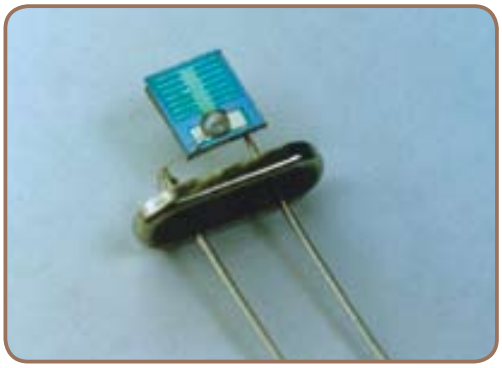
Figure


14-inch (diagonal) full-color LCD

# Manufacturing technology of capacitive humidity sensitive element

| | |
|---|---|
| Researcher | YAMAMOTO Tatsuo (Shizuoka University) |
| Company | KURABE INDUSTRIAL CO., LTD. |
| Development Period | March 1989 – March 1991 |
| Development Fund | Approx. 150 million yen |
| Abstract | A humidity sensitive element produced through this technology is capacitive and arranges polyimide films as humidity-sensitive materials over a silicon substrate. Polyimide resin ensures high stability since the thermal dependency of its permittivity is low and it is not subject to nonreversible absorption compared with highly polymerized cellulose.<br>This technology improves reliability of the element under high humidity and/or temperature by reviewing arrangement of polyimide resin to allow high-precision measurement over a wide range of relative humidity; in particular, for an element used in a dewing environment, by forming a resistive layer on the back side of the substrate and electrifying and heating the layer, it is expected to maintain its high-humidity sensitivity also in higher humidity areas.<br>Since the humidity sensitive element is formed on a silicon semiconductor wafer (i.e., circuit elements), which processes signals output from the humidity-sensitive elements as well as temperature, sensitive elements can be integrated on the same wafer, providing opportunities for use in industrial or home air conditioning. |
| Use and Application | Weather observation, measuring instruments, air-conditioner, damp-proof storage, perishable storage, food storage, etc. |

Figure



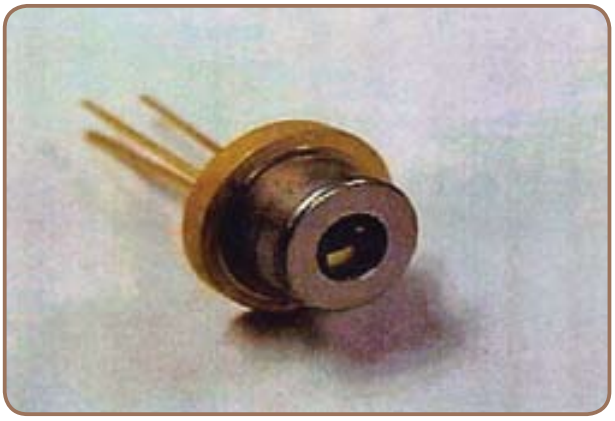
Magnified photo of comb-electro on element surface


Capacitive humidity-sensitive element created by this technology

# Manufacturing technology of GaN short wave semiconductor laser

| | |
|---|---|
| Researcher | AKASAKI Isamu, AMANO Hiroshi (Meijo University) |
| Company | Toyoda Gosei Co., Ltd. |
| Development Period | March 1993 – April 2000 |
| Development Fund | Approx. 710 million yen |
| Abstract | A crystal of gallium nitride (GaN) is required to oscillate a short-wavelength semiconductor laser with a wavelength around 400 nm; however, producing a high-quality GaN crystal was very difficult with conventional technology, and making a short-wavelength semiconductor laser practical was also difficult.<br>This technology thermally disassembled multiple organic metal compounds containing GaN elements and raised the crystal, and succeeded in (1) producing a high-quality multiple quantum well, (2) developing a high-quality GaN semiconductor crystal using a proprietary growth technology with extremely few defects, (3) the light trapping efficiency was significantly improved by developing a proprietary optical waveguide structure, and (4) a semiconductor laser, which can be oscillated continuously in the short-wavelength area by developing a proprietary implementation technology with excellent heat dissipation.<br>When recording information onto an optical medial (e.g., an optical disk), a smaller spot diameter is possible as the wavelength of the laser used is shorter, resulting in significantly higher recording density. Furthermore, its short wavelength and high energy promise micro-processing via laser and high-speed laser printer. It is also expected to be applied to a light source for plant cultivation, laser light shows, holography, and color display combined with the red laser. |
| Use and Application | Light source for reading high-density DVD, full-color display, laser light show, laser beam pointer, holography, micro-processing on semiconductors, high-speed laser printer, light source for plant cultivation |

Figure



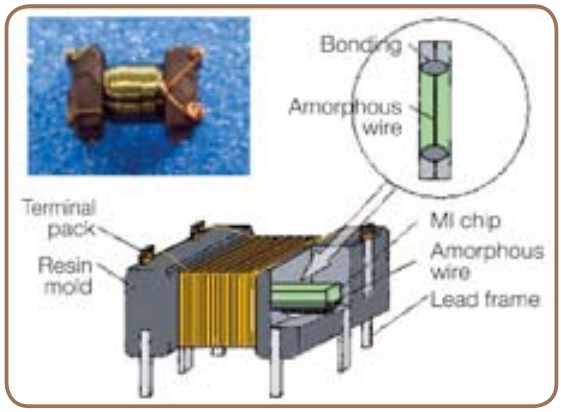
Outer view of short-wavelength semiconductor laser product

# Magneto-Impedance (MI) sensor for automobile use

| | |
|---|---|
| Researcher | MOHRI Kaneo (Nagoya University) |
| Company | Aichi Steel Corporation |
| Development Period | March 1999 – August 2001 |
| Development Fund | Approx. 260 million yen |
| Abstract | Magneto-Impedance sensor (MI sensor) is a new sensitive micro sensor to convert small magnetic field to electrical signal.<br>In this new technology, as an MI element, which is an important part to detect small magnetic field, an amorphous wire composed of iron (Fe), cobalt (Co), silicon (Si), and boron (B) is used, and the stable detection of minute magnetic field is possible even under severe conditions such as high temperature and strong vibration even near the engine room of an automobile. This technology succeeded in the mass production of the MI sensors. |
| Use and Application | Application development for engine revolution speed sensors and acceleration speed sensors is expected. In addition, as the further development of these results, MI sensor has been adopted in cellular phones in the form of electronic compass and motion sensor H-IC chips. |

Figure

External appearance and structure of MI element




Application products utilizing research results

Cellular phone (AMI602 installed)

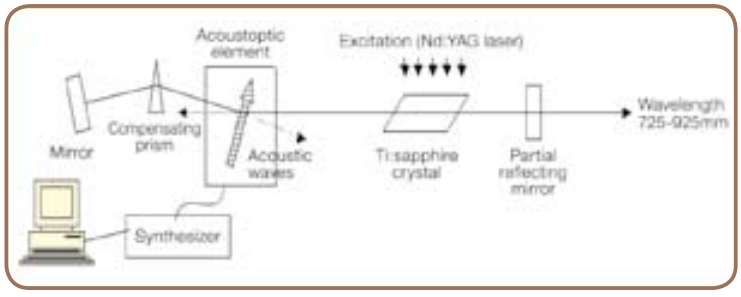

3-axis magnetic sensor chip


6-axis motion sensor chip

# CW-pumped wavelength-tunable laser

| | |
|---|---|
| Researcher | TASHIRO Hideo, WADA Satoshi (RIKEN) |
| Company | Megaopto Co., Ltd. |
| Development Period | March 2000 – March 2002 |
| Development Fund | Approx. 200 million yen |
| Abstract | In laser beam spectroscopy for the analysis of material structure and chemical phenomena, laser beams with various wavelengths are required.<br>In the past, a birefringent filter or a grating has been used as a device to select a wavelength in the wavelength-tunable laser. This may require mechanical drives and wavelength sweep speed was slow. In addition, there was a limit in mechanical accuracy, workability, and adaptability to peripheral equipments.<br>In this technology, an acoustoptic device is inserted into the laser path, and by utilizing its acoustoptic effect, the light at the selected wavelength is diffracted in the direction of the laser path, and thus lasing wavelength can be changed. This technology is applied to the continuous wave (CW) pumped wavelength-tunable laser.<br>The equipment is composed of Ti:sapphire crystal as a laser medium, CW YAG laser to exite Ti:sapphire, resonator mirrors, an acoustoptic device/controller, and a compensating prism. The acoustic frequency signal produced in synthesizer is inputted as acoustic waves into the acoustoptic device. Corresponding to the frequency of acoustic waves, the direction of the acoustoptic diffraction is slightly shifted, and then oscillated wavelength is shifted. The compensating prism is positioned so as for laser path to be vertically to mirror plane for a whole wavelength tuning range.<br>As a result, the wavelength tuning range is 725-925 nm, the spectrum bandwidth is 0.02 nm, and the long-term output stability is ±2.3% or less. |
| Use and Application | Spectroscopic analyzers |

Figure




Basic composition

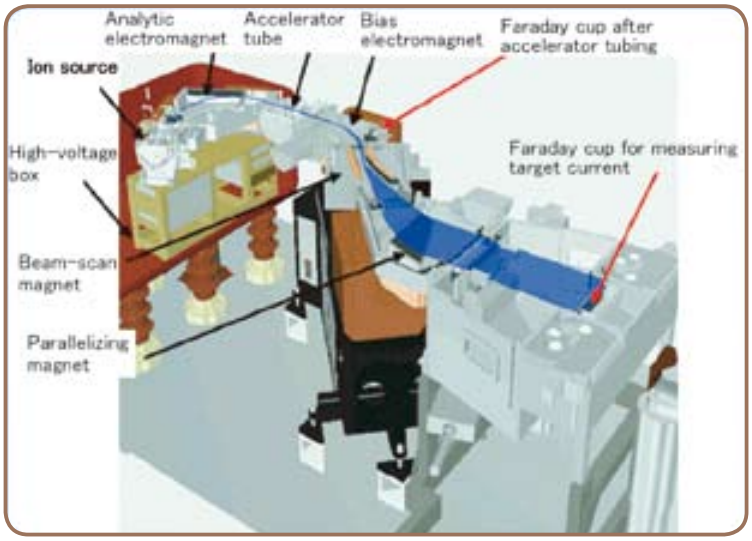
External appearance of equipment

# Decaborane ion beam generator

| | |
|---|---|
| Researcher | YAMADA Isao, MATSUO Jiro (Kyoto University) |
| Company | Nissin Ion Equipment Co., Ltd. |
| Development Period | February 2002 – February 2005 |
| Development Fund | Approx. 69 million yen |
| Abstract | With the performance of the large-scale integrated circuit improved, a new ion-injection technology that enables both low-speed ion injection and high ion current value was required for the ion-injection method that forms an impurity layer on a semiconductor element.<br>This technology uses decaborane ions, which carries a large quantity of boron to enable ion injection to a micro-area by suppressing beam spattering due to charge repulsion as well as extremely shallow forming of a boron-injection layer via low-speed ion injection.<br>This decaborane ion beam generator allows for injecting boron ions efficiently into a micro- and extremely shallow area and enables to produce further micro-LSIs with less leak current. It is expected to contribute to higher integration, acceleration, and power saving of integrated circuits. |
| Use and Application | Manufacturing of highly integrated LSI |

Figure

Outer view of decaborane ion-injection instrument

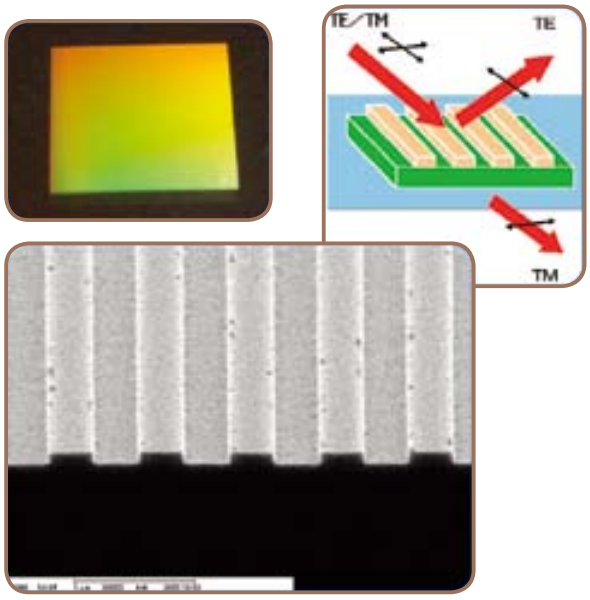



Decaborane ion beam generator

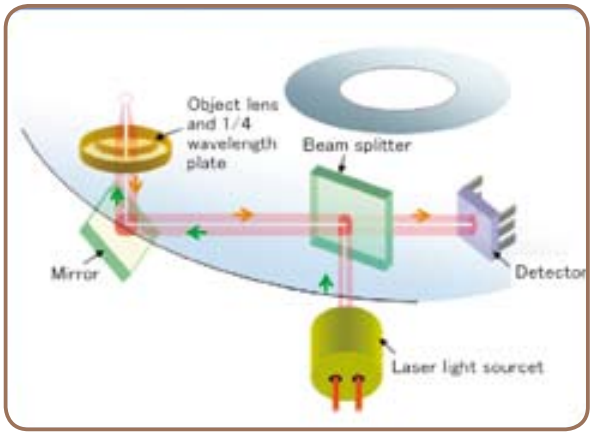
# 3-dimensional hyperfine structure plastic optical element

| | |
|---|---|
| Researcher | IWATA Koichi, KIKUTA Hisao (Osaka Prefecture University) |
| Company | NALUX Co., Ltd. |
| Development Period | February 2002 – September 2004 |
| Development Fund | Approx. 320 million yen |
| Abstract | As large-capacity high-speed communication and data recording are becoming popular, multiple functions are required for the optical elements. Conventional optical elements were made of glass, crystal, thin film, and their combinations; however, the productivity was low while the production cost was high, failing to meet market demands.<br>This technology applies 3-dimensional micro-patterns, which are similar in size to the wavelength, to the surface using plastic injection forming technology, to produce a plastic optical element that provides a sufficient refractive index, optical anisotropy, and optical wave-division functions.<br>This technology allows efficient production of high-performance optical elements, and it is expected to be used widely as functional optical elements such as the wavelength-splitting filter for optical multiplexing communication, the polarization splitter for the optical system of DVDs/CDs, as well as the anti-reflection functional plate of mobile device liquid crystals. |
| Use and Application | Optical elements |

Figure




Polarizing splitting element

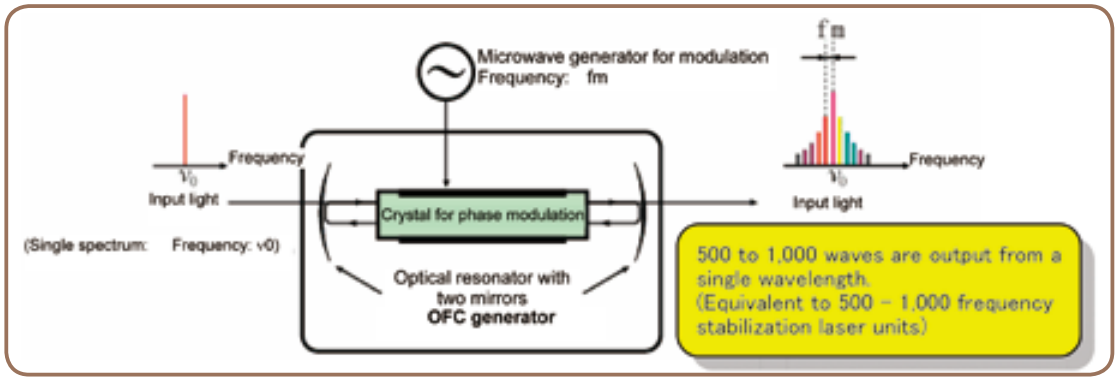



Application to CD/DVD optical system (Beam splitter)

# Optical frequency comb generator

| | |
|---|---|
| Researcher | KOUROGI Motonobu (Tokyo Institute of Technology) |
| Company | Optical Comb, Inc. |
| Development Period | March 2003 – September 2005 |
| Development Fund | Approx. 120 million yen |
| Abstract | This technology is related to the optical frequency comb that can output multi-wavelength laser with even frequency intervals and uniform strength by adding the electro-optic modulator and optical resonator to a non-linear optical crystal and applying a single-wavelength laser. The optical frequency comb technology refers to a light source with spectrum distribution at equal intervals, and this technology enables applying the optical frequency comb technology to large-capacity optical communication. By forming waveguide paths and electrodes on a non-linear optical crystal of lithium niobate via the semiconductor manufacturing process, forming filters and mirrors as films on the side of the waveguide paths by the vacuum evaporation, and adding the electro-optic modulator and optical resonator functions, efficient and high-yield production of a new optical frequency comb generator that provides high strength, low noise, stable frequency, power-saving, downsizing, and light-weight has been realized.<br>The optical frequency comb provides, as a multi-wavelength light source, extremely stable frequency intervals as well as high output strength, and is expected to be used as a light source for wavelength-division multiplexing optical communication and time-division multiplexing optical communication, for ultra-high-precision measurement of optical frequency, light source for OCT (Optical Coherence Tomography), and for high-precision distance meter. |
| Use and Application | High-transfer-capacity optical communication device, high-speed transfer, high-quality transfer, light source for OCT, light source for high-precision distance meter |

Figure




Principle diagram

Waveguide-type Fabry-Perot electro-optic modulator

Optical frequency comb generator

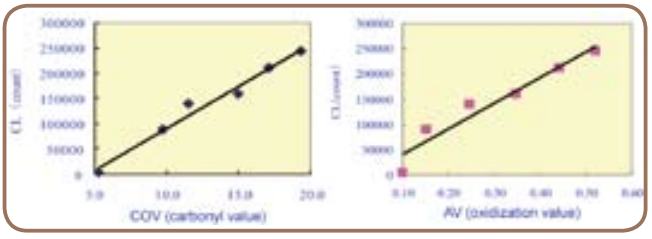
# Oil deterioration measuring instrument using micro luminescence

| | |
|---|---|
| Researcher | INABA Humio (Tohoku University) |
| Company | Tohoku Electronic Industrial Co., Ltd. |
| Development Period | March 1978 – March 1980 |
| Development Fund | Approx. 27 million yen |
| Abstract | Oils and fats are indispensable for everyday life. For industrial use, lubricating and insulating oils are indispensable and deterioration results in accidents such as machine damage or transformer insulation breakdown. Compared to industrial oils, cooking oils are subject to deterioration, resulting not only in inferior taste, but also in food poisoning.<br>At the time of development, chemical analysis was usually used to measure deterioration of oils and fats; however, this type of measurement required time, skill, and extraction using an organic solvent. Therefore, an easier deterioration measurement method was needed.<br>This technology allows determining the safety margin of cooking oils/fats and industrial lubricating oils with a few samples, by measuring micro-luminescence generated when oils are deteriorated. Based on the theory that the chemiluminescence strength is closely related to deterioration, the oil deterioration measuring instrument displays the luminescence quantity as the number of pulses, it is compared with the reference line, and deterioration status of oil is determined in a short time, without preparation.<br>This technology made it easier to measure deterioration of oils in laboratories or at site inspections. It also allows detecting slight deterioration at an early stage as well as measuring solid materials, and was recently used in measuring oxidization deterioration of macro-molecules such as rubber, resin, paint, film, polymer (PP, PE, PC), evaluating stabilizers or additives, and in forecasting lives. In 1983, this instrument won the Minister of State for Science and Technology Award for its achievement in science and technology promotion in Japan. The instrument was further enhanced to secure greater functions and higher performance, and has become state-of-the-art. |
| Use and Application | Deterioration measurement of food, macromolecular material, pharmaceutical products, biomaterial |

## Figure

Oil deterioration measuring instrument (under development)
Chemiluminescence analyzer
OX-7 (standard type)

CLA-FS3 system (latest type)
Best-in-the-world-level luminescence detection instrument with spectrum measuring function to meet every demand of chemiluminescence measurement.
Sample chambers can be selected depending on various samples and several measurement options including heating, atmosphere replacement, optical excitation luminescence are available.




