March 28, 2016
Corporate R&D Department
Showa Denko K.K.
Main Businesses of SHOWA DENKO

Petrochemicals 31%

Chemicals 15%

Electronics 15%

Inorganics 7%

Aluminum 11%

Others 21%

2014 Consolidated net sales 876.6 billion yen

- Lithium-ion battery (LIB) materials, building products, and general trading, etc.
- Olefins (ethylene and propylene) and organic chemicals (ethyl acetate), etc.
- Rolled products (high-purity foils), specialty components (cylinders for LBPs), and beverage cans, etc.
- Graphite electrodes, and ceramics (alumina and abrasives), etc.
- Functional chemicals, industrial gases, basic chemicals, and electronic chemicals (specialty gases), etc.
- Hard disks (HDs), compound semiconductors, and Rare earth magnetic alloys, etc.
## Inventory/Summary of Technologies

**Strength = Diversified Range of Core Technologies**

### Existing Businesses

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### Material Design

- **Core Technologies**
  - High-performance Catalysts: ●
  - Specialty Gas Chemicals: ●
  - Molecular Structure: ○
  - Functional Resins: ●
  - Metallic Materials: ○
  - Inorganic Materials: ●
  - Carbon Structure: ●

### Synthetic Process

- **Polymerization Control**
  - Purification: ○
  - Micro-particulation: ○
  - Membrane/Crystal Growth: ●

### Manufacturing Process

- **Element Manufacturing**
  - High-heat Processing: ●
  - Mixing/Dispersion: ●
  - Casting/Molding: ●
  - Surface Treatment: ○
  - Interface Bonding: ○
  - Heating/Cooling Control: ○
  - Laminate/Printing: ●

### Fundamental Technology & Business Assistance

- Computational Science and Technology Information Center,
  Analysis & Physical Properties Center, Safety Evaluation Center

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Petrochemicals

Material Design Technologies
Synthetic Process Technologies
Manufacturing Process Technologies

Common Technologies: Center
Peculiar Technologies: Next to the Products

Purification
High-performance Catalysts
Polymerization Control
Molding/Casting
Surface Treatment

Basic Petrochemicals
Olefin Derivatives
Organic Chemicals
Ethyl Acetate
Allyl Alcohol Derivatives

Molecular Structure Design
Heat-resistant Transparent Film
SHORAYAL™
Chemicals-1 ~Gas Products~

High-purity Gases/Solvents for Electronics

SOLFINE™

Purification

Surface Treatment

Clean-S™

High Corrosion Resistant Plating

Fluorine Chemicals

Specialty Gas Chemicals

Mixing/Dispersion

High-heat Processing

Supercritical Carbon Dioxide(CO₂)

SHOWA DENKO GAS PRODUCTS

Industrial Gases

ECOANN™
Chemicals-2 ~Functional Products~

- **Functional Monomers**
  - Karenz™
  - NVA

- **Molecular Structure Design**
- **Surface Treatment**

- **Functional Cosmetic Raw Materials**
  - Apprecier™

- **Purification**

- **Polymerization Control**

- **HPLC Columns**
  - Shodex™
  - CIM™
  - Autoprep™

- **Water-soluble Polymers**
  - VISCOMATE™
  - PNVA™
Chemicals-3 〜Resin Products〜

- **Resins for Electronic Materials**
  - Ripoxy™
- **Substrate solder mask**
  - Nippon Polytech Corp.
- **Synthetic Resin Emulsion**
  - Polysol™
- **Chlorinated Polyethylene**
  - Elaslen™
- **Mixing/Dispersion**
- **Molding/Casting**
- **Resins for Composite Materials**
  - Rigolac™, Ripoxy™
- **Polymerization Control**
- **Functional Resin Design**
- **Molding Compounds**
  - Rigolac™ Molding Material
- **Biodegradable Plastic**
  - Bionolle™
Inorganics ~Carbon~

Graphite Electrodes

Carbon Structure Control

Mixing/Dispersion

High-heat Processing

Purification

Molding

Graphite Grain

Shocaraiser™

Whole grain-M
Advanced Battery Materials

Artificial Graphite Negative Electrode Materials

SCMG™

High-heat processing

Carbon Structure Control

Membrane/Crystal Growth

Vapor-grown Carbon Fiber

VGCFTM

Mixing/Dispersion

Laminate/Printing

Micro-particulation

Carbon Coated Foil

Separators

Casting/Molding

LIB Packing Materials

SPALF™

Showa Denko Packaging Co., Ltd.
Projects

- SiC Epitaxial Wafers
- Membrane/Crystal Growth
- High-heat Processing
- Surface Treatment
- Specialty Gas Chemicals
- Casting/Molding
- Plant Growth Facilities
  - SHIGYO™ Method (Fast Cultivation Method)
  - SHIGYO™ Cultivation Unit
- LED Technology
- Aluminum Technology
R&D

Printed Electronics

- Functional Resin Design
- Membrane/Crystal Growth
- Micro-Particulation
- Metallic Materials
- Polymerization Control
- Mixing/Dispersion
- Laminate/Printing
- High-heat Processing

Ag Nanowire Ink

(Printing performance) Line/Space = 110/70μm

Ag Nanowire

Printed Electronics

Line/Space = 110/70μm
Fundamental Technology & Business Assistance

Computational Science and Technology Information Center

Computing Science

Chemical Analysis/Structure Analysis

Safety Evaluation

Analysis & Physical Properties Center

Fundamental Technology Assistance

Business Assistance

Safety Evaluation Center
Ideas, hopes and dreams for your happily ever after.