Relationship between oxidization values (COV and AV) of cooking oil and chemiluminescence quantity

High-sensitivity luminescence image detecting instrument (latest type)
CL-Cube

# Specific heat measuring instrument using intermittent heating

| | |
|---|---|
| Researcher | IKUSHIMA Akira (The University of Tokyo), HATTA Ichiro (Nagoya University) |
| Company | ULVAC-RIKO, Inc. |
| Development Period | September 1983 – December 1985 |
| Development Fund | Approx. 47 million yen |
| Abstract | High-precision measurement technology for specific heat was demanded in the semiconductor and superconductivity areas in addition to the conventional physical characteristics study.<br>This instrument intermittently heats samples at a constant interval by photo-irradiation and measures the obtained alternating current signal via the lock-in amplifier. Then it obtains the specific heat using the inverse-proportion characteristic under a particular condition between the thermal amplification value and specific heat of the sample. The new instrument ensures 100x - 1000x measurement precision and resolution compared with the conventional heat-insulating specific heat measurement instrument. It can also measure thin-film material, single crystal, and very small amount of sample, contributing to new material and product development. |
| Use and Application | Specific heat measuring instrument, heat diffusion measuring instrument |

Figure

Specific heat measuring instrument (under development)

Instrument configuration
1. Specific heat measuring instrument (sample system, light source, heating forge)
2. Control processing unit (including digital lock-in amplifier)
3. Temperature controller
4. Data processing unit

# Manufacturing technology of gas sensor using high-sensitive thin membrane

| | |
|---|---|
| Researcher | MASUMOTO Tsuyoshi (Tohoku University) |
| Company | Riken Corporation |
| Development Period | March 1988 – December 1991 |
| Development Fund | Approx. 300 million yen |
| Abstract | In the past, gas sensors have been faced with various problems: a semiconductor sensor used in domestic-use gas leak alarm unit consumed large electric power, and an electrolysis type gas sensor used in organic toxic gas detection had short life.<br>This technology prepares a gas-sensitive membrane with the minute projections of metal or metal oxide by combining plasma etching or spattering, and manufactures a thin membrane semiconductor gas sensor and a potentiostatic electrolysis type gas sensor. Thanks to this technology, a gas sensor with power saving feature and long life has been realized. |
| Use and Application | (1) gas leak alarm instrament for domestic use, and (2) toxic gas detector for semiconductor manufacturing |

Figure

Gas-sensitive membrane

Portable gas detection and alarm instrument

Gas sensor part

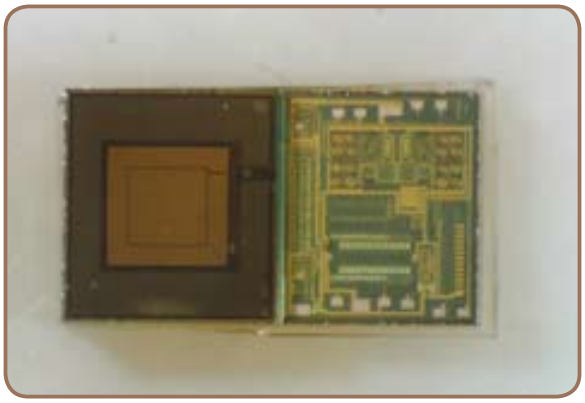
Stationary gas detection and alarm instrument

# Manufacturing technology of integrated semiconductor pressure sensor

| | |
|---|---|
| Researcher | ESASHI Masayoshi (Tohoku University) |
| Company | JTEKT Corporation |
| Development Period | January 1989 – January 1992 |
| Development Fund | Approx. 720 million yen |
| Abstract | At the time of development, half of the sensors were semiconductor sensors, and as the conventional technology formed piezoresistive elements at a location where stress of diaphragm is concentrated, imbalance of output sensitivity could not be avoided or pressure resistance had to be given up to improve the sensitivity. In addition, assembly and packaging technologies were lacking skills to manufacture small and low-cost sensors while retaining air tightness.<br>This technology is based on the theoretical advantage of capacitive characteristic, improvement of edging, the positive-pole junction method, review of proper signal adjustment circuit, invention of improvement methods, and improved balance of output sensitivity, identifying junction condition, increasing yield, and improving packaging technology.<br>This technology realized the integration center mass-production technology and opened the door to the integration center, producing smaller and lower-cost sensors, which can replace large mechanical sensors used in home appliances and medical equipment. |
| Use and Application | Smaller and easier sensors for home appliances and medical equipment |

Figure

Capacitive monolithic pressure sensor



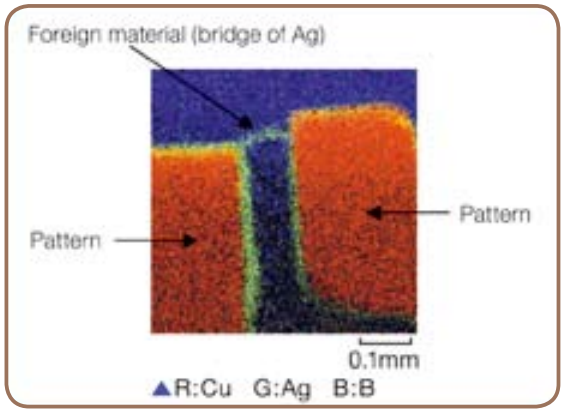
Internal structure of pressure sensor

# Scanning X-ray analytical microscope

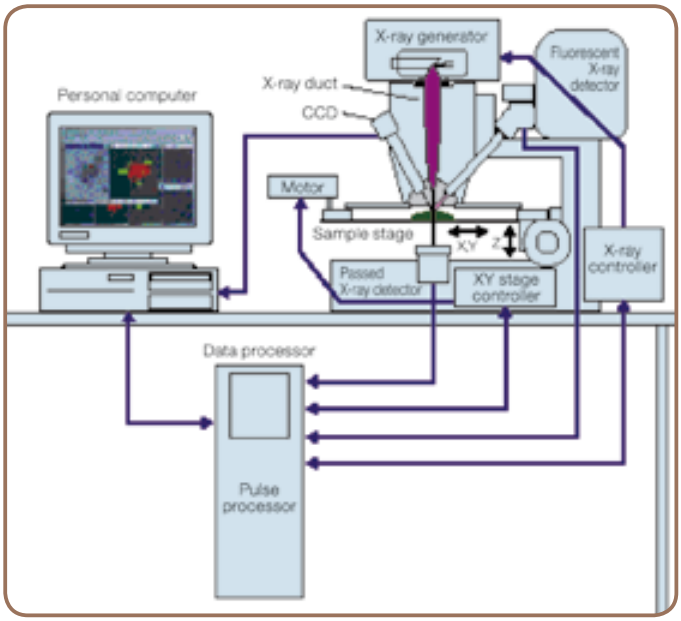
| | |
|---|---|
| Researcher | NAKAZAWA Hiromoto (National Institute for Materials Science) |
| Company | HORIBA, Ltd. |
| Development Period | March 1990 – February 1993 |
| Development Fund | Approx. 230 million yen |
| Abstract | X-ray is widely been used for the analysis of crystal structure, but it has not been used for the microanalysis, since there was no optical element such as a lens to focus X-rays.<br>In this technology, X-ray is introduced to a sample through capillary glass tube that has paraboloid of revolution formed at inner wall, and thus focused X-ray scans over the sample in X and Y directions. With this technology, transmitted X-ray intensity distribution and fluorescent X-ray intensity distribution are simultaneously obtained as precise images, which enabled the microanalysis. |
| Use and Application | Analyzer for metals, ceramics, semiconductor, polymers, and biological materials |

Figure

External appearance of-X-ray analytical microscope




Analytical image of a foreign material in IC package

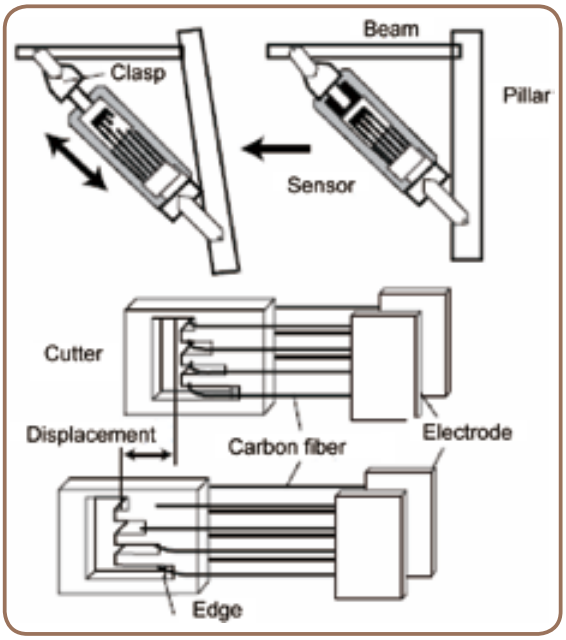



Key diagram of-X-ray analytical microscope

# Maximum value storage displacement sensor

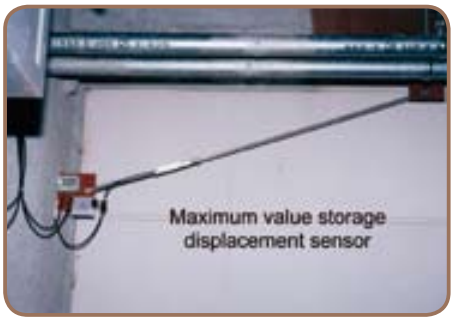
| | |
|---|---|
| Researcher | YANAGIDA Hiroaki (The University of Tokyo, Japan Fine Ceramics Center) |
| Company | NAGANO KEIKI CO., LTD. |
| Development Period | March 1995 – March 1997 |
| Development Fund | Approx. 102 million yen |
| Abstract | For safety evaluation and maintenance of constructions such as buildings and bridges, it is important to detect abnormal deformation (i.e., displacement) to properly diagnose construction status or aging level. Such methods as attaching a deformation gauge to buildings and bridges have conventionally been used to detect deformation; however, in order to check that deformation does not exceed the allowable range, it was required to monitor deformation constantly or record momentary deformation, thereby increasing the complexity of the system.<br>The displacement sensor developed from this technology does not require constant monitoring or a complex system, but can detect and record, with no power supply, the maximum displacement of each construction part that has been deformed by force. Multiple carbon fibers, which are used as detectors, are aligned with comb-style grooves with cutters, and the maximum displacement is recorded when the carbon fibers are sequentially cut according to the cutter movement level. Since the structure and operation principle are simple, this sensor can be applied to a wide range of measurement and provides excellent advantages, including the ability to record and store maximum displacement for a long time without the help other active elements. |
| Use and Application | Safety evaluation and maintenance of constructions in the civil engineering and architecture fields |

Figure




Operation principle of sensor

Maximum value storage displacement sensor



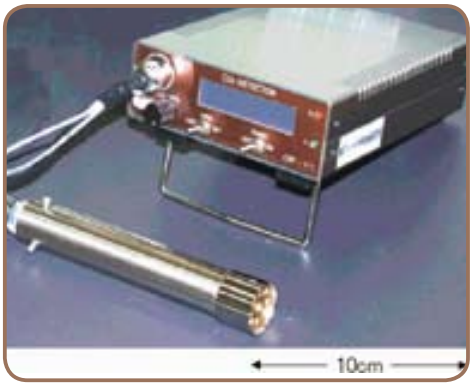

Installation example

# Carbon dioxide sensor based on solid electrolyte

| | |
|---|---|
| Researcher | TAGAWA Hiroaki (Yokohama National University),<br>MIZUSAKI Junichiro (Tohoku University) |
| Company | Akebono Brake Industry Co., Ltd.,<br>Akebono Research & Development Centre Ltd. |
| Development Period | March 1996 – March 1999 |
| Development Fund | Approx. 260 million yen |
| Abstract | There is a growing demand for carbon dioxide sensors for such purposes as monitoring carbon dioxide density within the atmosphere, ventilation control in a room or working site, or carbon dioxide control in hothouse cultivation and plant factory. The conventional carbon dioxide sensor currently on the market uses the characteristics of the carbon dioxide molecule to absorb infrared rays; however, this type of gas sensor has disadvantages including (1) it is bulky and expensive because influence by coexisting gasses such as carbon monoxide or nitrogen monoxide must be eliminated, and (2) it requires frequent maintenance since it is subject to dirt or dust, etc.<br>The new carbon dioxide sensor developed from this technology consists of three layers of detection pole (e.g., lithium carbonate), lithium ion conductor (e.g., crystallized glass), and reference pole (e.g., two types of lithium ferrite), and utilizes the fact that the density of carbon dioxide can be determined due to the electromotive force generated when carbon dioxide contacts with the detection pole.<br>This carbon dioxide sensor has advantages including that (1) it enables downsizing element, (2) it is relatively insensitive to dirt or dust, and (3) it can be manufactured at a lower cost, and is expected to be applied to ventilation control in a room or working site, as well as carbon dioxide control in hothouse cultivation. |
| Use and Application | Ventilation control in a room or working site, carbon dioxide control in hothouse cultivation, etc. |

Figure

Outer view of detecting element

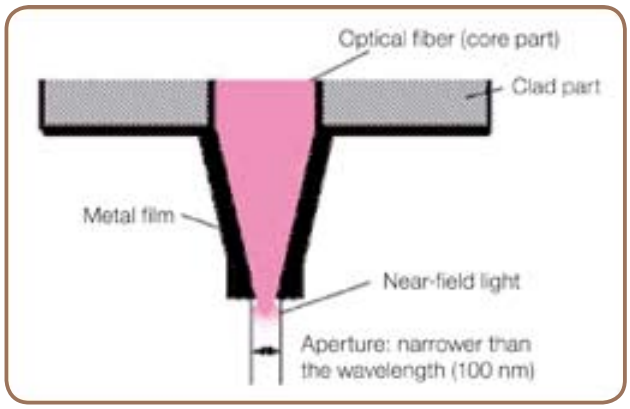


Entire view (controller and measurement section)

# Near-field microspectrophotometric system

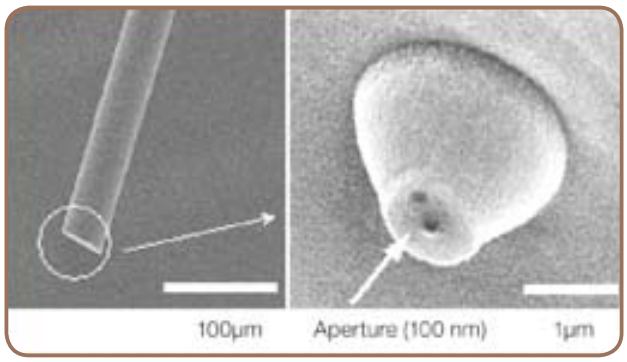
| | |
|---|---|
| Researcher | OHTSU Motoichi (Tokyo Institute of Technology) |
| Company | JASCO Corporation |
| Development Period | March 1998 – June 2000 |
| Development Fund | Approx. 200 million yen |
| Abstract | In the spectrometry to investigate the microstructure of semiconductors, biomedical tissues etc., this technology has realized microspectrophotometric system enabling the spectrometry in the minute region smaller than the wavelength of the light.<br>The probe with a sub-wavelength aperture is approached to a sample, and by injecting excited light, leaking near-field light (light to be localized on the surface of the object and reach up to shorter distance than the wavelength of the light) is generated around the probe tip. This technology has enabled the observation of sub-wavelength materials. |
| Use and Application | Advanced research such as the analysis of component/crystal structure of minute part of high-integrated devices, as well as analysis of substances locally existing in minute structure in biomedical tissues etc. |

Figure




Structure of probe tip

Near-field microphotospectrometric system

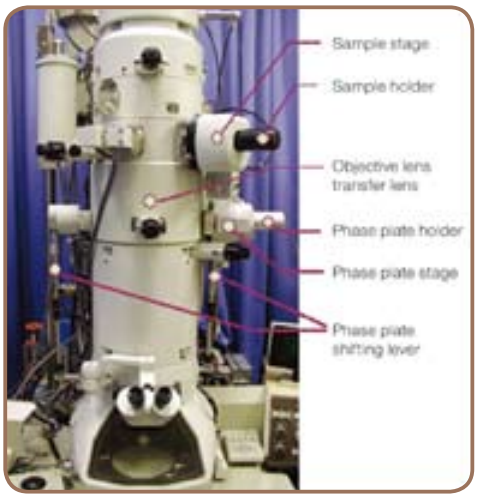



Whole image of probe and detailed shape

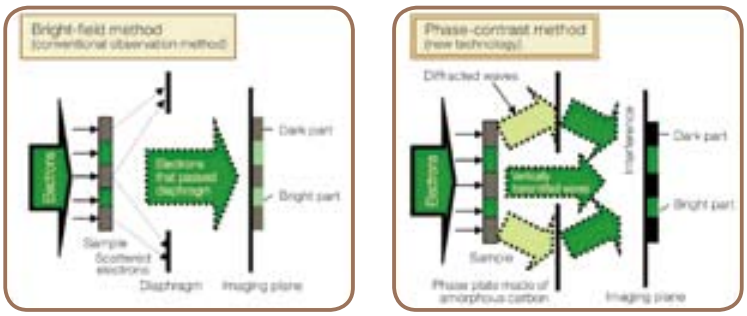
# Phase-contrast transmission electron microscope

| | |
|---|---|
| Researcher | NAGAYAMA Kuniaki (National Institutes of Natural Sciences) |
| Company | JEOL Ltd. |
| Development Period | March 2003 – March 2005 |
| Development Fund | Approx. 150 million yen |
| Abstract | In the observation using transmission electron microscope (TEM), it was necessary to enhance contrast based on pretreatment with heavy metals, since samples that contain light elements such as biological specimens and polymers have low contrast.<br>This equipment is a phase-contrast transmission electron microscope with functions acquiring both the common TEM images and the phase-contrast images of observable samples made of light elements without cell staining. This equipment can observe the identical visual field with TEM image and phase-contrast image. In particular, the improvement in the contrast of nanometer-scaled structure in phase-contrast images, which is important for biological samples, has become possible, while maintaining resolution.<br>Using this technology, the high-contrast observation of cells and polymers has become possible under just-focused condition. In particular, this technology contributes to the prevention of quality deterioration due to cell staining as well as the improvement of throughput due to shortening of sample preparation time. |
| Use and Application | Structure analysis of soft materials, such as protein and polymer with nanometer scale |

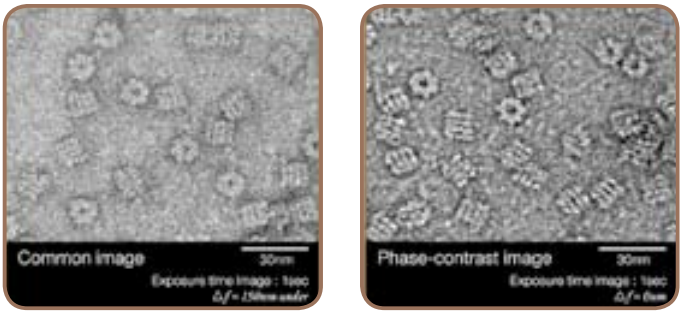
Figure




Phase-contrast TEM




Difference between bright-field method and phase-contrast method




Common TEM image and phase-contrast image of GroEL (protein)

# Heavy metal analyzer utilizing minute electrochemical cell

| | |
|---|---|
| Researcher | SUZUKI Hiroaki (University of Tsukuba) |
| Company | SEKISUI CHEMICAL CO., LTD. |
| Development Period | March 2004 – March 2007 |
| Development Fund | Approx. 180 million yen |
| Abstract | Heavy metals dissolved into groundwater etc. have high toxicity against human body, and tend to accumulate in soil for a long period, resulting in the contamination of plants and farm products and the damage of human health. The soil contamination due to heavy metals exceeding environmental standards has become social problems.<br>This development is to answer the request to analyze collected samples on onsite basis. The sensor chip used for measurement is highly accurately integrated from sensor, flow channel, and pretreatment function, and the chip is inserted to a small-sized reader with hand-paper box size for measurement. In the small-sized reader, a unit of software to optimize the flow channel and flow rate according to the characteristics of a sample solution is introduced. As a result, it has become possible to analyze heavy metals designated as toxic substances (such as Pb, Cd, As, Se, and Hg) with performance far exceeding ±50% of analytical accuracy within 5 min of analysis time, even with high sensitivity (under 1/10 of environmental standards).<br>The analytical equipment for multiple heavy metals based on this technology is a portable type most suitable for onsite analysis, and in addition quick analytical performance and analytical sensitivity equivalent to official analytical method can be expected. In addition, the disposable microchip based on polymer material technology for IC is possible to reduce cost due to mass production. This technology can be expected to contribute to the boost and expansion of the market as an indispensable tool for soil contaminant remediation business. |
| Use and Application | (1) soil contaminant remediation business, (2) various environment assessment fields, (3) process control at manufacturing sites, (4) component control at small-scale business, and (5) analysis in research |

Figure

Minute electrochemical cell (sensor chip)

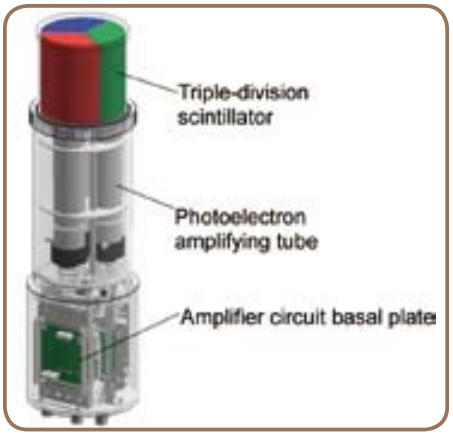
Compact size reader

# Omni-directional gamma-ray detector

| | |
|---|---|
| Researcher | SHIRAKAWA Yoshiyuki (National Institute of Radiological Sciences) |
| Company | ALOKA CO., LTD. |
| Development Period | March 2005 – March 2008 |
| Development Fund | Approx. 47 million yen |
| Abstract | The conventional gamma-ray detector using a single scintillator can detect changes of environmental radiation but cannot detect the direction of the radiation source.<br>The newly developed gamma-ray detector arranges three fan-shaped scintillators within a fixed cylindrical container at even intervals. The quantity of photoelectrons generated inside each scintillator differs depending on the direction of gamma-rays. Based on this principle and using differences between the quantities of photoelectrons generated inside each scintillator, the new gamma-ray detector can determine the direction of the gamma-ray source and its energy area, without any moving mechanism. It has been proved that this gamma-ray detector can identify the radiation direction immediately in all directions with sufficient precision, and can also measure the energy area of the radiation.<br>This gamma-ray detector is expected to contribute to improving social well-being and security, for example, by monitoring facilities using nuclear power. |
| Use and Application | Detection of abnormal radiation in a nuclear power station or around facilities handling radiation, monitoring of illegal movement or smuggling of radioactive substances in an airport or harbor |

Figure

Omni-directional gamma-ray detector



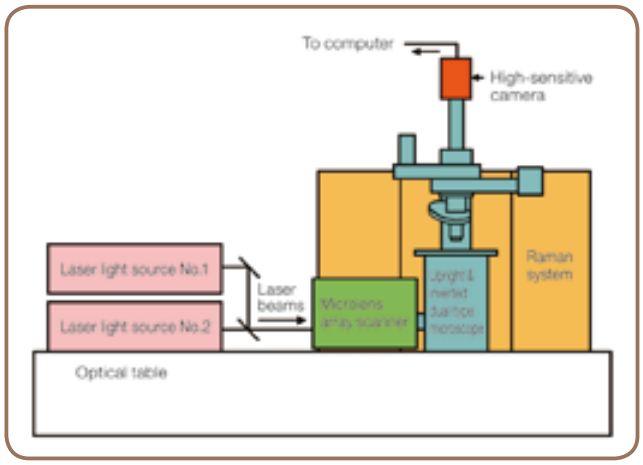

Conceptual view

Monitoring post

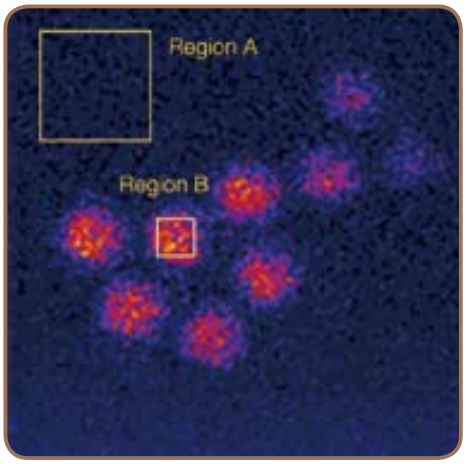
# High-speed 3D molecular spectromicroscope

| | |
|---|---|
| Researcher | KAWATA Satoshi (Osaka University) |
| Company | Nanophoton Corporation |
| Development Period | March 2005 – March 2008 |
| Development Fund | Approx. 25 million yen |
| Abstract | Confocal and multi-photon fluorescence microscopy has been used for observing biological specimens. However, those systems all require sample pretreatment that damages biological specimens. In addition, recording motion of the samples has been difficult.<br>The High-speed 3D Molecular Spectromicroscope utilizes the phenomena called coherent anti-stokes Raman scattering (CARS): When a biological specimen is irradiated with the laser beams of two different frequency of light wave, and the difference of these frequency accord to the frequency of biological molecules, CARS light with shorter wavelength than incident light is generated.<br>In addition, the use of microlens-array with a number of arrayed minute lenses on a rotating disk enabled scanning of multiple foci in high speed and acquiring video rate movie of the sample.<br>With these technologies, a high resolution microscopy that can observe high-speed 3D movie without dyeing biological specimens was realized.<br>Using the spectromicroscope, it has become possible to observe living specimen without any pretreatment, and the spectromicroscope is expected to be utilized in many fields including medical field and biology. |
| Use and Application | (1) medical field such as cell biology, immunohistochemistry, (2) biology field, and (3) material analysis field |

Figure




Block diagram of developed microscope system




Example of acquired image :
Image of polystyrene beads of 3 μm in diameter, which was continuously acquired with a time resolution of 30 ms/frame. The S/N of image (ratio of the signal intensity of signal region B and the signal intensity of background region B) is about 15.

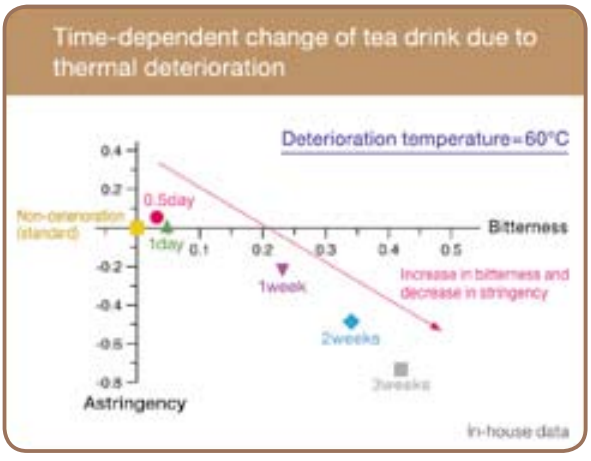
# High-durability and high-speed taste sensor for quality control using artificial lipid membrane

| | |
|---|---|
| Researcher | TOKO Kiyoshi (Kyushu University) |
| Company | Intelligent Sensor Technology, Inc. |
| Development Period | March 2005 – February 2007 |
| Development Fund | Approx. 160 million yen |
| Abstract | On food manufacturing fields, taste tests depending on human's sense are widely performed for the taste quality control, however, there is a limit in treating quantity due to personal skill difference of technicians. In addition, although test sensors are partly practically used, its application is limited due to the inferior durability of a sensor head. Taste sensors with high durability have been required at the manufacturing sites of food.<br>This technology is related to a high-durability and high-speed taste sensor that digitalizes taste using artificial lipid membranes. Using five types of artificial lipid membranes corresponding to basic taste such as sweetness and acidity etc., and by measuring the electric potential of the artificial lipid membranes changing due to adsorption reaction with a taste component, taste is digitalized. By extending the length of hydrophobic chains of lipid polymer, the adhesion of the artificial lipid was improved, elusion and peeling were prevented, and the durability of the sensor head was improved. The taste sensor based on this technology is highly durable, and enables the quick digitalization of taste. |
| Use and Application | Quality control system of food manufacturing plants |

Figure


Taste sensor
(whole appearance of apparatus)

Taste sensor
(multi channel sensor head)




Lipid membranes with five types of different qualities are attached, and detected their voltage changes caused by taste. By judging the change of the pattern taste can be digitalized.

# Multi-negative electrode method ionization plating technology

| | |
|---|---|
| Researcher | MATSUBARA Kiyoshi (Tokai University) |
| Company | CITIZEN WATCH CO., LTD. |
| Development Period | March 1974 – September 1976 |
| Development Fund | Approx. 110 million yen |
| Abstract | At the time of development, environmental pollution was a major social problem in Japan, and liquid wastes from the electric plating process were denounced and proper processing was demanded, requiring a new technology to eliminate or suppress pollution.<br>This technology ionizes the evaporation material gas using electrons radiated from a major negative electrode retaining the plating target and multiple thermal negative electrodes arranged around it. Since the temperature of the plating target retained by the main negative electrode is controlled by a variable resistor, reverse spattering and re-evaporation of formed film are prevented. The film is formed in a vacuum environment, no liquid waste is produced, and layers of metal can be ion-plated over a substrate of plastic, metal, ceramic, glass, and other materials.<br>Through further improvement, CNG (Citizen New Gold) was developed to plate thin gold over titanium nitride, drastically improving the anti-wear and anti-corrosion characteristics while retaining the same color as conventional gold plating. Currently, CNG film structure is the world standard for gold plating by dry-coating. |
| Use and Application | Forming ion-plated film on plastic clock plate |

Figure

Ion plating unit

Watch ion-plated to have gold appearance

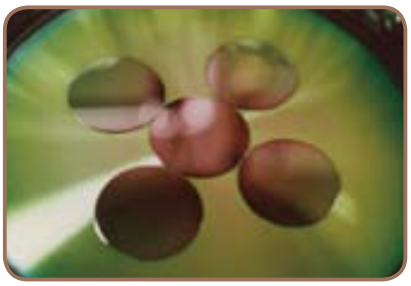
Ion-plated products

# Semiconductor wafer oxidization instrument using gas and plasma

| | |
|---|---|
| Researcher | SUGANO Takuo (The University of Tokyo) |
| Company | ULVAC, Inc. |
| Development Period | March 1977 – March 1979 |
| Development Fund | Approx. 190 million yen |
| Abstract | Among the semiconductor manufacturing processes, the oxidization technology to form the diffusion mask and surface protection film is indispensable. Conventionally, these films are formed via the thermal oxidization or CVD (chemical vapor deposition) method; however, with the thermal oxidization method, the material must be exposed to a high temperature (up to 1000℃) for a long time and the material is subject to damage from heat. With the CVD method, adhesiveness of oxidization film and the base as well as the film quality are not necessarily sufficient because it is a chemical evaporation process.<br>Now a new instrument, which quickly forms a high-quality oxidization film and nitride film without damaging or deteriorating a silicon wafer by heat, has been developed. This technology is indispensable for wafer processing for a high-density circuit or LED, and is a base for the plasma CVD instrument. |
| Use and Application | Film processing for silicon wafer |

Figure

Outer view of unit



Wafer after oxidization

# Highly flexible multi-production system of pressed parts

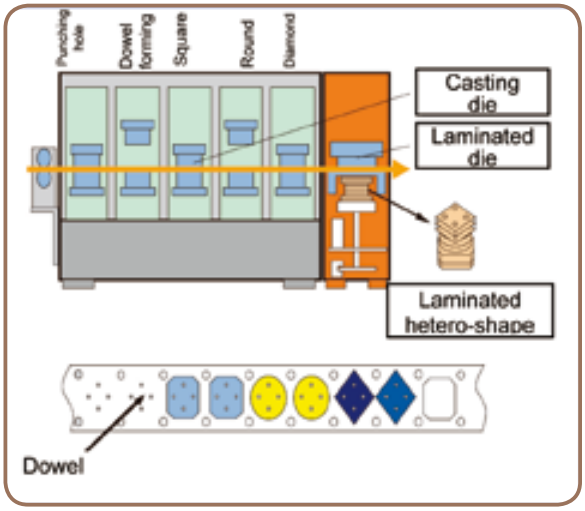
| | |
|---|---|
| Researcher | AOKI Isamu (Kanagawa University) |
| Company | HODEN SEIMITSU KAKO KENKYUSHO CO.,LTD. |
| Development Period | March 1998 – January 2001 |
| Development Fund | Approx. 270 million yen |
| Abstract | In the press-working industry, as consumer needs' diversify, higher-precision parts or more value-added processes, as well as a new production system that enables further cost reduction and addresses high-mix, low-volume production is needed.<br>This technology builds a new production system to enable integral molding of 3-dimensional parts, in a sequential process, which conventionally, could only be manufactured using multiple processing technologies and had to be combined with another process. |
| Use and Application | Already adopted by electronic component manufacturers since it allows production of high-value-added parts at low cost quickly. |

Figure

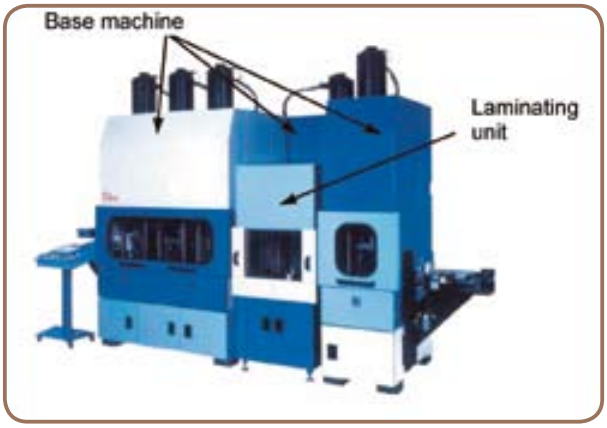
Prototype of HDD parts

Prototype of PC cooling fan

Example of high-precision parts manufactured by laminating parts with different shapes




Hetero-shaped lamination method based on this technology




System example
(rotary-type hetero-shaped lamination system)

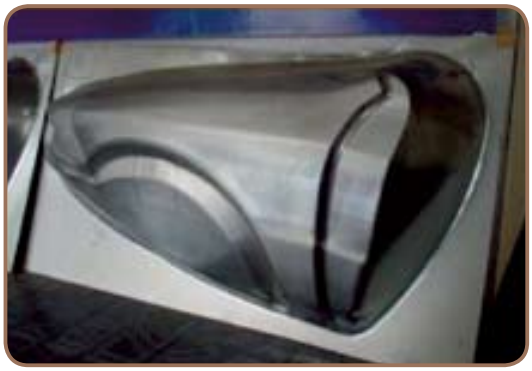
# Dieless forming machine

| | |
|---|---|
| Researcher | MATSUBARA Shigeo (Polytechnic University) |
| Company | Amino Corporation |
| Development Period | March 2000 – February 2002 |
| Development Fund | Approx. 270 million yen |
| Abstract | In the past, large press machines and expensive metal mold facilities were needed to form vehicle bodies and automobile bodies. This technology is to form a metal sheet without using metal mold. This machine presses a metal sheet as it moves on its surface drawing contour lines in accordance with data designed by a dedicated software.<br>Press metal molds are saved, in addition, the complicated shape that is impossible to make with the conventional press forming can be formed. It is also possible to shorten manufacturing time considerably, and to reduce the cost for trial manufacturing and development significantly. Metal materials such as aluminum, steel, stainless steel, and titanium can be utilized. |
| Use and Application | (1) vehicle bodies, (2) automobile parts, (3) home appliance products, and (4) office equipment parts |

Figure

Dieless forming machine (appearance)

Dieless forming machine (working space)



Application example of automobile parts (fender)

Application example of the top edge of Shinkansen

# Manufacturing technology of spiral bevel gear by forging

| | |
|---|---|
| Researcher | YOSHIDA Akira (Okayama University) |
| Company | ZENO TECH Co., LTD. |
| Development Period | March 2001 – December 2002 |
| Development Fund | Approx. 120 million yen |
| Abstract | Because the spiral bevel gear provides high power transmission efficiency and can transmit power smoothly at a right angle or 60 degrees, it is widely used for industrial machine parts. It was conventionally manufactured using a dedicated-gear cutting machine; however, the cutting method required a long time for cutting (i.e., low yield) and the precision was restricted. Therefore, a new technology to manufacture spiral bevel gears with high tooth-surface precision efficiently at a lower cost was demanded.<br>This technology has achieved a life of 10,000 shots or more, tooth precision of JIS Class 4 or higher, and dimensional precision of ±0.025 mm or less, by developing a new electrode for discharge processing of the spiral bevel gear with higher precision using NC data and a new die, which uses high-speed powder steel, which excels in toughness, as well as adopting closed die forging suitable for the spiral bevel gears and fine adjustment of die position for continuous casting.<br>With this technology, the spiral bevel gear is expected to be used widely in farm machinery parts such as bush cutters and electric tools. |
| Use and Application | Parts of farm machines such as bush cutter and electric tools |

Figure

Spiral bevel gear

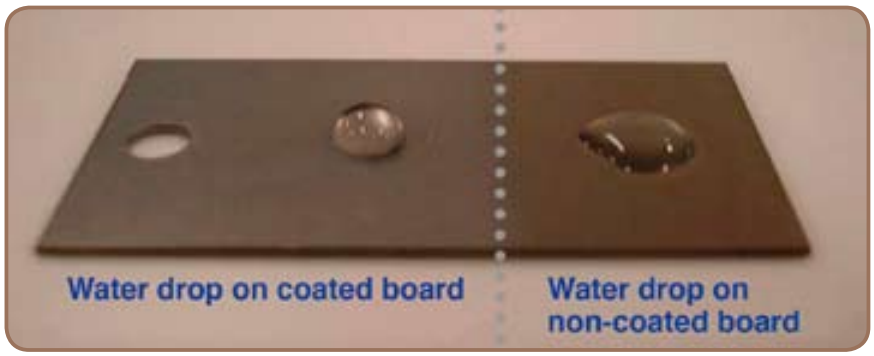
Upper die

Spiral bevel gear

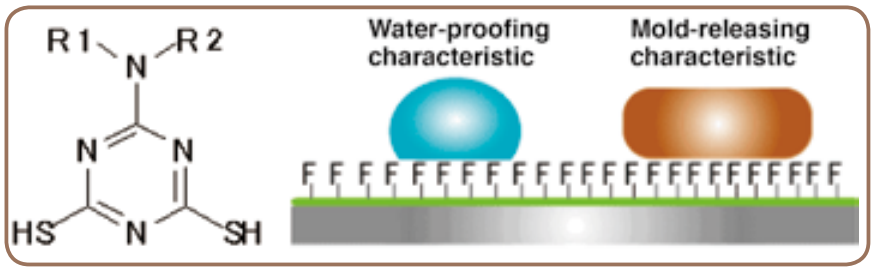
# Processing technology of coating for die casting

| | |
|---|---|
| Researcher | MORI Kunio (Iwate University) |
| Company | Takeuchi Vacuum Deposition Co., Ltd. |
| Development Period | March 2001 – March 2004 |
| Development Fund | Approx. 87 million yen |
| Abstract | When using die molding products made of rubber, resin, or plastic, the die is coated with a fluorine-and-silicon mold-releasing agent to form a film between the die and product for easy release; however, the mold-releasing agent may deteriorate the products by contaminating the die and deforming the product, and frequent maintenance is necessary, increasing the production cost. Therefore, a die coating technology which retains the mold-releasing effect for long time has been demanded.<br>This technology is related to a process which forms a strong triazine-dithiol film over a die. The triazine-dithiol film formed by this technology shows excellent waterproofing characteristics and endurance, and ensures a long-term mold-releasing characteristic between the die and the product. By forming the film on the die, products can be molded continuously from several thousands to several tens of thousands of shots at high yield.<br>Dies coated with this technology shows good mold-releasing characteristics, endurance, and dust-proofing, which reduces maintenance and drastically improves production efficiency, and are expected to be used for manufacturing liens of die-molding products. |
| Use and Application | Die-molding |

Figure




New technology of coating dies with triazine-dithiol shows that water-proofing and mold-releasing characteristics are improved.

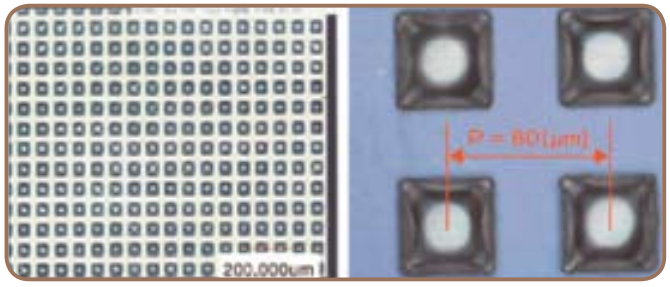



Mold-releasing mechanism with triazine-dithiol.
Strong and stable film can be formed by heat-curing. Excellent mold-releasing characteristic is provided as fluoro-organic compounds combined with the substituent appear on the surface.

# High-density semiconductor soldering system

| | |
|---|---|
| Researcher | KANO Yoshio (Tokyo University of Agriculture and Technology) |
| Company | TAMURA Corporation |
| Development Period | March 2001 – March 2004 |
| Development Fund | Approx. 160 million yen |
| Abstract | This technology is related to a high-density semiconductor soldering system, which allows high-precision positioning and enables flip-chip connection using Pb-free solder on highly integrated semiconductors. (Flip-chip connection forms bumps on chip I/O terminals to directly connect to electrode terminals on a printed circuit board.)<br>As the semiconductor becomes denser, spacing between adjacent electrodes becomes narrower (to less than 100 μm), making it difficult to form protruding electrodes (i.e., bumps) on electrodes. In addition, the gap between the semiconductor chip and the board becomes narrower (less than 50 μm), and demand for Pb-free soldering is growing. For these reasons, cleaning the flux residue becomes impossible and a new reliable flip-chip connection method is required.<br>This development has produced the bump-forming method that enables high-precision positioning (within ±3 μm) on electrodes arranged with 80 μm or less of spacing between adjacent electrodes by melt-depositing micro-particles of solder. The new method also enables highly reliable flux-free and Pb-free soldering by improving solder surface quality with plasma. |
| Use and Application | Semiconductor implementation |

Figure




80 μm pitch bumps forming photo

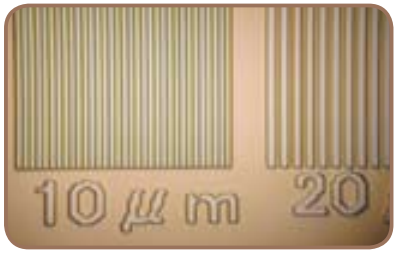
Bump forming instrument

# Multi-polygon direct laser drawing system

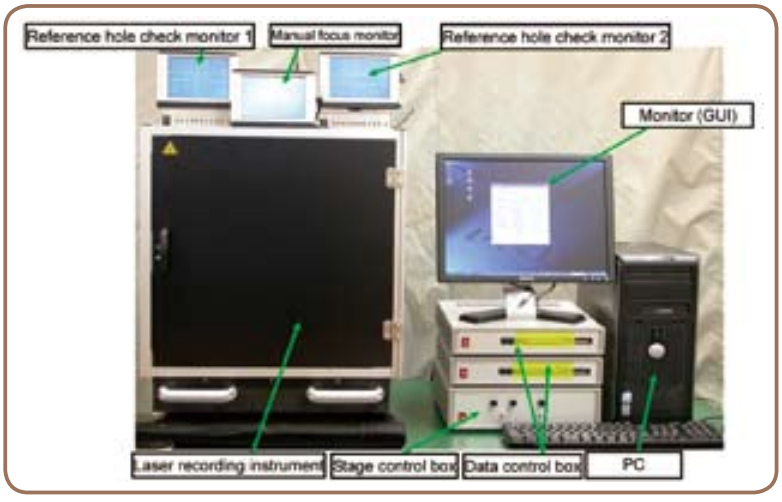
| | |
|---|---|
| Researcher | NITTA Isami (Niigata University) |
| Company | OPCell Co., Ltd. |
| Development Period | March 2003 – March 2006 |
| Development Fund | Approx. 99 million yen |
| Abstract | This development is related to a direct laser drawing system, which allows high-precision and large-area pattern drawing quickly for the printed circuit board and FPD industry. With the conventional pattern exposure using mask films, drawing micro-patterns was difficult, and the large-scale single polygon-type direct laser drawing system suffered from the large beam diameter.<br>This technology was intended for a low-cost and compact system that automatically divides the entire drawing data with internal software and uses multiply polygon scanning laser units to coordinate exposure control, to smoothly connect images from different sections and allow high-speed exposure over a large area with a micro laser beam.<br>It is expected to be an effective exposure method, not only in plain pattern exposure for the printed circuit board or FPD industry, but also for such uses as forming seamless patterns by rotating rollers or cylinders. |
| Use and Application | Printed circuit board and FPD industry, and any areas requiring low-cost and efficient fine pattern forming of many patterns with small quantity |

Figure

System configuration (3-scan unit): Upon completion of development




Exposure sample: Liquid resist

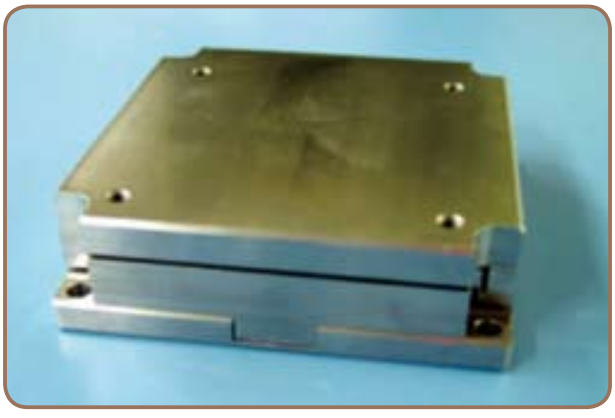



Direct multi-polygon laser instrument: Sample configuration

# Machining precision improving unit for high-precision machines

| | |
|---|---|
| Researcher | HIGUCHI Toshiro (The University of Tokyo) |
| Company | NANO CONTROL CO., LTD. |
| Development Period | March 2003 – September 2005 |
| Development Fund | Approx. 100 milliom yen |
| Abstract | High-precision cutting and sharpening of optical parts, without regard to the performance improvement of processing machines, still depend on the feel and skills of craftsmen in the pre-process adjustment such as tool-bit positioning and processing start-point detection. In addition, measurement of constant loads is necessary to improve the cutting precision by load control and to protect the tool-bit or product from abnormality in cutting (e.g., sudden load). For these reasons, a new force sensor which can facilitate the pre-process adjustment and detect constant loads.<br>This technology is related to force sensors, which allow measuring constant loads by combining a high-sensitive distortion gauge, distortion magnifying mechanism, a rigid mechanism, and ensures high rigidity and resolution. It adopts the distortion-gauge type that does not inherently produce any drift. Since rigidity of the distortion gauge is reduced when sensitivity becomes higher, the distortion magnifying mechanism is used to ensure both of rigidity and sensitivity, and the combination with the rigid mechanism ensures high rigidity and resolution.<br>The force sensor manufactured via this technology provides high rigidity and resolution, suppresses drift, and enables measurement of constant loads, and it is expected as the force sensor of instruments requiring measurement of constant loads for detecting the start point for processing free curved surfaces, measuring cutting and sharpening forces, and load control for nano-imprinting. |
| Use and Application | Force sensor of instruments requiring measurement of constant loads for detecting the start point for processing free curved surfaces, measuring cutting and sharpening forces, and load control |

Figure



Force sensor (power meter)

# Manufacture of seamless flexible container

| | |
|---|---|
| Researcher | IKEDA Tsutomu (Research Institute for Production Development) |
| Company | TAIYO KOGYO CORPORATION |
| Development Period | May 1966 – January 1968 |
| Development Fund | Approx. 54 million yen |
| Abstract | For containers to transport powders, flexible containers made of tarpaulin or synthetic rubber have been used; however, to support economical growth propelled by technology innovation, an urgent need has arisen to streamline transportation, requiring a stronger, lower-cost, and more versatile container.<br>This technology uses a metal die (which can be disassembled) and puts a nylon thread around it diagonally and horizontally, applies resin over the surface, and processes and hardens it in a drying chamber to form a tarpaulin film to produce a container.<br>A container manufactured in this way has no seam of materials and provides the advantage that it can be produced (from materials to final product) within a single factory. Productivity also is high since the manufacturing process is automated, producing durable containers at a low cost. |
| Use and Application | Transportation of powder or liquid |

Figure

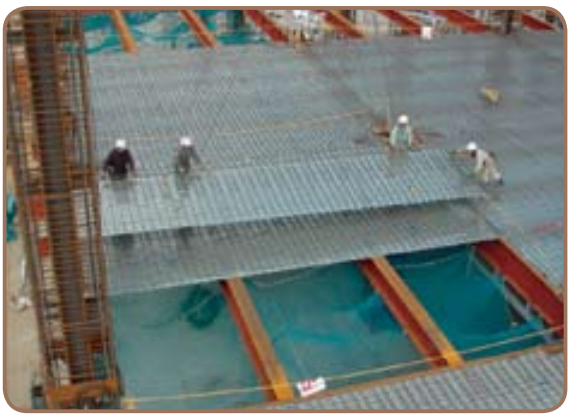
Seamless flexible container

# Manufacturing and work technologies for plate 3D welding steel frame (fab deck floor plate method)

| | |
|---|---|
| Researcher | TAKEMOTO Toshio (Takemoto Architectual Institute) |
| Company | Marubeni-Itochu Techno Steel Inc., Nittetsu Tokai Steel Wire Co., Ltd. |
| Development Period | March 1980 – March 1983 |
| Development Fund | Approx. 290 million yen |
| Abstract | Critical components of the construction of steel frame concrete structures, such as floor walls, pillars, and beams, have usually depended on the manual labor of steel frame assembly and other skilled workers (e.g., molding workers), and have contained significant internal problems in every area (i.e., construction costs, work terms, quality, and worker accidents). Quality and anti-earthquake measures are desired in construction and buildings systems. Therefore, consideration of the steel frame concrete method has been the most important issue in the construction industry.<br>This technology (i.e., the fab deck floor plate method) is a method of assembling 3D steel frame in the form of plates by spot-welding the steel frames in each steel frame concrete floor assembly, and of lifting down thin steel plates to each steel frame as a concrete mold frame using spacers so that mold work and concrete casting can be carried out simultaneously. Furthermore, by utilizing the steel structure performance attached to the 3D steel frame, there is no need to use the temporary support materials as in the conventional method. The fab deck panel and components of this method are manufactured at the plant with uniform accuracy, representing the technology of joint-structural units, such as simplified beams at the work site.<br>This technology converts the manual-labor techniques at building sites into industrial methods, such as mechanical processing and plant production technology, and is expected to improve the quality of both production and construction. Therefore, a new technique has been developed for multi-purpose use of 3D steel frames (i.e., fab deck steel frame). |
| Use and Application | Steel frame and molding work |

Figure

Plate 3D welding steel frame manufacturing system (fab deck panel)



Fab deck floor mold work site

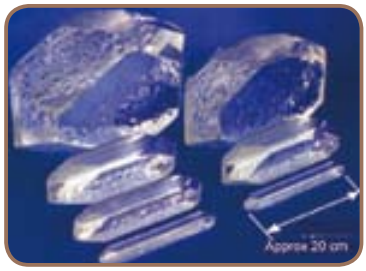
# Manufacture of synthetic quartz crystal

| | |
|---|---|
| Researcher | KUNITOMI Minoru, TAKI Sadao (University of Yamanashi) |
| Company | EPSON TOYOCOM CORPORATION |
| Development Period | June 1959 – May 1960 |
| Development Fund | Approx. 27 million yen |
| Abstract | Natural crystal is used as an important electronic component, essential in certain electronic equipment (e.g., portable telephones, automobiles, and digital cameras) due to crystals' electric and optical characteristics (i.e., the piezoelectric phenomena). Synthetic quartz crystal, when used in a crystal unit, shows similar performance to natural crystal, and has the merit of being more uniform than natural crystal. Synthetic quartz crystal also is used in the optical industry thanks to the smaller content of boron and higher light- transmission ability.<br>In this technology, alkali solution and raw rasca (small pieces of crystal) are placed lower in the autoclave of the extra-high pressure vessel, while seed crystal is placed in the upper area, heated, thus generating temperature differences between the upper and lower areas. Since rasca is carried upward by detention to be re-crystallized continuously on the seed crystal, uniform artificial crystal is produced. This has contributed to wider use of artificial crystal (i.e., crystal unit) in the electronics industry, domestically and overseas. |
| Use and Application | Timing device (crystal unit and crystal oscillator); sensing device (gyro sensor, pressure sensor); optical device (optical low-pass filer) |

Figure

Manufacturing system (as developed)

Natural crystal




Artificial crystal

Example application of artificial crystal (crystal gyro sensor)

Mechanism of hand movement


"Hand movement" is rotating motion around joints by person holding the camera. Shaking of images due to hand movement is corrected by detecting the angular speed of this rotating motion and moving optical parts and CCD momentarily in the inverse direction.

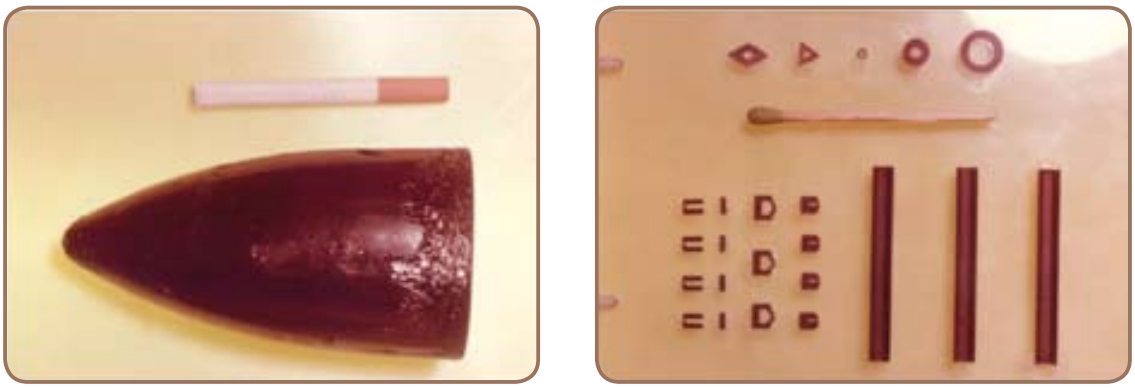
**Correction of hand movement to camera by gyro sensor**

For details of crystal devices, see. www.epsontoyocom.co.jp/english

# Manufacturing and processing technologies for composite ferrite large-scale single crystal

| | |
|---|---|
| Researcher | SUGIMOTO Mitsuo (RIKEN) |
| Company | FDK CORPORATION |
| Development Period | July 1967 – June 1970 |
| Development Fund | Approx. 69 million yen |
| Abstract | Single crystal ferrite is a material widely used in the electronics industry, particularly in the magnetic head core sector. This technology was used to create a large-scale high-temperature, high-pressure furnace by applying the Bridgeman method (a method of growing a single crystal), and to establish the manufacturing/processing technologies for large-scale manganese ferrite single crystal by solidifying zinc oxide. Zinc oxide is known to separate and evaporate selectively from a molten body when heated to 1500°C or higher; however, the uniformity of crystal is deteriorated by evaporation and change in composition.<br>Single crystal ferrite in this process is superior in uniformity with little strain. When processed for a magnetic head, superior characteristics such as high magnetic transmission and smaller drive current are realized.<br>Single crystal ferrite is widely used as the material of electronic parts, including magnetic heads for video tape recorders (VTR), which continue to become more compact and high-performance. |
| Use and Application | Magnetic heads |

Figure

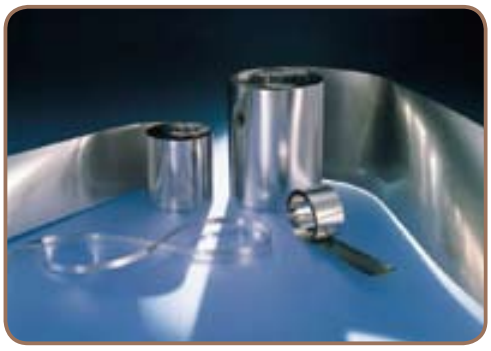


Composite ferrite large-scale single crystal and processing example

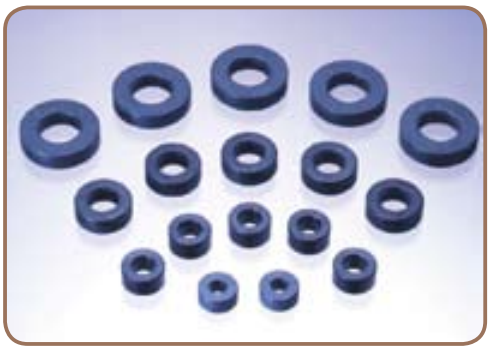
# Manufacturing technology for magnetic material amorphous metals

| | |
|---|---|
| Researcher | MASUMOTO Tsuyoshi (Tohoku University) |
| Company | Hitachi Metals, Ltd., Hitachi, Ltd. |
| Development Period | January 1978 – December 1980 |
| Development Fund | Approx. 380 million yen |
| Abstract | Amorphous metals are superior in mechanical properties, such as hardness and tensile strength, and have superior magnetic characteristics (i.e., soft magnetic) for ease of magnetization.<br>In this context, high-performance magnetic parts utilizing features of high magnetic permeability and low-loss were developed by establishing the manufacturing technology for wide and long amorphous metal thin bands. These are the various transformers (i.e., magnetic parts to suppress noise and magnetic shields and antennas, which contribute to energy savings by reducing power loss and higher efficiency and equipment performance). |
| Use and Application | Magnetic parts in electronic equipment (e.g., variable saturated reactor for switching power source, magnetic shield sheet/tape, amorphous antenna, etc.). |

Figure

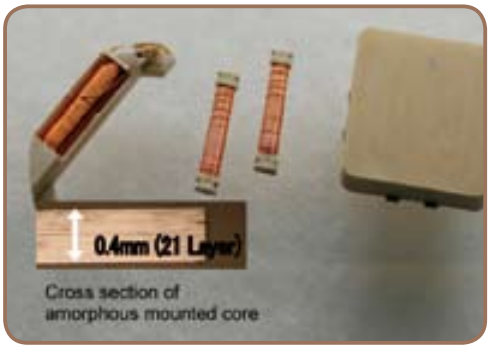


Wide and long amorphous metal thin ban



Variable saturated reactor for switching power source

Magnetic shield sheet/tape

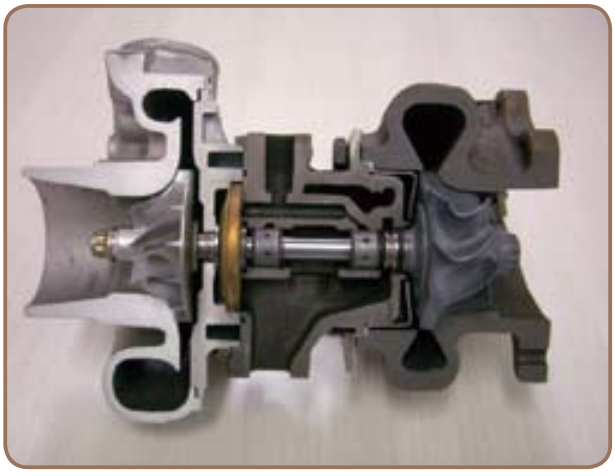



Amorphous antenna

# Manufacturing technology for silicon nitride sintered body by gas pressure sintering method

| | |
|---|---|
| Researcher | MITOMO Mamoru (National Institute for Materials Science) |
| Company | NGK SPARK PLUG CO., LTD. |
| Development Period | January 1984 – December 1986 |
| Development Fund | Approx. 507 million yen |
| Abstract | Silicon nitride ($Si_3N_4$) is superior in light-weight, in strength at high temperatures, in toughness and shock resistance among non-oxide ceramics, and therefore has been highly expected as the material for car engines. In the conventional reaction sintering method or room pressure sintering method, however, only simple-shaped items were able to be produced, since silicon nitride lacks the mechanical characteristic resistant to the harsh operating conditions of engines.<br>In this technology, nitrogen gas is charged by pressure in a large-scale sintering furnace to sinter while pressuring at high temperatures, which prevents thermal decomposition of silicon nitride. This method achieves sintering, even in denser, complicated shapes compared to conventional methods. Through the mass production of silicon nitride of high quality and reliability, this technology has been co mmercialized as a turbo charger rotor in cars for the first time ever. |
| Use and Application | Engine parts for cars |

Figure



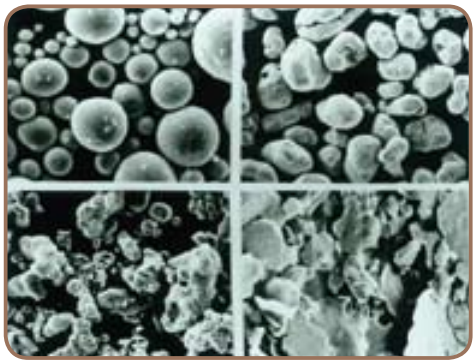
Turbo charger ceramic rotor

# Manufacturing technology for super-fine metals from the atomizing method

| | |
|---|---|
| Researcher | TAKEDA Toru, MINAGAWA Kazumi (National Institute for Materials Science) |
| Company | Nippon Atomized Metal Powders Corporation |
| Development Period | August 1984 – August 1986 |
| Development Fund | Approx. 130 million yen |
| Abstract | Metal powders are used in large quantities in blending paints and resins to achieve functionality or in catalysts and sintering auxiliary agents, such as power metallurgy. These metal powders are manufactured by electrolysis and the oxide reduction method, the carbonyl method, and the atomizing method. These three methods allow manufacturing a super-fine powder size (i.e., 1 to 10 μm), though the material is single metal only. For alloys, these three methods have not been put to practical use because of the limitation of textures. The atomizing method, on the other hand, has been widely used in the manufacturing of single metal as well as alloy powders. Due to structural limitations, however, the limit was the average powder diameter of several tens of micrometers.<br>Based on these findings, powder of shorter diameter was expected, as well as active super fines of high performance, to improve the sintering performance in powder metallurgy and the dispersibility to paint and resin.<br>In the spray atomizing method of molten metals, this technology is used to manufacture high-performance metal super fines of several micrometers average powder diameter by increasing energy when jets collide with molten flow by increasing the angle of collision and increasing the injection speed of cone-shaped jets. |
| Use and Application | Powder metallurgy |

Figure

General view of manufacturing system



Super-fine metals in various shapes, from this technology

Upper left : Ball powder
Upper right : Lump powder
Lower left : Porous powder
Lower right : Scale-shaped powder

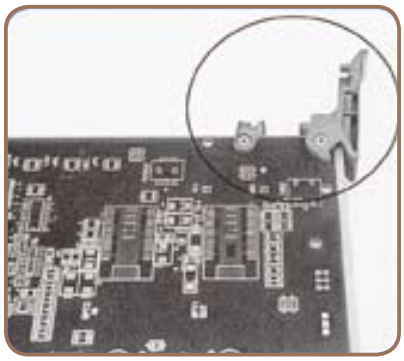
# Manufacturing technology for white conductive materials for composite materials

| | |
|---|---|
| Researcher | MORIMOTO Takuo (Research Institute for Production Development) |
| Company | Otsuka Chemical Co., Ltd. |
| Development Period | February 1986 – July 1990 |
| Development Fund | Approx. 370 million yen |
| Abstract | Conductive composite materials consisting of polymer and fine powder carbon have been used conventionally. Due to being black, it was difficult to dye to a specified color, and it was impossible to improve the strength and heat resistance of polymer materials via conventional technology for composites.<br>In this technology, by forming and burning a coat of hydroxide of tin chloride and antimony chloride on the surface of white potassium titanate in fibrous form, and by converting it into a transparent conductive oxide film, a white conductive material is obtained. This technology enables the manufacturing of conductive material white in color and superior in strength and heat resistance. |
| Use and Application | Electrostatic preventive floor material in clean room, housing for electronic devices, conductive primer for car (for electrostatic painting), etc. |

Figure

Application to electrostatic painting conductive primers for cars

TEM photo of white conductive material

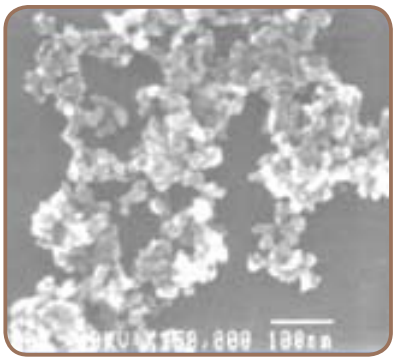


Application to charge-preventive ejector (upper right)

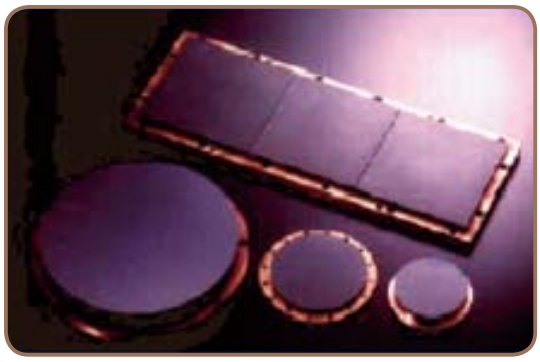
# Manufacturing technology for high-density silicon carbide sintered body

| | |
|---|---|
| Researcher | KIJIMA Kazunori (Kyoto Institute of Technology) |
| Company | Sumitomo Osaka Cement Co.,Ltd. |
| Development Period | December 1988 – June 1992 |
| Development Fund | Approx. 280 million yen |
| Abstract | Silicon carbide is superior in strength at high temperatures and anti-corrosiveness, and is used in heat-resistant structural materials. Due to poor sintering characteristics, however, it is necessary to add a sintering-aiding agent. As a result, the original characteristics of silicon carbide have been lost.<br>In this technology, by adding super fines of highly active silicon carbide, manufactured via the plasma CVD method, to normal silicon carbide powder and by sintering at high temperature and high pressure, the sintered body of silicon carbide is obtained without adding a sintering-aiding agent. |
| Use and Application | Etching equipment electrodes utilizing high purity, density and anti-corrosiveness, and heater utilizing high resistance to oxidation and high thermal conductivity |

Figure



SiC super fines



Spattering target

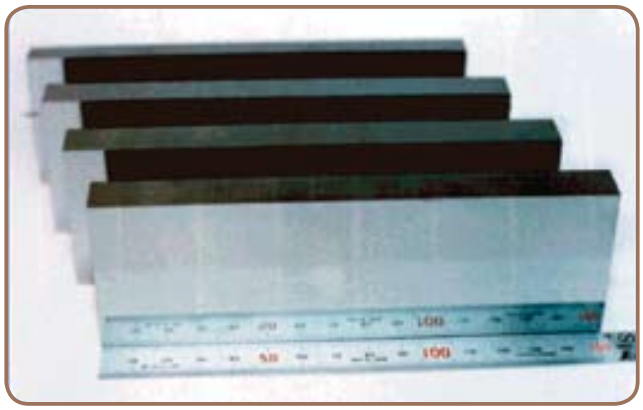
Electrode of plasma etching equipment

Heater unit

# Manufacturing technology for high-quality graphite

| | |
|---|---|
| Researcher | YOSHIMURA Susumu |
| Company | Panasonic Electronic Devices Co., Ltd. |
| Development Period | March 1989 – March 1992 |
| Development Fund | Approx. 300 million yen |
| Abstract | Single crystal graphite and high-quality graphite having similar physical properties and are used in the radiation of optical elements. In the conventional manufacturing method, however, it was hard to realize large areas and thickness, and the process was very complicated, thus taking considerable time to manufacture.<br>In this technology, high-quality graphite is manufactured by accumulating heat-resistant polymer films such as polyamide, and by heat-treating at high temperatures. This technology enables quick manufacturing of largeareas and thick high-quality graphite blocks still retaining similar heat-resistance and crystallinity as single crystal graphite. |
| Use and Application | Radiation optical elements in the neutron ray, X-ray, radiated light monochrometers |

Figure



Appearance of high-quality graphite

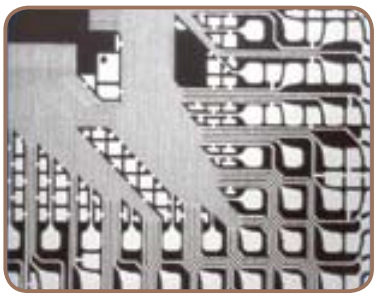
| Item | Characteristics | |
|---|---|---|
| Max size | Mosaic spread: 0.4-0.5° | 40 × 4 (mm) |
| | Mosaic spread: 2.0-3.0° | 140 × 40 × 12 (mm) |
| Electric conductivity | ab face direction | 23000 S/cm |
| Heat resistance | Oxygen-less | 3000°C or higher |
| Density | 2.2 g/cm$^3$ | |

# Manufacturing technology for independent metal super fines

| | |
|---|---|
| Researcher | HAYASHI Chikara, ODA Masaaki |
| Company | ULVAC Materials,Inc. |
| Development Period | December 1990 – March 1994 |
| Development Fund | Approx. 330 million yen |
| Abstract | Metal super fines (grain size 1-100 nm) were more likely to coagulate (i.e., phenomenon of forming a large grain by collecting numerous super fines).<br>This technology is to manufacture continuously the metal super fines with diffused individual independent particles by preventing coagulation by coating the super fines with an organic agent after their growth in inactive gases. As compared with chemical reaction, higher purity is realized because of lack of alkali, chlorine, etc.<br>Also, by using the liquid diffused with these super fines in the form of ink or paste, it is possible to formulate a micro-wiring of electronic circuits from tens of microns to submicron width with ink jet printing, screen printing, or contact copy printing method. |
| Use and Application | (1) Wiring and electrode of large displays of PDP, LC and organic EL<br>(substitute technology for vacuum film forming, lower cost) ;<br>(2) Micro wiring of organic substrate for mounting<br>(substitutes for vacuum film forming and wet plating) ;<br>(3) Metal reflective film; and<br>(4) Metal particle diffusion type color filter. |

Figure

Image of independent metal super fines by transmission electron microscope



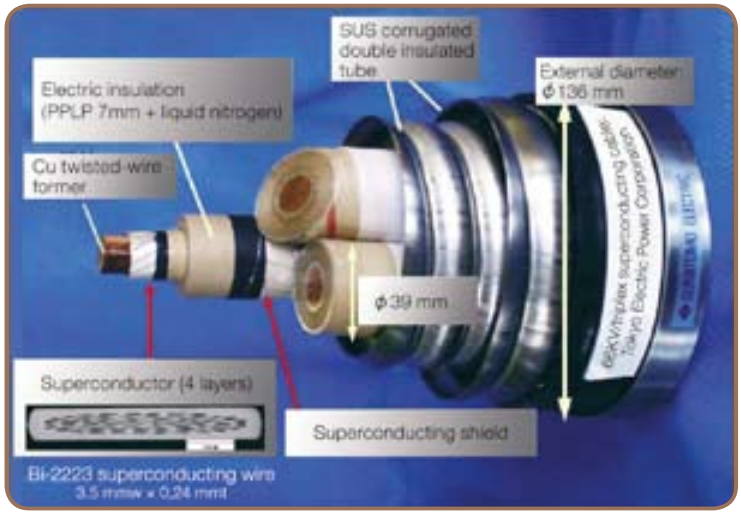
Line and space by screen printing method
Wiring pattern of 20 microns
Substrate: polyamide

Solution with dispersed independent metal super fines

# Manufacturing technology of oxide superconducting material (Bi–based superconducting wire)

| | |
|---|---|
| Researcher | FUEKI Kazuo, KITAZAWA Koichi (The University of Tokyo), MAEDA Hiroshi (National Institute for Materials Science) |
| Company | Sumitomo Electric Industries, Ltd. |
| Development Period | March 1991 – March 1996 |
| Development Fund | Approx. 930 million yen |
| Abstract | Since oxide superconductors can utilize cooling with liquid nitrogen (about 77K), a wide range of commercial application has been expected. However, since these materials are high-anisotropic ceramics based on layered crystal structure, and their crystal grain size and crystal orientation are closely related to superconductivity, the development of sophisticated manufacturing technology has been required.<br>In this technology, in the manufacturing process of oxide superconductors composed of bismuth-strontium-calcium-copper-oxygen (Bi-Sr-Ca-Cu-O), the processes of plastic forming and sintering are delicately controlled to obtain intended superconducting characteristics. The superconducting wires based on this technology have the world highest critical current density at 30,000 A/cm$^3$ or above with the length of more than 1,000 m. |
| Use and Application | large-capacity power cables, and coil wires for magnet |

Figure




High-temperature superconducting wire

Bi-based superconducting wire

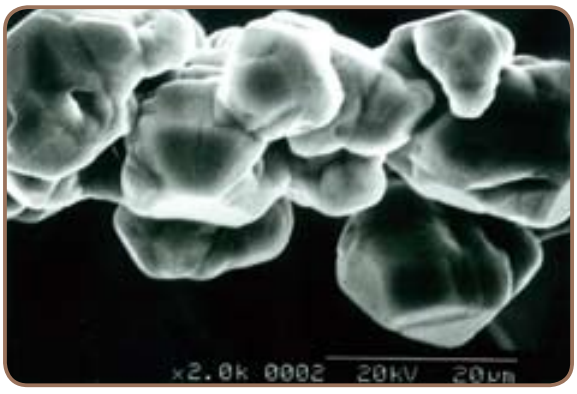
High-temperature superconducting magnet for Si single-crystal grower

# Manufacturing technology for highly thermal resistant silicon carbide fabric by electron beam irradiation

| | |
|---|---|
| Researcher | SEGUCHI Tadao, OKAMURA Kiyohito (Japan Atomic Energy Agency) |
| Company | Nippon Carbon Co., Ltd. |
| Development Period | February 1992 – August 1995 |
| Development Fund | Approx. 1.2 billion yen |
| Abstract | Fiber reinforcing ceramic base composite material combined with ceramic and inorganic fiber is expected to become the mainstream of heat-resistant composite materials; however, the withstanding temperature of conventional inorganic fiber stayed at 12,000℃, even in the best silicon carbide fiber. Therefore, heat resistance of ceramic base composite materials is restricted by inorganic fiber. Silicon carbide fiber is manufactured by melting spinned polycarbosilane and burning at high temperatures. In order to prevent polycarbosilane of lower melting point from melting, an oxidizing treatment was carried out, in which polycarbosilane was heated and oxidized in air prior to burning. Therefore, silicon carbide fiber manufactured this way was coupled with oxygen of about 12wt. If silicon carbide fiber is used at temperatures of 1,200℃ or higher, oxygen coupled with this fiber left, thus deteriorating the fiber strength.<br>This technology is to manufacture the silicon carbide fiber of heat resistance 1,700℃ and high tensile elasticity by preventing oxygen from being mixed up in the fiber by means of oxidizing treatment of bridging by irradiating the electron beam to fiber of polycarbosilane in inactive gases. Fiber so obtained is expected to be used in the power generating high-temperature gas turbine and aircraft jet engine as a composite material with ceramic. |
| Use and Application | Power-generating, high-temperature gas turbine, aircraft jet engines, nuclear fusion reactor wall material, etc. |

Figure

Example of ceramic-base composite material using silicon carbide fiber using this technology

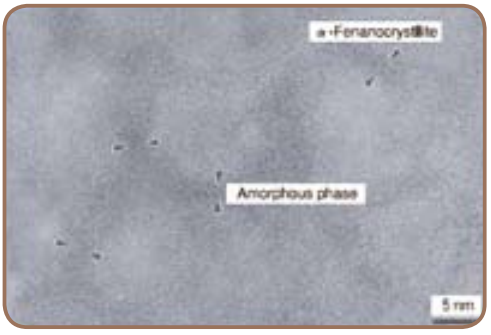



Scan-type electron microscope photo of silicon carbide fiber after high-temperature environmental testing (2000℃ - for 1 hr)

# Manufacturing technology for iron-transitional metal nano crystal soft magnetic alloy

| | |
|---|---|
| Researcher | MASUMOTO Tsuyoshi, INOUE Akihisa (Tohoku University) |
| Company | ALPS ELECTRIC CO., LTD. |
| Development Period | March 1993 – March 1997 |
| Development Fund | Approx. 1.07 billion yen |
| Abstract | In order to make magnetic devices better performing and compact, it was requested to develop new materials retaining both high saturated magnetic flux density and super soft magnetic characteristics such as magnetic permeability and magnetic coercive force.<br>This technology is for manufacturing alloys having higher saturated magnetic flux density and magnetic permeability than conventional materials by making a texture with uniformly diffused micro iron crystal of grain size 5 nm to 15 nm in amorphous phase, through the heat treatment of iron/transition metal amorphous alloys at 500℃ to 700℃.<br>Alloys created from this technology are superior in characteristics such as saturated magnetic flux density and magnetic permeability, and are characterized by low core loss even in the high-frequency area. |
| Use and Application | Cores in magnetic parts such as transformer and noise filter used the kHz band switching power supply |

Figure




High-resolution transmission electron microscope photo of Fe-M-B nano crystal soft magnetic alloy

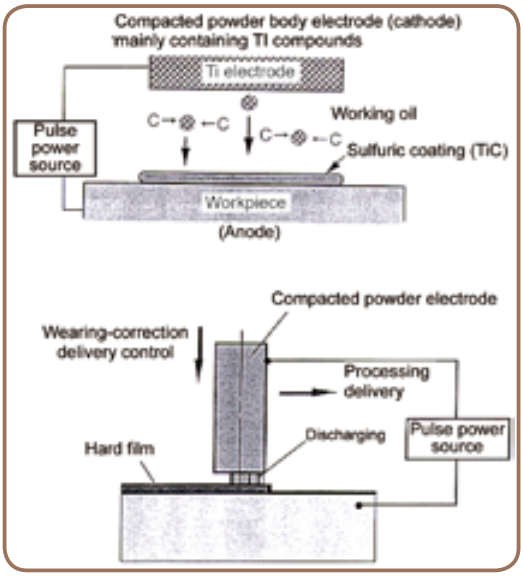
Fe-M-B nano crystal soft magnetic alloy thin band

# Ceramic membrane-forming equipment by submerged discharge method

| | |
|---|---|
| Researcher | SAITO Nagao, MOHRI Naotake, TSUNEKAWA Yoshiki (Toyota Technological Institute) |
| Company | Mitsubishi Electric Corporation |
| Development Period | March 1994 – March 1997 |
| Development Fund | Approx. 180 million yen |
| Abstract | To add wearing resistance and heat resistance to cutting tools and dies, it is effective to form thicker ceramic films. Conventionally, therefore, film-forming methods used were the PVD method (Physical Vapor-phase Deposition), the CVD method (Chemical Vapor-phase Deposition) and flame gunning. Problems include, however, insufficient film quality (such as density and adhesion), inability to deal with complicated shapes, and high treatment cost.<br>This technology is related to the film forming equipment discharging in the insulating liquids including oil with a compacted powder body such as titanium compound powder as cathode and the metal base material to be processed as anode. Film-forming mechanism is to deposit and adhere to ceramics such as titanium carbide generated by active wearing of cathode (titanium compound) and carbon source in liquid, on/to the surface of metal base material by using a local occurrence of heat and pressure and higher current density in cathode side.<br>This technology is expected to be used extensively as a new surface improvement method for the metal base materials of cutting tools and dies, because it is capable of forming films of high density and adhesion and of being applied to complicated shapes. |
| Use and Application | New surface improvement method for metal base materials of cutting tools and dies |

Figure

Appearance of equipment

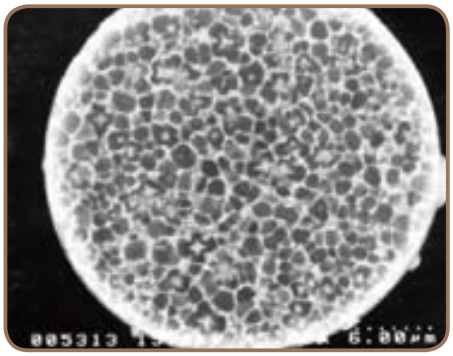



Principle of ceramic film forming by submerged discharge method

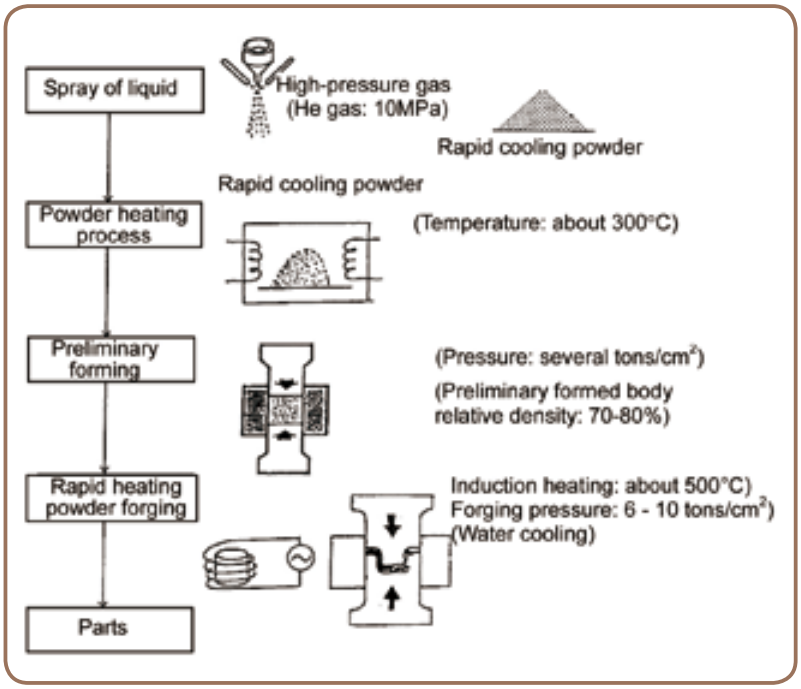
# Manufacturing technology for aluminum alloy parts by rapid heating powder forging method

| | |
|---|---|
| Researcher | MASUMOTO Tsuyoshi, INOUE Akihisa (Tohoku University) |
| Company | Sumitomo Electric Industries, Ltd. |
| Development Period | March 1995 – March 2000 |
| Development Fund | Approx. 304 million yen |
| Abstract | In the field of mechanical industry, efforts are made toward high efficiency and energy saving. One measure being studied is how to replace the conventional iron-base parts with aluminum-base parts lighter in weight. High strength and toughness are required. For the conventional aluminum alloys, however, so far it has been realizing both at the same time has not been successful. Problems will be resolved before commercialization.<br>To realize both high strength and high toughness, how to make super fines of crystal grain constituting metals has been researched. In this technology, transition metals, rare earth metals and zirconium were added to the main material of aluminum, and alloy powder having micron crystal grains was produced from these melting metals. Furthermore, by heating rapidly in the process of solidification forming, structure was prevented from getting larger in grain size, and the metal crystal grain was reduced successfully to 1/100th to 1/1000th of conventional aluminum alloys. This enables the manufacturing of aluminum alloy superior in strength and toughness. Also, it is hard to change the metal crystal structure of this alloy, even if the temperature is raised. Therefore, it was also found to be superior in high-temperature strength and to show good characteristics in fatigue strength. |
| Use and Application | Aircraft parts and transport vehicles requested to have high strength and toughness, engine parts, etc. |

Figure



Crystalline structure of raw powder of aluminum alloy by rapid heating powder forging method
Photo is an electron microscope photo of actual aluminum alloy structure, where very small crystal grains of about hundreds of nanometer are seen. Between the crystal grains are the transition metal and aluminum alloy (inter-metal compounds).

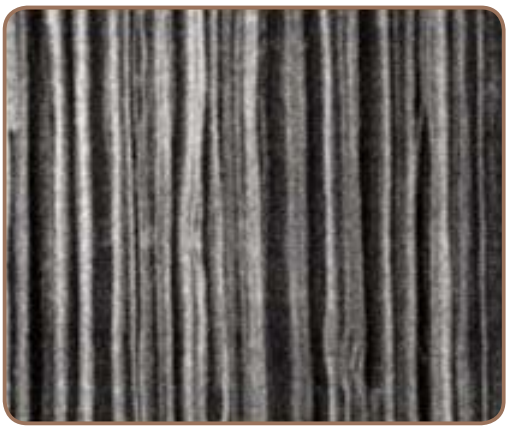



Aluminum alloy parts manufacturing process by rapid-heating powder forming method

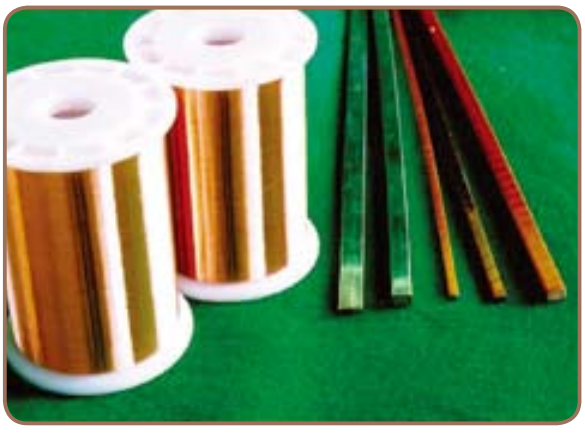
# Manufacturing technology of high-strength copper alloy for use in conducting materials

| | |
|---|---|
| Researcher | INOUE Kiyoshi, SAKAI Yoshikazu (National Institute of Materials Science), MAEDA Hiroshi (Tohoku University) |
| Company | SWCC SHOWA HOLDINGS CO., LTD. |
| Development Period | March 1995 – March 1998 |
| Development Fund | Approx. 92 milliom yen |
| Abstract | Although alloys containing copper as a major component have been developed as conductive materials for use in electric wires and electric parts, alloys with reinforced strength without decreasing the high conductivity of copper has never been obtained.<br>In this technology, copper is blended with a proper quantity of silver, and the alloy that has complex structure composed of a phase with copper as a major component and a eutectic phase is cast. In addition, by repeating heat treatment and cold working alternatively, fine filament structure can be obtained. With the addition of silver as the highest conductive metal, the copper alloy with coexistence of high strength and high conductivity becomes possible. In addition, environmental load and recyclabilty are also excellent.<br>Since the copper alloy based on this technology has various advantages such as high strength, good conductivity, and easy recycling, contribution to various fields is expected: such as miniaturization and reliability improvement of electrical and mechanical products, development of conductive spring in consideration of environment, and development of high magnetic field generation technology. |
| Use and Application | (1) parts for electronics and mechatronics, (2) cables (highly bending and ultrathin), (3) sheet heating element (heater), and (4) conductive materials for generating strong magnetic field |

Figure



Structure of copper alloy based on this technology (filament reinforcement)

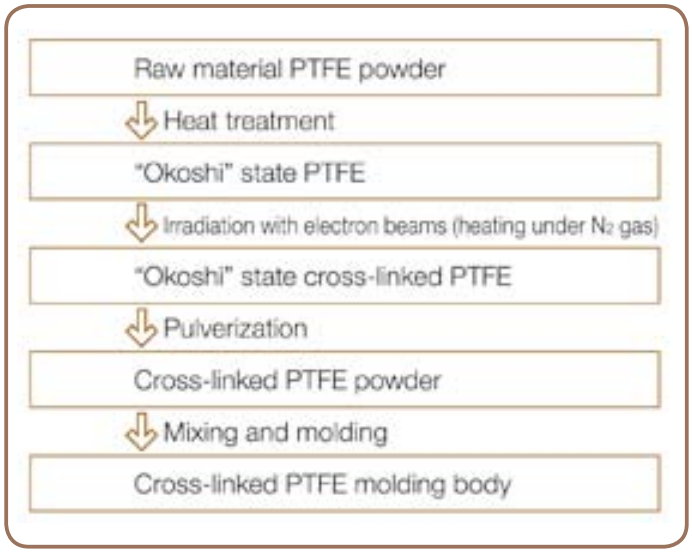


Copper alloy based on this technology

# Manufacturing technology of high-functional fluorine resin based on electron beam irradiation

| | |
|---|---|
| Researcher | SEGUCHI Tadao (Japan Atomic Energy Agency) |
| Company | Hitachi Cable, Ltd. |
| Development Period | March 1997 – March 2002 |
| Development Fund | Approx. 540 million yen |
| Abstract | Polytetrafluoroethylene (PTFE) is a fluorine resin excellent in lubricity, heat resistance, chemical resistance, and electric isolation, and is used in wide fields such as slide member and searing part. However, due to its insufficient abrasion resistance, materials with higher performance have been required in semiconductor manufacturing facilities, where clean environment with little abrasion dust is necessary. In this technology, PTFE is maintained in molten condition at 340±5°C, and PTFE is intermolecularly cross-linked by irradiating with electron beams under anoxic environment.<br>In this development, as a method to realize the above purpose, firstly powdery PTFE as raw material is heat-treated for melting point adjustment to produce "Okoshi (millet-and-rice cake)" state PTFE. This PTFE is irradiated with electron beams in a thermostat chamber filled with nitrogen. The "Okoshi" state cross-linked PTFE is pulverized to make the powdery product. This powder is pressed under high temperature to make shaped products. It has been verified that the final product has about one thousandth of abrasion rate and about one fourth of creep residual deformation compared with PTFE before treatment, showing a large extent of improvement in abrasion resistance and creep resistance. |
| Use and Application | (1) semiconductor, food, and medical care fields where clean environment without abrasion dust is required, and (2) space field where radiation resistance is required |

Figure




Manufacturing process of cross-linked PTFE

Products based on this technology

# Development of flaky titanium oxide ($TiO_2$)

| | |
|---|---|
| Researcher | WATANABE Mamoru, SASAKI Takayoshi (National Institute of Materials Science) |
| Company | Ishihara Sangyo Kaisha, Ltd. |
| Development Period | March 1999 – March 2002 |
| Development Fund | Approx. 180 million yen |
| Abstract | Titanium oxide ($TiO_2$) is widely used as pigments for various coating materials, UV-ray shielding substances for cosmetics, and raw materials for dielectrics for use in electronic parts. The shape of titanium practically used at present is mostly particle state.<br>In this technology, layered titanic acid crystals, in which sheet-shaped titanic acid is multiply laminated, are synthesized. These crystals are stirred in an aqueous amine solution to be separated and dispersed into each layer. Through spray-drying and calcining, hollow $TiO_2$ spheres are prepared. By grinding, fine flaky $TiO_2$ particles with good extending performance and adhesion for thinly covering the surface can be manufactured. |
| Use and Application | Since this product has good extending performance and adhesion for thinly covering the surface, application to cosmetics and coating materials can be expected. In addition, hollow $TiO_2$ before pulverizing into flake-shape can be used for the same application. |

Figure

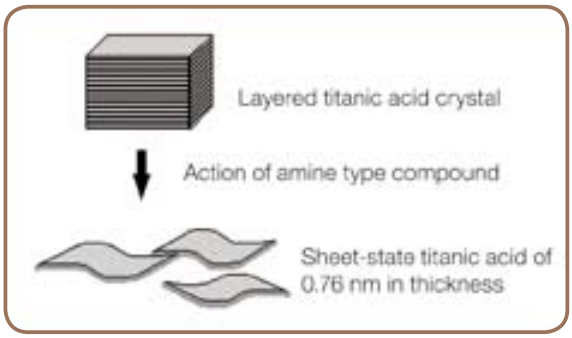



Image of separation of layered titanic acid crystal


SEM photograph of flaky $TiO_2$ particles

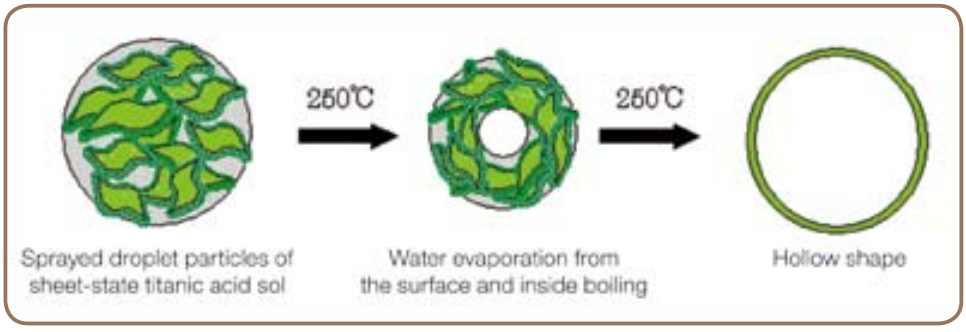
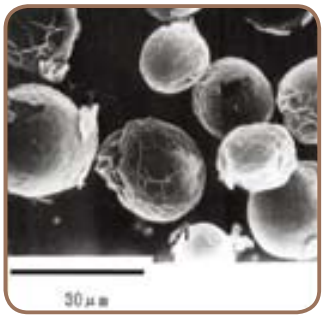



Image of formation of hollow $TiO_2$ spheres

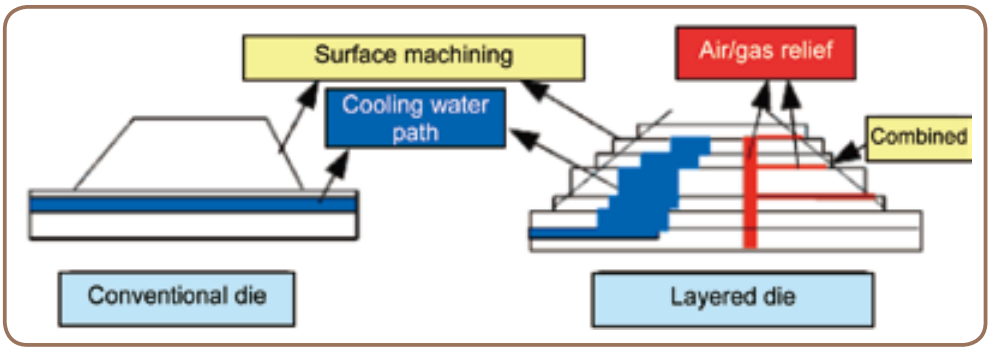



SEM photograph of hollow $TiO_2$ spheres

# Laminated die for high-cycle resin forming

| | |
|---|---|
| Researcher | NAKAGAWA Takeo (RIKEN) |
| Company | SEKISOU KANAGATA CO., LTD. |
| Development Period | February 2002 – August 2004 |
| Development Fund | Approx. 140 million yen |
| Abstract | Dies conventionally were produced by cutting the cast or steel blocks. Due to the low degree of freedom in the forming path of cooling water, however, it was hard to reduce the forming cycle, and it took longer time and greater cost to process.<br>With this technology, the slice data of die structure, cooling water path, etc., is optimum for blow forming are generated from the 3D CAD data of products, and a die is produced by accumulating the later materials by processing cooling water path, etc. based on such data. This technology enables the improvement of cooling efficiency and shorter forming cycle, thus ending in a shorter term for producing dies. |
| Use and Application | Dies for resin forming in care parts and electrical equipment |

Figure




Structure of layered die

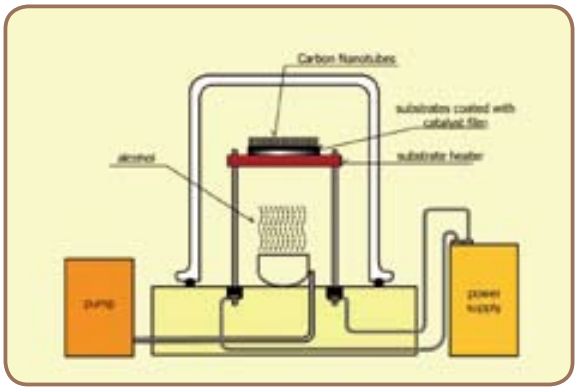
Blow-forming layered die

Blow formed item

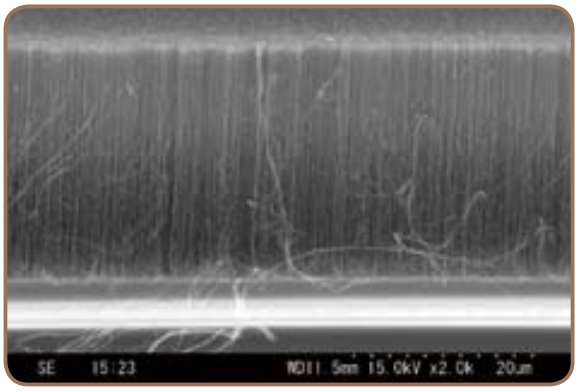
# Carbon nano tube liquid phase synthesis device

| | |
|---|---|
| Researcher | ANDO Toshihiro (National Institute for Materials Science) |
| Company | Microphase Co., Ltd. |
| Development Period | March 2003 – March 2006 |
| Development Fund | Approx. 170 million yen |
| Abstract | Currently, various methods have been studied and developed as methods for synthesizing carbon nano tubes; however, large amount of soot is created as a byproduct, from which carbon nano tubes must be selected. One of the problems was a long time required to synthesize. Further, carbon nano tubes should be arraigned vertically on the substrate to be commercialized. It was difficult, however, to synthesize stably such carbon nano tubes on a substrate of a larger area.<br>This technology is unique in supplying carbon as nano tubes by alcohol organic solution such as ethanol, and enables synthesizing carbon nano tubes while bypassing the vacuuming process by heating the target substrate in solution or its saturated vapor. Carbon nano tubes synthesized this way have high quality characteristics and very small amounts of byproducts, including soot. Additionally, decomposition of raw materials occurs in conjunction with the growth of nano tubes simultaneously on the surface of the substrate. Therefore, high-speed synthesis of carbon nano tubes arraigned vertically to the surface of substrate is possible.<br>Technologies related to carbon nano tubes have attracted considerable attention. Applied development in practical levels has not yet been attained. This technology enables many engineers to produce high-quality carbon nano tubes on the spot and research/evaluate results. Applied development is expected to be accelerated in the fields of electronics and energy such as fuel battery separators and electronic heat sinking components. |
| Use and Application | Electronics |

Figure




Concept of carbon nano tube synthesis equipment



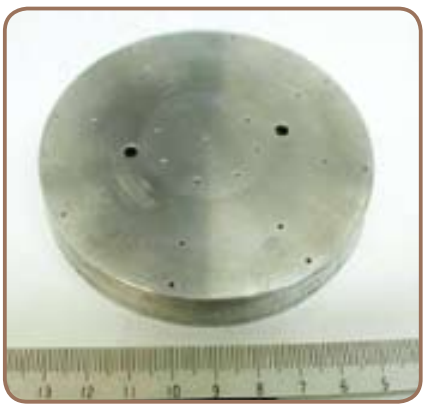

Carbon nano tube synthesis

# Heat exchanger composite materials using carbon nano tube

| | |
|---|---|
| Researcher | KAKITSUJI Atsushi (Technology Research Institute of Osaka Prefecture) |
| Company | Sumitomo Precision Products Co., Ltd. |
| Development Period | March 2004 – March 2008 |
| Development Fund | Approx. 250 million yen |
| Abstract | Aluminum alloys are mainly used for materials associated with radiation equipment, such as heat exchangers and heat sinkers. As represented by the rise in use of heat-generating density of power semiconductors, improved performance of radiation equipment is strongly desired; however, performance improvement measures taken so far by densifying the radiation fin have almost reached the limit from the viewpoint of machinability and pressure loss. Therefore, it was desired to secure material with higher thermal conductivity than aluminum alloys.<br>Carbon nano tubes, upon which applied research is promoted, are extremely high in thermal conductivity. Therefore, if these were oriented to aluminum alloys as fillers, thermal conductivity is expected to be greatly enhanced. In this technology, small amounts of carbon nano tube and the larger vapor-grown carbon fiber (VGCF) were added to aluminum alloys to develop a composite material of greatly improved thermal conductivity. In manufacturing, discharge plasma sintering system was used, and a manufacturing process has been established for the high-performance thermal conductivity material surpassing three times that of aluminum alloys. This technology is expected to enable some compact and light-weight radiation equipment in car and aircraft. |
| Use and Application | Heat exchanger composite materials in the semiconductor and aviation industries |

Figure

Discharge plasma sintering system



Composite material using carbon nano tube

# Manufacturing technology for high-efficiency optical battery using amorphous silicon carbide (for civil use)

| | |
|---|---|
| Researcher | HAMAKAWA Yoshihiro (Osaka University), TAWADA Yoshihisa (KANEKA CORPORATION) |
| Company | KANEKA CORPORATION |
| Development Period | December 1982 – July 1984 |
| Development Fund | Approx. 670 million yen |
| Abstract | The conventional amorphous photo-electric cell, in its manufacturing method, formulated devices on one face of discharge electrodes facing each other, and, therefore, the defective density of film became high because film-forming advances while affected by acceleration and collision from the electrical field of decomposed ions. The photo-electric cell then produced was lower than the single crystal product in photo-electric conversion efficiency, and the light-receiving area of modules was forced to increase if any specified power was to be obtained. Nonetheless, power tended to become short under weak lighting, and was finally rendered unable to work.<br>This technology is based on the lateral plasma method of suppressing defects due to ion collision in the precipitation of amorphous silicon films. From the highly efficient battery with cells directly connected to flexible substrate of 0.1 mm, an extra-thin photo-electric cell for civil use has been developed by using amorphous silicon carbide.<br>This technology is expected to improve the value of products because it can be used in energy saving, reduction in cost in variable cost per minute or module, and by scale merit, and because it can generate power to activate LSI, etc. even under weak lighting. |
| Use and Application | Photocells for civil use such as in desktop calculators, wrist watches |

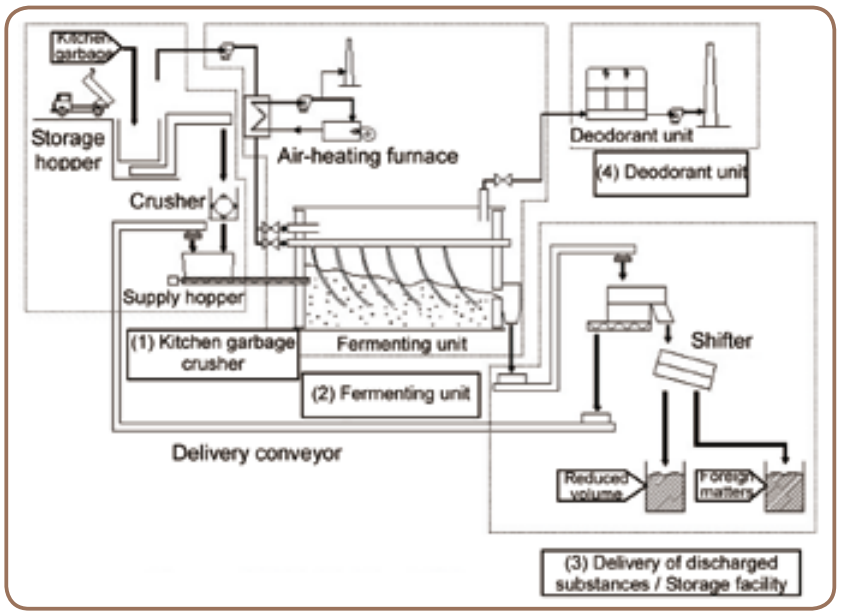
Figure


Products using amorphous silicon carbide hetero joint photo-electric cell

# Kitchen garbage high-speed volume reduction system

| | |
|---|---|
| Researcher | MIYAUCHI Shuhei, IMOTO Taizo (Technology Research Institute of Osaka Prefecture) |
| Company | Hitachi Zosen Corporation |
| Development Period | March 1999 – May 2001 |
| Development Fund | Approx. 860 million yen |
| Abstract | A system of disposing capacity of a maximum of 50 tons per day has been developed, which decomposes kitchen garbage by microorganism treatment, and is capable of reducing large volumes in short periods of time. In this system, aerobic fermentation is promoted by providing sufficient air into a fermenting bath from an air-supply mechanism installed in a rotary kiln-type fermentor. By maintaining appropriate values of temperature and water content in the fermenting bath, the development of fermentation is stabilized, thus absorbing the changes in condition of kitchen garbage. High-speed reduction of volume was realized this way. Odorous components contained in the exhaust gases from fermenting baths are deodorized by thermal decomposition.<br>The kitchen garbage high-speed volume reduction system using this technology is capable of reducing large volumes of kitchen garbage, such as vegetables, fruits, or sea food waste in less than a day to one week, and is characterized by discharging neither odor nor contaminated water. This is expected to be used as a treatment system attached to central wholesale markets etc. where large amounts of kitchen garbage are produced. |
| Use and Application | Treatment system attached to central wholesale market, etc. |

Figure




System configuration

Kitchen garbage volume reduction plant

# Roof afforestation technology using superior water-holding light-weight mat

| | |
|---|---|
| Researcher | MORI Yuichi (Waseda University) |
| Company | Kuboco Co. |
| Development Period | March 2001 – March 2004 |
| Development Fund | Approx. 100 million yen |
| Abstract | Roof afforestation has attracted attention as an effective method to deal with heat-island effect in cities; however, buildings were heavily burdened in terms of liver loads and construction and increased maintenance and cost control.<br>Superior water-holding gel using this technology is able to reduce absorption of calcium iron critical to plant growth and, therefore, is able to prevent weak plant growth. By using an artificial light-weight soil blended with the gel, a roof afforestation system has been realized, which grows plants with reduced amounts of irrigation water.<br>Thanks to ease of use, a general purpose application from an extra-thin layer of lawn afforestation (soil thickness: 8 cm) to medium-to-high tree afforestation, there is no need for maintenance and control, such as with irrigation. This technology is expected to promote artificial ground afforestation on roofs, etc. |
| Use and Application | Afforestation of artificial grounds on roofs, etc. |

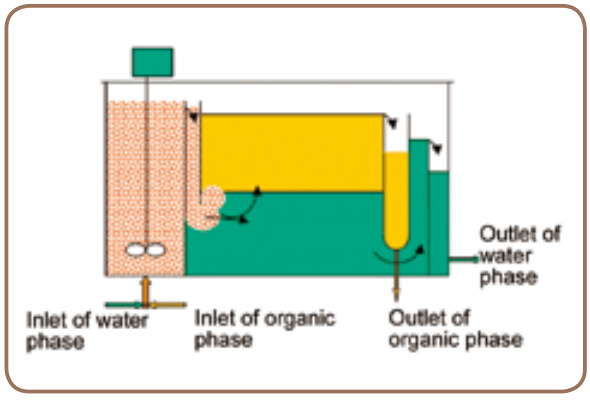
Figure

Example of works

# Acid recovery system for mixed acid waste liquids by solvent extraction method

| | |
|---|---|
| Researcher | SHIBATA Junji, YAMAMOTO Hideki (Kansai University) |
| Company | SANWAYUKA INDUSTRY CORPORATION |
| Development Period | February 2002 – February 2004 |
| Development Fund | Approx. 150 million yen |
| Abstract | In the manufacturing process of electronic parts such as semiconductors and liquid crystals, etching treatment is carried out. In this treatment, however, mixture of acetic acid-nitric acid-fluorinated acid is used, and large amounts of mixed acid waste liquids are produced. Currently, mixed acid waste liquids are treated by alkali neutralization. From the viewpoint of reducing environmental load, however, it was necessary to develop a technology to separate and recover waste liquids.<br>This technology separates and recovers acids contained in mixed acid waste liquids by using the solvent extraction method. The actual plant consists of a multi-stage mixer settler, and is capable of recovering, sequentially and in high purity, acids such as acetic acid, nitric acid, and fluorinated acid from waste liquids.<br>This technology enables the separation/recovery of acids with fewer impurities from etching waste liquids, such as in the surface treatment of silicon wafers, and there is no need for the process of alkali neutralization, thus reducing the cost of waste liquid treatment at plants. This technology is expected to be applied widely to the waste liquid treatment at LC manufacturing plants and various electronic parts plants. |
| Use and Application | Treatment of waste liquids occurring from manufacturing of semiconductor and LC |

Figure



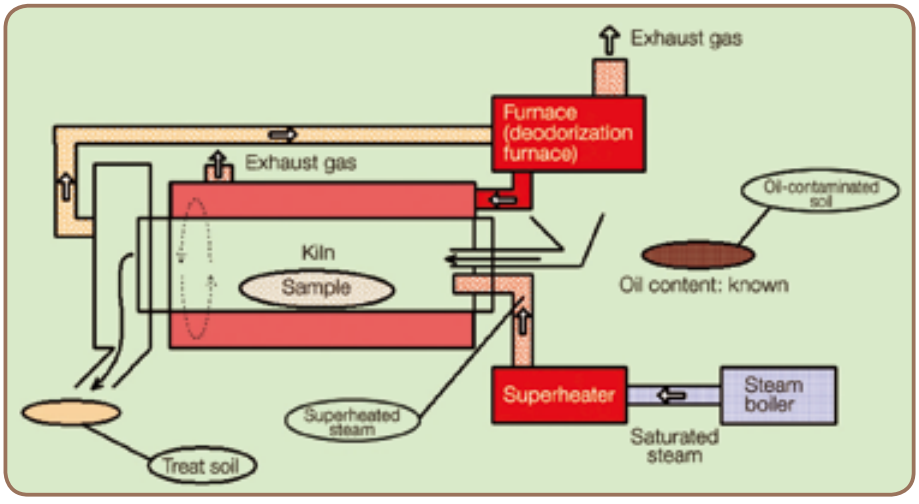

Principle of mixer settler

Extraction unit at demonstration plant

# Oil-contaminated soil remediation technology using superheated steam

| | |
|---|---|
| Researcher | NAKAMURA Hiroshi (Tokyo University of Marine Science and Technology) |
| Company | TOYO CONSTRUCTION CO., LTD. |
| Development Period | March 2005 – September 2007 |
| Development Fund | Approx. 200 million yen |
| Abstract | Although the soil of the vacant lots of oil tank yard, oil refiner, and gas station need the remediation treatment of oil contamination, it was difficult to remove the oil attached to the soil composed of fine particles by conventional technologies.<br>This technology is related to the remediation technology of oil-contaminated soil using superheated steam. By utilizing the high thermal conductivity and anoxic atmosphere of the superheated steam which is prepared by superheating saturated steam to 400-500˚C, superheated steam and contaminated soil are brought into contact while mixing in an injection furnace, and the oil component is separated through steam distillation and recovered. Since it is possible to easily dissolve oil into superheated steam, contaminated soil with fine particles containing 30,000 ppm of oil can be purified to 100 ppm or less of oil content. The development of this equipment has successfully been completed.<br>In addition, by adopting a car-mounted rotary kiln as injection furnace, onsite treatment at a contaminated site became possible without transporting highly contaminated soil. This merit, together with the nonuse of chemical substances in oil recovery, gives expectation of the effective utilization of resources, in the way of recycling of treated soil and recovered oil. |
| Use and Application | remediation of oil-contaminated soil |

Figure




Outline of oil-contaminated soil treatment system using superheated steam

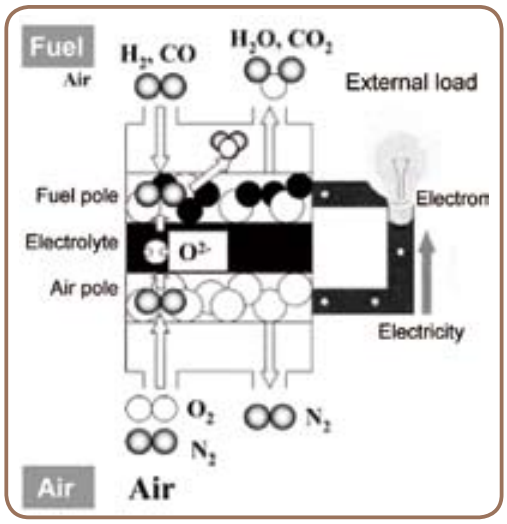
Before treatment

After treatment

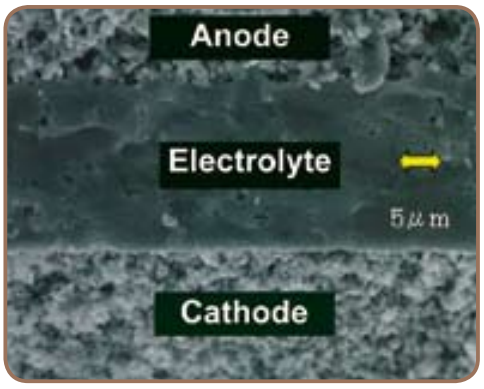
# Fuel battery low-temperature operating cell by particle interface structure control

| | |
|---|---|
| Researcher | NAITO Makio (Osaka University) |
| Company | HOSOKAWA POWDER TECHNOLOGY RESEARCH INSTITUTE |
| Development Period | March 2005 – March 2008 |
| Development Fund | Approx. 160 million yen |
| Abstract | Concerning solid oxide fuel cells, attempts have been made to develop batteries working at 700˚C or higher by improvement of materials. In the meantime, however, reducing manufacturing costs emerges as a major problem.<br>This technology enables material synthesis at 900˚C or lower, far lower than conventional sintering temperature, by using the unique technology of controlling particle interface to reduce the cost of manufacturing air polar materials.<br>Since it was confirmed that practically enough power of 0.4 W/cm$^2$ or higher is obtained under the conditions of operating temperature 700˚C and cell voltage 0.7 V, this technology is expected to be used widely in the commercialization of solid oxide fuel batteries. |
| Use and Application | Reduction of high-performance SOFC cell (solid oxide fuel cell) production cost |

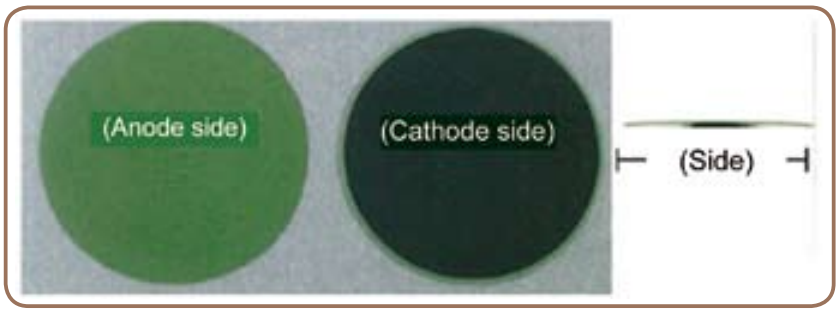
Figure




Principle of fuel cell




Example of cell cross sectional structure




Appearance of cell
In the drawing, cathode means air pole, and anode means fuel pole.

# Manufacturing technology for maltol by electrolytic organic synthesis

| | |
|---|---|
| Researcher | SHONO Tatsuya (Kyoto University) |
| Company | Otsuka Chemical Co., Ltd. |
| Development Period | March. 1977 – December. 1979 |
| Development Fund | Approx. 510 million yen |
| Abstract | Maltol is a substance contained in many natural foods and smells sweet, making it an essential flavor substance used in the fields of aroma chemical blends and processed foods. Conventionally, Maltol has been produced by a combination of fermenting and synthesis because of the extreme difficulty of total synthesis. This method, however, suffered various industrial problems, such as waste treatment, public hazard treatment and yields, and, as application increased, it was demanded that a method of synthesis that overcomes the defects of conventional methods be developed.<br>This technology totally synthesizes maltol from cheap materials easy to obtain and ordinary reagents. The greatest feature of this technology is that electrolysis technology hardly applied in organic reactions is applied to organic synthesis and that the electrode oxidation method is applied for oxidizing reaction as one of the most difficult processes in chemical reaction. This electrode oxidation method is to oxidize flowing current through solution and is epoch-making in resolving problems in conventional methods.<br>Thanks to the ability to supply maltol at half price or less, which had been expensive and monopolized by U.S. companies, consumption increased, thus contributing to not only economy but also a rich dietary life. |
| Use and Application | Foods |

Figure

Manufacturing plant and Maltol compound

# Measuring technology for shellfish toxin by organic solvent resistant antibody

| | |
|---|---|
| Researcher | TAKAGAKI Yutaka, HAMANO Yoneichi (Osaka Prefectural Institute of Public Health) |
| Company | Mitsubishi Kagaku Iatron, Inc. |
| Development Period | March 1993 – February 1997 |
| Development Fund | Approx. 150 million yen |
| Abstract | This technology is related to the method of measuring in simplified method and high sensitivity the diarrhetic shellfish toxin, in which hybridoma-generating organic solvent resistant monoclonal antibody is produced, and antigen-antibody reaction takes place in the organic solvent, such as alcohols using refined antibodies.<br>The detection method for shellfish toxin using this technology is capable of measuring more simply and in less time and higher sensitivity than the method of evaluating toxicity by intraperitoneal administration in mice of the samples obtained from complicated pretreatment such as extraction and refining of less water-soluble shellfish toxin. This enables checking the toxication of farm shellfish in a shorter time. |
| Use and Application | Farm shellfishes |

Figure

Shellfish toxin detection reagents

# Manufacturing technology of vitelline-derived sialic acid and sialyl oligosaccharide

| | |
|---|---|
| Researcher | YAMAMOTO Takehiko (Fukuyama University) |
| Company | Taiyo Kagaku Co., Ltd. |
| Development Period | March 1995 – March 1998 |
| Development Fund | Approx. 800 million yen |
| Abstract | Sialic acid and its derivative, sialyl oligosaccharide, appear to play a variety of physiological roles, such as bonding and blocking of cells and viruses; however, there have not been adequate methods for their mass-production, resulting in the products' high cost.<br>This manufacturing technology of sialyl oligosaccharide includes the following: after hydrolysis of defatted yolk of hen eggs used as a raw material, sialic acid is produced with processes including membrane fractionation, electrodialysis, and chromatographic isolation. After enzyme degradation of the same raw material, processes including membrane isolation are performed.<br>Through this technology, defatted yolk of hen eggs is used as raw material, which is provided at a low price with stable volume so that large quantities can be produced. |
| Use and Application | Pharmaceutical intermediates, including anti-cancer drugs or anti-virus agents (sialic acid); food materials (sialyl oligosaccharide) |

Figure

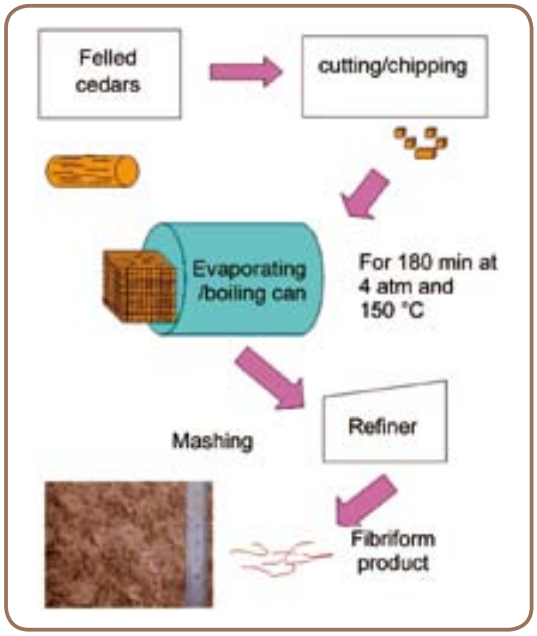
Membrane fractionation process system
(UF apparatus)

Sialyl oligosaccharide

# Manufacturing technology of coarse feed for livestock from felled cedar trees

| | |
|---|---|
| Researcher | TERADA Fuminori (National Agriculture and Food Research Organization ) |
| Company | Miyazaki Midori Pharms. Inc |
| Development Period | March 2000 – March 2003 |
| Development Fund | Approx. 180 million yen |
| Abstract | Recently, it has been difficult to supply rice straw, which has been used as coarse feed for livestock for many years because of (1) its fragmentizing character and (2) plowing under soil by introducing self-propelled combine harvesters in rice cultivation. As a result, approximately 20% of rice straws coarse feed for livestock has been imported from China, Taiwan, and South Korea. Haulms also has been imported to Japan. A new source of coarse feed for livestock is needed as a reserve for securing food safety since imported rice straw can contribute to foot-and-mouth disease in livestock.<br>This technology provides coarse feed for livestock as an alternative to rice straws by producing from felled cedar trees, which was developed through the results of technology introduced in Betula coarse feed. Coarse feed produced with this technology is fibrous and soft for cattle, and is less than 2 cm wide. When this coarse feed was mixed in concentrated feed, cattle growth was comparable to regular feed. Other favorable results for using the coarse feed include improved nature, improved bowel movement with increased ruminating, decreased diarrhea and healthy hair complexion. |
| Use and Application | Coarse feed for livestock |

Figure




Manufacturing flow of coarse feed for livestock from felled cedars

Manufacturing plant

Coarse feed for livestock

# Manufacturing technology of functional sweetener arabinose

| | |
|---|---|
| Researcher | HIZUKURI Susumu (Kagoshima University) |
| Company | SANWA CORNSTARCH CO., LTD. |
| Development Period | March 2000 – September 2003 |
| Development Fund | Approx. 1.5 billion yen |
| Abstract | In the process of manufacturing starch using corn as a raw material, a large quantity of corn fiber is produced as a by-product. Although its major application is feed, its constituents contain a large quantity of functional saccharide “arabinose,” which generated demand for efficient extraction technology for this substance.<br>In this technology, arabinose as a cereal cellulose (hemicellulose) is selectively cut and freed to obtain a mixed saccharide solution. This mixed saccharide solution is fed into serial separation columns, and high-purity arabinose solution is continuously extracted, and thus arabinose is efficiently produced.<br>Using this technology, high-purity arabinose can be manufactured in a large scale, and a wide range of application as raw materials for functional foods for the diet therapy or prevention of diabetes is expected. In addition, arabinoxylo-oligosaccharide and xylo-oligosaccharide, which are also produced from this process, are expected as functional materials for prebiotics. |
| Use and Application | (1) sweetener for diabetes diet and protective diet<br>(2) sweetener for suppression of the increase of plasma glucose |

Figure

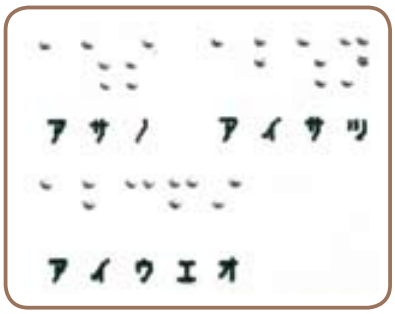
Acidolysis facilities

Separation and crystallization facilities

# Typewriter for simultaneous Katakana/Braille printing

| | |
|---|---|
| Researcher | OHTSUKI Naoto (Technol Eight Group) |
| Company | Technol Eight Group, ONKYO ENTERTAINMENT TECHNOLOGY CORPORATION |
| Development Period | March 1981 – September 1982 |
| Development Fund | Approx. 56 million yen |
| Abstract | Using this typewriter, which includes an internal computer with memory-and-copy functions, Katakana characters and Braille can be printed out simultaneously or separately. This product allows sight-impaired persons with little familiarity with Braille or persons with normal vision to operate easily.<br>It also is used in schools for special assistance of vision as well as office counters of communal facilities or emergency institutions, and contributes to a barrier-free society and social participation of persons with impaired vision.<br>With the oncoming advanced information age, a Braille printer connected to a personal computer has been subsequently developed, and three new models are currently on the market. |
| Use and Application | Local governments (community newsletters); educational institutions (examinations, communication documents); financial institutions (notifications such as account balance certification); NTT (bill and receipt); volunteer Braille transcribers; monthly publications (food/song books, etc.) |

Figure




First Braille printer (developed in 1982) and its output of Braille and Katakana characters


Activity for a barrier-free society

# Sensor integrated portable blood glucose meter

| | |
|---|---|
| Researcher | KARUBE Isao (Tokyo University of Technology) |
| Company | GUNZE Limited |
| Development Period | March 1998 – March 2002 |
| Development Fund | Approx. 100 million yen |
| Abstract | Conventional portable blood glucose meters tended to be difficult in determining the low blood sugar range (under 40 mg/dl), which creates a great risk of diabetic coma, and the high blood sugar range of over 600 mg/dl.<br>This technology represents a new portable blood glucose meter, and is able to scan the sensor's electrode potential by using cyclic voltammetry method. It also allows users to determine blood sugar level in the wide range between 20-900 mg/dl in a short period by corpuscularizing the enzyme layer in the sensor electrode.<br>This blood glucose meter is expected to be used as a portable blood glucose meter and bedside monitoring device for blood glucose in medical settings. |
| Use and Application | Blood glucose meter |

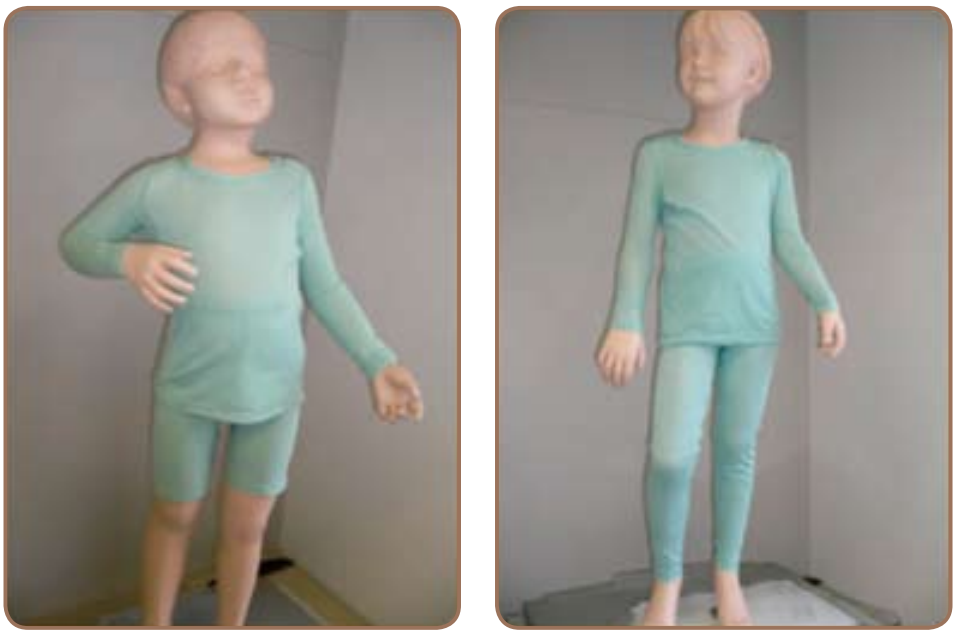
Figure


Blood glucose meter

# Fabric with itching-sedative function

| | |
|---|---|
| Researcher | KOMIYAMA Atsushi, SHIRAI Hirofusa (Shinshu University) |
| Company | Daiwabo Neu Co., Ltd. |
| Development Period | March 2002 – February 2006 |
| Development Fund | Approx. 240 million yen |
| Abstract | Atopic dermatitis is a recurrent eczematous skin disease followed by itching. When patients scratch the affected site intolerantly against itching, itching further increases due to the deterioration of skin conditions. So the sedation of itching in skin care has been an important challenge in the therapy of atopic dermatitis.<br>In this technology, fabric is dyed with iron phthalocyaninetetracarboxylic acid. This material has the following functions: (1) to adsorb and eliminate the factors to worsen itching such as mite allergen, house dust, and sweat antigen, and (2) to prevent the serious proliferation of bacteria such as Staphylococcus aureus, which are detected in the eczema lesion of nearly 100% of atopic dermatitis patients, and decrease its toxin.<br>Different from the therapy to take antiallergic drugs, this technology sedates itching by just wearing the underwear, and is expected to improve the QOL (quality of life) of not only patients themselves but also their family members. |
| Use and Application | Itiching sedation of patients with atopic dermatitis |

Figure



Underwear with itching sedation function

# Human simulation model for training resuscitation

| | |
|---|---|
| Researcher | SAKURAI Yasuhisa (Tokyo Women's Medical University) |
| Company | KOKEN CO., LTD. |
| Development Period | April 1979 – February 1981 |
| Development Fund | Approx. 41 million yen |
| Abstract | Foreign (i.e., not it Japan) simple simulation models mainly for chest massage and artificial breathing have been used as a device for training cardiopulmonary resuscitation; however, such devices had only functions that light a lamp to display effectiveness of chest massage.<br>In this human simulation model, resuscitation performance input signals are transmitted to a microcomputer through each sensor, and parameters such as blood pressure, cardiac output, and amount of ventilation are calculated as results of the training procedure. The calculated signals then are transferred to effectors to display vital reactions. In addition, this system has a monitor that can display stroke length and rhythm in cardiac massage, ventilation volume of artificial respirator, and heart rate.<br>Since this system also has a vital reaction display in a simulator and therefore the trainer can appropriately set individual reactions to procedure, trainees can train resuscitation almost without decreased training motivation due to "habituation." Currently, the fourth-generation model has a new function to perform international standard procedures and has been developed on the basis of the technology of the first model. |
| Use and Application | Human simulation model for training procedures of cardiac massage and artificial respiration |

Figure

Set of current model
Human simulation model for training resuscitation
KOKEN RESIM

Training with using simulation model

Inside of the product

# Portable electron scanning ultrasonic diagnostic instrument

| | |
|---|---|
| Researcher | ITO Kenichi (Tokyo University of Agriculture and Technology) |
| Company | ALOKA CO., LTD. |
| Development Period | November 1980 – August 1982 |
| Development Fund | Approx. 170 million yen |
| Abstract | This electron scanning ultrasonic diagnostic instrument allows users to image the real-time tomogram of a human body's inner tissues and to visualize internal organs such as heart and fetus as an effective diagnostic tool. It is easy to use the attached probe because the tomogram can be displayed immediately after users touch it onto the surface of a human body. Clinicians thus have been calling for development of a downsizing and portable electron scanning ultrasonic diagnostic device like an auscultator.<br>Previously, a scan conversion-type electronic scanning ultrasonic diagnostic system has been generalized using the XY monitor method, requires a measurable amount of power without displaying a tomographic image on a TV monitor or by the digital scan converter method, which can display the tomogram on TV monitors; however, both methods made it hard to reduce size and weight due to scale of system composition and electric power consumption.<br>The present portable device, developed by this technology, has a new standard television system to process images by the electron scanning ultrasonic diagnostic system. Since its display and body are downsized and light-weight, one can easily handle and transport to medical wards and patients' homes at a moderate price and with high-quality diagnostic images. |
| Use and Application | Downsized and light-weight ultrasonic diagnostic device |

Figure

Appearance of the product

Diagnosis with the instrument

# Immediate-acting oxygen concentrator for medical use

| | |
|---|---|
| Researcher | SATO Toru (Tottori University) |
| Company | Air Liquide Japan Ltd., SANYO ELECTRONIC INDUSTRIES CO., LTD. |
| Development Period | November 1980 – November 1982 |
| Development Fund | Approx. 91 million yen |
| Abstract | Generally, high-pressure oxygen gas is used in home oxygen therapy for treatment of chronic respiratory failure. It is hard for patients to handle the high-pressure oxygen gas and to exchange or refill gas into cylinders with the required special equipment. Also, the cost is high because of repeated transporting of small volumes of the gas to patients' homes.<br>In this technology, absorbent that can absorb nitrogen better than oxygen is used to continuously produce concentrated oxygen for medical use. Advantages in oxygen concentrator include easy and safe operation system, no concern for refilling oxygen gas and low cost for inhaling oxygen, compared with conventional therapy of high-pressure oxygen gas.<br>The importance of long-term home oxygen therapy for patients with chronic respiratory failure has increased, resulting in these patients and their families having particularly large expectations for oxygen concentrators, which can provide safe and economic home oxygen therapy on a regular basis. This product, therefore, is expected to become popular. |
| Use and Application | Long-term home oxygen therapy |

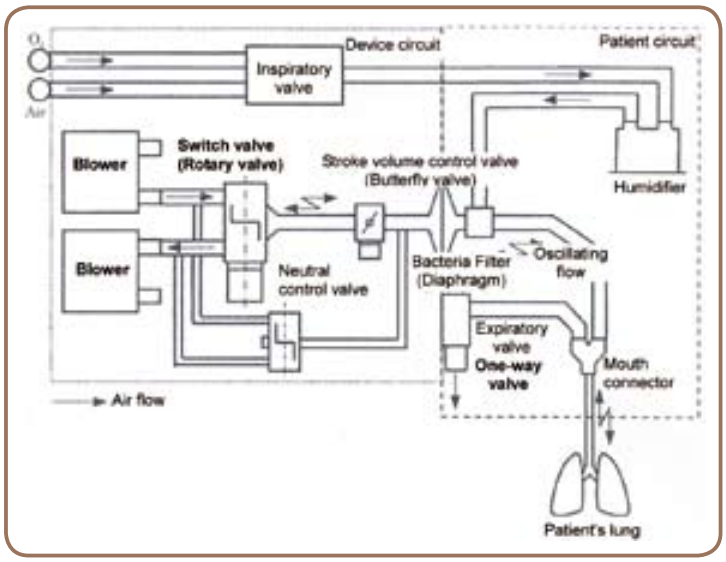
Figure

Immediate-acting oxygen concentrator for medical use

# High-frequency ventilator for adults

| | |
|---|---|
| Researcher | YAMADA Yoshitsugu (The University of Tokyo) |
| Company | SUZUKI MOTOR CORPORATION, Metran Co., Ltd. |
| Development Period | January 1992 – July 1998 |
| Development Fund | Approx. 270 million yen |
| Abstract | In general, mechanical ventilation is performed when first a large volume of fresh air is slowly supplied into the lung then exchanged for carbon dioxide reserved in the lung. Thus, the lung is over-dilated unintentionally because of the increased pressure, particularly in cases of severe lung disease.<br>In contrast, with this high-frequency ventilator for adults, fresh air volume in the lung, breath-by-breath, will decrease and ventilation frequency will increase by introducing shallow and rapid ventilation (high-frequency ventilation), thereby reducing the extent of lung dilation and suppressing increased pressure in the lung.<br>This technology can reduce a compulsive lung movement during ventilation and transfer to normal breathing status smoothly according to patient's recovery, suggesting that incidence of lung injury may decrease compared with conventional ventilator usage. For this reason, the high-frequency ventilation is suitable for patients with severe respiratory failure whose lung function has substantially decreased, as well as artificial breathing for patients undergoing chest surgery. At present, the high-frequency ventilation is attracting considerable attention from foreign countries and a clinical trial is in progress in the UK as a three-year project (i.e., the OSCAR Trial). |
| Use and Application | Reducing lung burden during normal mechanical ventilation, mechanical ventilation for patients with respiratory failure and patients having undergone surgery |

Figure




Overview of high-frequency ventilator for adults

High-frequency ventilator for adults

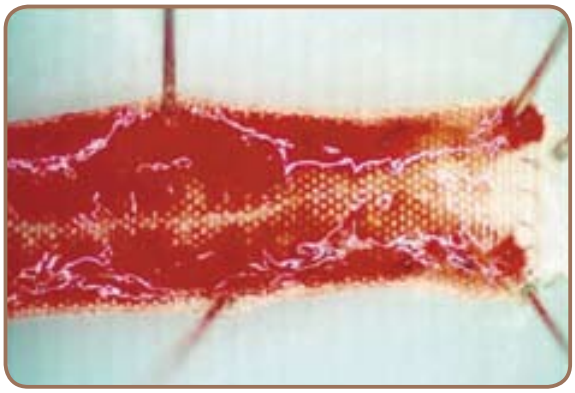
# Manufacturing technology of polymer with phospholipid polar group

| | |
|---|---|
| Researcher | NAKABAYASHI Nobuo (Tokyo Medical and Dental University),<br>ISHIHARA Kazuhiko (The University of Tokyo) |
| Company | NOF CORPORATION |
| Development Period | March 1994 – March 1999 |
| Development Fund | Approx. 800 million yen |
| Abstract | Although silicone and polyethylene are used as materials for tubes and catheters for medical use, these materials had problems such as inducing rejection like blood coagulation due to being recognized by bioorganism as foreign matters.<br>This technology introduced phospholipid polar group (phosphorylcholine group) as a constituent of biomembrane (cell membrane), and succeeded in manufacturing polymer with excellent biocompatibility in such a point that protein and blood cells hardly attach to it, which has never achieved in the conventional products. |
| Use and Application | Raw materials for contact lens and cosmetics |

Figure

Evaluation of the biocompatibility of MPC polymer applied to artificial blood vessels

Artificial blood vessel coated with MPC polymer
(opened even after 8 months)



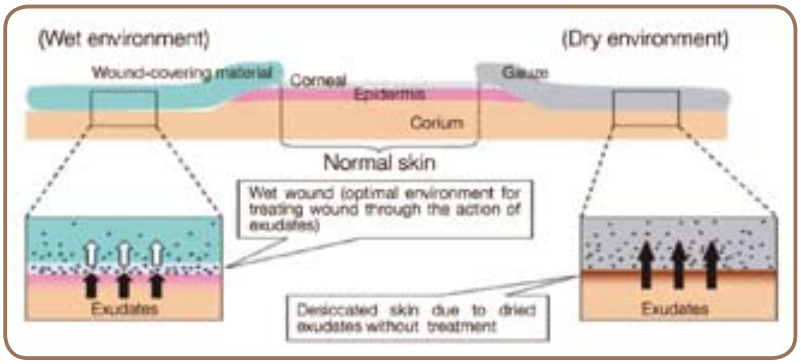
Artificial blood vessel without coating of MPC polymer
(closed in 90 min)

Cosmetics blended with MPC polymer

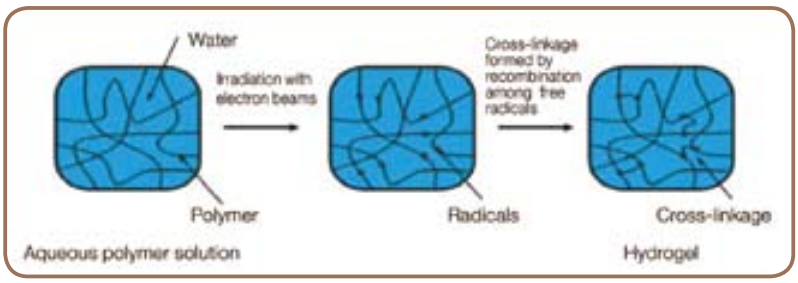
# Hydrogel formulation type for wound-covering material

| | |
|---|---|
| Researcher | YOSHII Fumio (Japan Atomic Energy Agency) |
| Company | NICHIBAN CO., LTD. |
| Development Period | March 1996 – September 2002 |
| Development Fund | Approx. 320 million yen |
| Abstract | In recent years, in the treatment of wounds healing such as burn wound, bedsore, and traumatic injury, wet healing, which is a therapy to encourage wound-healing by utilizing the components of exudates, is expanding. A medical device used at that time, which absorbs excessive exudates and maintains moderate moisture, is called wound-covering material. Since the conventional device had problems such as solution due to absorbing excessive exudates as well as opacity to conceal the wound site, the improvement of such problems has been expected.<br>In this technology, by applying electron beams to aqueous polymer solution, cross-linkages are formed among polymer molecules, leading to the generation of transparent hydrogel. Network structure formed at this time retains moisture, which gives wound covering material with moderate water absorbability and strength. In addition, this hydrogel does not dissolve even after absorbing exudates, and thus the wound-covering material easier for handling than the conventional products has been realized. |
| Use and Application | Wound-covering material for medical device |

Figure




Treatment of wound under wet environment and dry environment



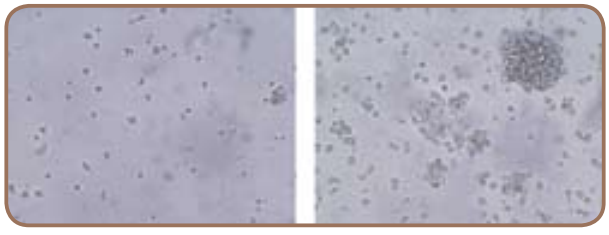

Formation mechanism of hydrogel

# Activated lymphocyte culture kit for treatment of virus infection

| | |
|---|---|
| Researcher | ITO Kiminari (Foundation for Biomedical Research and Innovation), SEKINE Teruaki (National Cancer Center) |
| Company | Lymphotec Inc. |
| Development Period | March 2000 – March 2004 |
| Development Fund | Approx. 420 million yen |
| Abstract | When patients with immunodeficiency due to congenital immune deficiency, cancer, or bone-marrow transplant are affected with viral opportunistic infection, serious symptoms can occur and be hard to completely improve using antiviral medication. Elimination of virus-infected cells is performed through T cells in the human body, and "activated self-reactive lymphocytes therapy," in which T cells collected from a patient are activated and amplified *in vitro* and then returned to the patient, is expected as a therapy for treatment of opportunistic infection. To become a popular therapy, this therapy has required a safe and effective culture method of lymphocyte that is standardized among medical settings.<br>This technology is a culture kit that can safely proliferate a large amount of lymphocytes from a small amount of the peripheral blood. This culture kit consists of a culture flask immobilized anti-CD3 antibody that activates lymphocytes and a medium for proliferating lymphocytes, and is produced in facilities conformed with GMP standards (GMP: Good Manufacturing Practice specified by the Ministry of Health, Labour and Welfare). |
| Use and Application | Research and prevention/treatment of various viral infections |

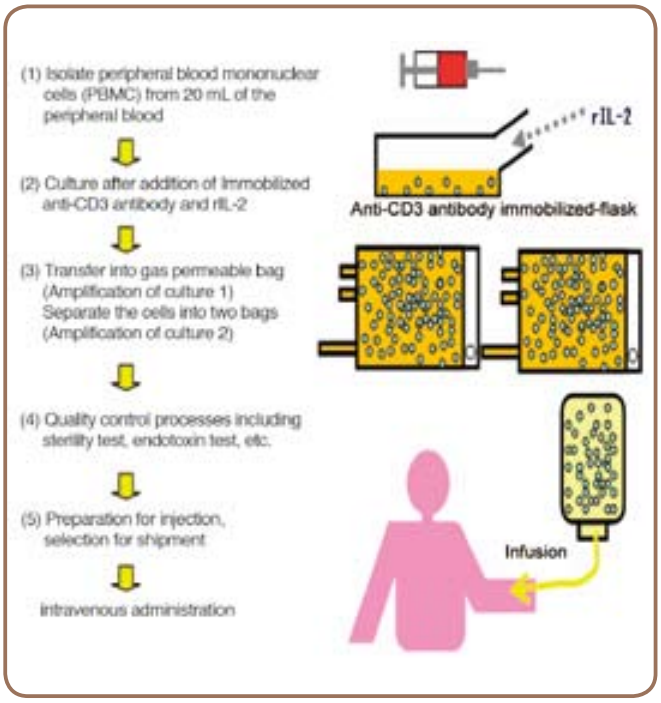
Figure

OKT3 antibody, which is anti-CD3 antibody, is physically adsorbed on the bottom surface of anti-CD3 antibody immobilized flask.



Non-immobilized Anti-CD3 antibody immobilized

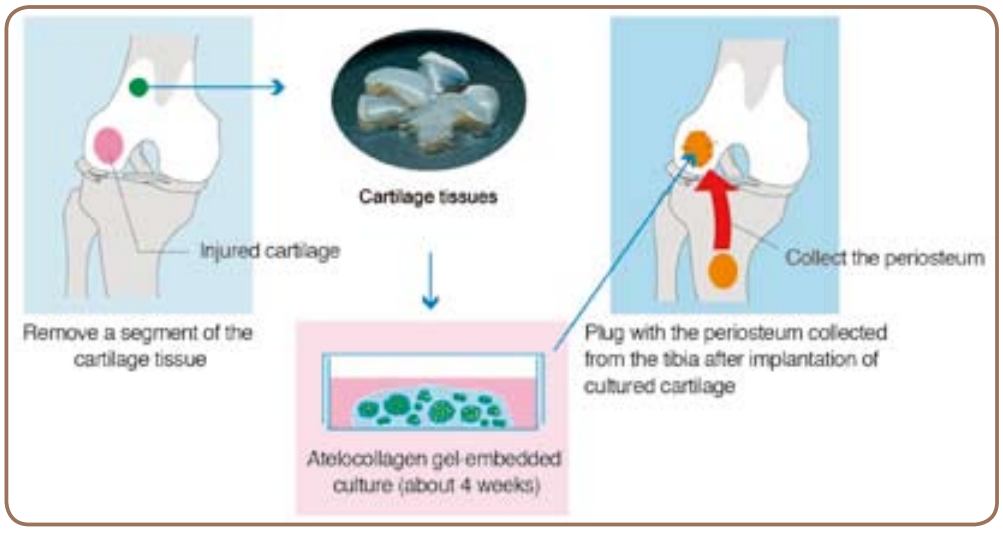
Lymphocytes from the peripheral blood of a healthy subject incubated in anti-CD3 antibody immobilized flask



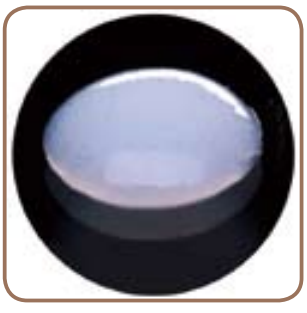
# Human culture cartilage using self-regulated culture method

| | |
|---|---|
| Researcher | OCHI Mitsuo (Hiroshima University), TAYA Masahito (Osaka University) |
| Company | Japan Tissue Engineering Co., Ltd. |
| Development Period | March 2000 – September 2007 |
| Development Fund | Approx. 460 million yen |
| Abstract | This technology represents a regenerative therapy for treatment of cartilage injury using autologous chondrocyte.<br>Since injury in the cartilage tissues does not recover spontaneously, only palliative therapy has been available for treating this disease. In addition, the number of patients with arthropathy is estimated to increase due to athletic injury and the increasing elderly population. Thus, a new therapy for cartilage injury is needed.<br>In this technology, a small amount of cartilage tissues is collected from patients with injury in the cartilage through arthroscopic surgery, and then cartilage tissues are implanted into the injured portion after they are three-dimensionally cultured in atelocollagen. The safety and effectiveness of this therapy has been evaluated in a clinical trial.<br>Treatment with autologous chondrocyte implantation represents a new opportunity for patients with impaired articular cartilage and is expected as a QOL (quality of life) improvement for patients suffering from arthropathy. |
| Use and Application | Treatment using autologous chondrocyte implantation |

Figure




Flow of cell isolation to tissue implantation

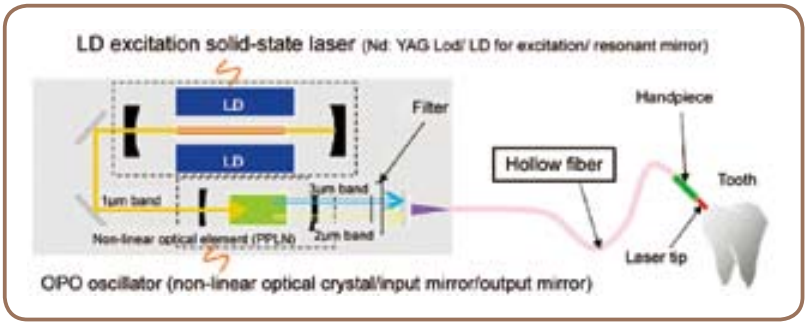


Cultured cartilage

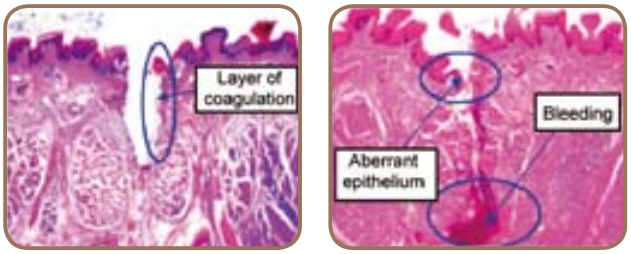
# Dual-wavelength laser device for dental care

| | |
|---|---|
| Researcher | MIYAGI Mitsunobu (Tohoku University) |
| Company | J. MORITA MFG. CORP. |
| Development Period | March 2001 – March 2005 |
| Development Fund | Approx. 220 million yen |
| Abstract | Recently, dental care laser treatment has become popular, and different types of lasers are needed for soft tissues, such as the gingiva and hard tissues, such as teeth. Several laser devices, however, are needed in a clinical setting because there has been no device that simultaneously generates a multiple-wavelength laser or fiber that can effectively transfer such a laser. There have, therefore, been problems, including installation location, high-cost structure, and increased duration of treatment.<br>This technology can efficiently transfer a dual-wavelength laser in the 2 μm band with hemostatic effect, and in the 3 μm band with the ability of incising and cutting hard tissues using a flexible hollow fiber with dielectrics embedded as a tool of transmitting the dual-wavelength laser. This device enables performing both incision/hemostasis of soft tissues and cutting of hard tissues in dental care, in hope reducing patients' mental burden due to decreased treatment duration. |
| Use and Application | Cavity protection or treatment for periodontal disease, treatment for root canal |

Figure




Overview of the Dual-Wavelength Laser Device

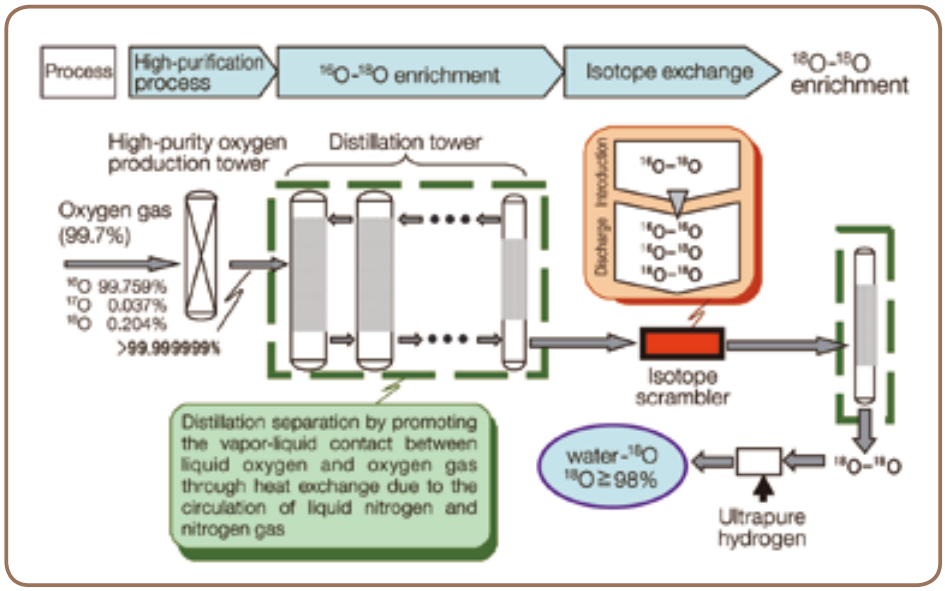



A case of results immediately after incision of soft tissues
(Left view, this device; right view, incision using a scalpel)

# Manufacturing technology of water–$^{18}$O for PET cancer diagnosis

| | |
|---|---|
| Researcher | ASANO Koichi (Tokyo Institute of Technology) |
| Company | TAIYO NIPPON SANSO CORPORATION |
| Development Period | March 2001 – June 2004 |
| Development Fund | Approx. 1.3 billion yen |
| Abstract | The FDG-PET examination method for the early diagnosis of cancer has been attracting considerable attention in recent years. Labeled water with oxygen 18 stable isotope, an original material for FDG drugs, was conventionally manufactured using water or nitrogen monoxide. However, the development of mass manufacturing process with less energy consumption and high safety has been expected.<br>In this technology, the distillation technology of multi-component system mixture based on simultaneous transfer model of heat and materials is applied to manufacturing. This process lowered energy cost with an one sixth of evaporative latent heat compared with the conventional method. In addition, since this process does not use nitrogen monoxide with chemical instability and toxicity, safety is ensured. Thus, mass production in the scale of 100 kg/year of high purity water-$^{18}$O (more than 97%) has become possible. |
| Use and Application | Water for PET cancer diagnosis |

Figure




Manufacturing process of water-$^{18}$O distilling

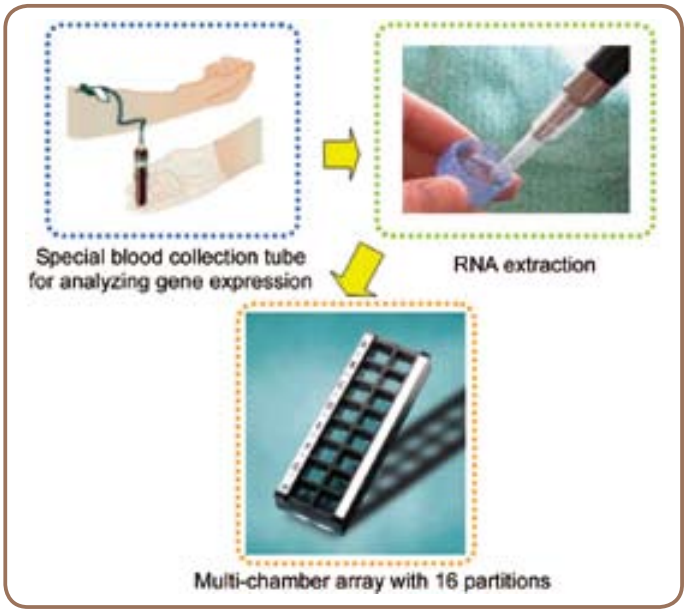
water-$^{18}$O distilling plant
Dimension : ca. 7m × 3.5m × 70m high.
It contains 13 distillation tower, ahigh-purity oxygen tower, a nitrogen circulation compressor, and an expansion turbine to generate frigidity.

※ PET : positron-emission-tomography
FDG : fluorodeoxyglucose

# Test kit for schizophrenia

| | |
|---|---|
| Researcher | NAWA Hiroyuki (Niigata University) |
| Company | SRL, Inc. |
| Development Period | March 2003 – March 2008 |
| Development Fund | Approx. 330 million yen |
| Abstract | Early treatment schizophrenia, which has a morbidity rate approximately 0.8%, is important, but no objective evaluation method using biological markers has been established. Diagnosis of schizophrenia largely depends on clinicians' experience, and thus there has been a need for a test method that can identify the disease in its early stages.<br>In the development phase, analysis results of approximately 55,000 genes using DNA microarray identified nearly 10 genes that have changed in association with schizophrenia as possible biological markers.<br>This test kit is expected to allow clinicians to diagnose schizophrenia in its early stages and contribute to avoiding the aggravation and improvement of recovery rate by realizing the early treatment. |
| Use and Application | Test kit as a support tool for diagnosis of schizophrenia |

Figure




Measurement method

Sample of measurement (approximately 2000 DNAs are identified per spot)

# Microsurgery device with high accuracy

| | |
|---|---|
| Researcher | GOTANI Hiroyuki (Osaka City University) |
| Company | NST Co., Ltd. |
| Development Period | December 2003 – December 2006 |
| Development Fund | Approx. 45 million yen |
| Abstract | Microsurgery, including angiorrhaphy for micro vessels, can only be performed in a medical institution that has experienced surgeons; however, medical service of this type is not provided in non-specialized hospitals.<br>The apparatus developed with this technology is a manipulator robot system that consists of the following two parts: the "master part" of the mechanical arm structure to input the operator's hand motion, and a "subordinate part" to scale down and duplicate motion of the master part.<br>This system helps surgeons in microsurgery and is expected to be useful for precision machines requiring micromotion and biotechnology-based manufacturing facilities. |
| Use and Application | Microsurgery |

Figure

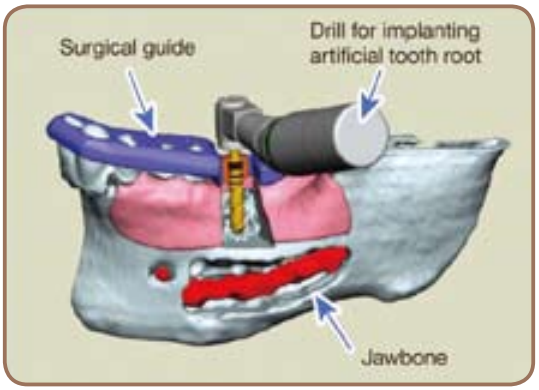
Master part

Subordinate part

# On-the-bone stent for dental implant surgery

| | |
|---|---|
| Researcher | SOHMURA Taiji (Osaka University) |
| Company | Wada Precision Dental Laboratories Co., Ltd. |
| Development Period | October 2004 – October 2007 |
| Development Fund | Approx. 130 million yen |
| Abstract | In recent years, dental implant treatment has been attracting people's attention. In this treatment, when a tooth is lost, an artificial tooth root (implant) is buried into the jawbone, and repairing tooth crown is placed on it. However, since surgical operation to bury dental implant by opening a hole in the jawbone is necessary, the development of a support system to enhance the safety and accuracy of surgery has been craved.<br>In this technology, instead of conventional 2D X-ray photograph, 3D image that precisely incorporates the positions of a denture mold and CT jawbone image, is used. By this originally developed means, the simulation of the proper position to bury an implant corresponding to each patient's symptom has become possible. In addition, a surgery supporting guide (surgical guide) for correctly and safely drilling in the jawbone and for burying the implant was designed based on CAD. Using RP (Rapid Prototyping) CAM technology based on a laminating method capable of rapidly molding the 3D model from the 3D CAD data, the surgical guide was precisely formed. In addition, by providing the jawbone model made by RP, diagnosis prior to an operation has become possible, and the training of operation has become possible.<br>Thanks to this technology, the precise and safe support for a variety of implant burying operations, including not only the cut-opening of gingiva but also a less-invasive operation technique with low load for patients without opening or peeling, has become possible. |
| Use and Application | (1) dental implant surgery, and (2) training tools for dentists and pre-surgery explanation tools for patients |

Figure




Schematic chart for surgery using jawbone model and surgical guide


Surgical guide molded using 3D resin lamination molding machine

# Automatic culture device for multiple patient cell lines

| | |
|---|---|
| Researcher | TAKAGI Mutsumi (Hokkaido University) |
| Company | Kawasaki Heavy Industries, Ltd. |
| Development Period | March 2005 – March 2008 |
| Development Fund | Approx. 400 million yen |
| Abstract | Cells cultured for regenerative medicine are adhesive cells that mainly consist of mesenchymal stem cells. Culture procedures of these adhesive cells are performed manually in CPC (Cell Processing Center) in sterilization rooms for medical use. In this condition, an aseptic technique is required to avoid cross-contamination, whereby it is difficult to treat multiple patient cells simultaneously and to prevent such a contamination with great distress to operators. An automated culture system for adhesive cells will contribute to spreading regenerative medicine. Moreover, it is expected to provide cells with a constant, stable quality because of needs in other areas, such as drug research.<br>For this technology, an automated culture system has been developed using elemental technologies, including sterilization, image processing, and robotics. This enables automatic culturing of multiple patient cell lines by combining technologies. The combined system also allows operators to steam-sterilize common operation parts by separating parts from several compartments for culture/proliferation of cells, to perform changing media and passage culture using robotics, and combining image processing. In addition, multiple patient cell lines can be cultured and evaluated simultanously. This automatic culture system was developed for drug research and development as a sample of the system. In the future, this system is expected to be used in areas including clinical settings in regenerative medicine and drug research towards accelerating applied development of iPS cells. |
| Use and Application | Regenerative medicine |

Figure

Automatic culture system

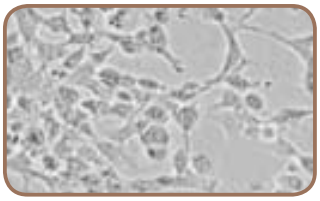
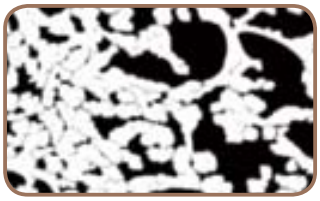


Image observed by users



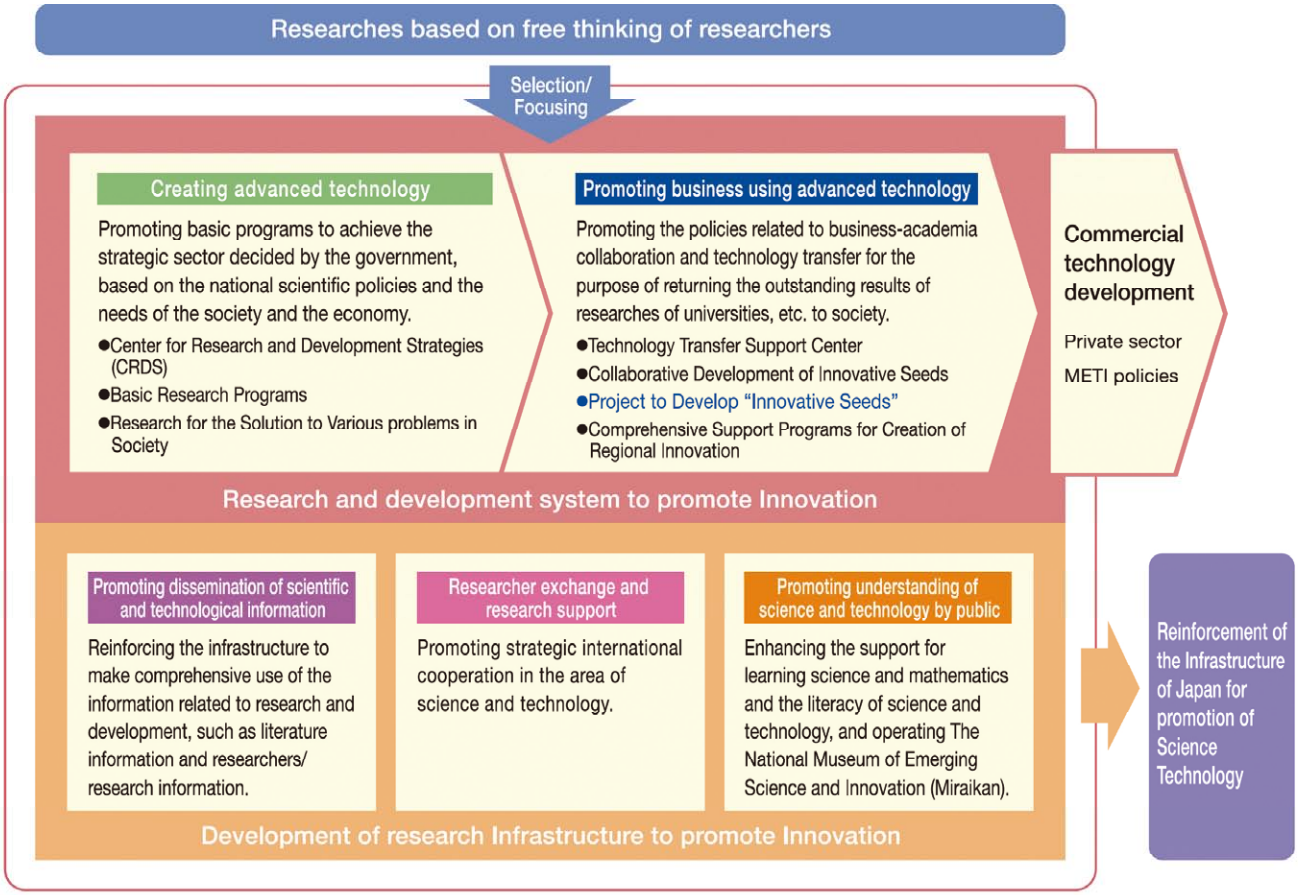
Cells displayed in white
(determined by computer)

Independent Administrative Institution
Japan Science and Technology Agency

# An integrated organization of science and technology in Japan that establishes an infrastructure for the entire process from the creation of knowledge to the return to the society.

## Content of Activities & Diagram

- Creating advanced technology
- Promoting business using advanced technology
- Promoting dissemination of scientific and technological information
- Researcher exchange and research support
- Promoting understanding of science and technology by the public





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