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**Inorganics**

- Graphite Electrodes
- High-purity Aluminum Foil
- Heat Exchangers
- Automotive Cooling Devices
- Continuously-cast Rods
- Hard Disks (HD)
- Rare Earth Magnetic Alloys
- Anode Material for Lithium Ion Secondary Batteries
- Carbon Coated Foil
- LiB Packing Materials
- SiC Epitaxial Wafer
- Plant Growth Facilities
- Printed Electronics
- Computational Science and Information Center
- Analysis & Physical Properties Center
- Safety Evaluation Center
**Organic Chemicals**

**Example products**

- **Ethyl acetate**
  - ⇒ Printing ink, paint, thinner, adhesive
- **Vinyl acetate**
  - ⇒ Raw materials for PVA, EVA, paint
- **n-propyl acetate**
  - ⇒ Printing ink, paint, thinner
- ** Allyl alcohol**
  - ⇒ Raw materials for ophthalmic lenses, perfume material, intermediate of medicine, epoxy resin, PBT

**Our technologies**

We own the following technologies:

- Catalyst design
- Catalyst analysis
- Catalyst performance evaluation

Using the catalysts we have developed, we are promoting the acetyl chain business at the Oita complex.

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Ethylene

Acetaldehyde

Ethyl acetate

Acetic acid

Vinyl acetate

Propylene

Allyl acetate

n-propyl acetate

Allyl alcohol

Ethyl acetate plant
Heat-resistant Transparent Film
〜 SHORAYAL™ 〜

Example products
Taking advantage of its high transparency and heat resistance, the film is expected to be applied to display-related components.

Example of application to protective film “SHORAYAL-GUARD™”

Our technologies
Molecular/catalyst design technologies combined with polymerization/molding/surface treatment technologies enable the manufacture of functional films superior in transparency and heat resistance.

- Molecular design technology
  + Property control

- Molding control
  + Roll-to-roll film formation

- High-performance catalyst technology
  +Polymerization control

- Surface treatment technology
  +Functionalities added (Hardness, tactile impression, optical characteristics)

Example of application to protective film “SHORAYAL-GUARD™”

Mobile device
Flexible display

SHORAYAL™

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Example of application to protective film “SHORAYAL-GUARD™”

Mobile device
Flexible display

SHORAYAL™
High-purity gases/chemicals for electronics ~ for most advanced semiconductors ~

Example products

High-purity gases / chemicals are used in the electronic industry for, for example, most advanced semiconductor manufacturing processes and FPD production processes.

Our technologies

Using purification technologies of “distillation, extraction, and filtration,” high-purity gases for semiconductors are manufactured.

To ensure the quality of the products, we own technologies including the following:

- Technology to treat and clean the inside of containers
- Sensitive analysis technology (LC, GC, ICP-MS)
- Plant construction and mass production technology

Example products:
- Plant to fill high-purity solvents
- Sensitive analysis instrument (ICP-MS)
Fluorine Chemicals

Example products

Fluorine compounds are used for dry-cleaning, whereby the dirt adhering to the reactor of semiconductor manufacturing devices is converted into gaseous substances to clean the devices.

Taking advantage of such characteristics, fluorine chemicals are used for dry-cleaning, whereby the dirt adhering to the reactor of semiconductor manufacturing devices is converted into gaseous substances to clean the devices.

Our technologies

Fluorine is an atom that can easily combine with any element. Utilizing such characteristics of fluorine, our fluorine technologies are applied to various products.

We own technologies including the following:
- Fluorine synthesis technology (2HF → F₂ + H₂)
- Fluorine compound synthesis technology (gas phase)
- Fluorine compound synthesis technology (liquid phase)
- Sensitive analysis technologies (LC, GC, ICP-MS)
- Plant construction and mass production technology
High Corrosion Resistant Plating
〜Clean-S™〜

Example products

We undertake the treatment of metal surfaces to prevent corrosion, such as cylinders, pipes, and valves.

Such treatment is used for various applications, such as semiconductor manufacturing device components, vacuum pumps (molecular pumps, dry pumps), and plastic injection molding machines.

Our technologies

■ Surface treatment technology

We own the technology to improve corrosion resistance performance by forming nickel alloy films on SUS and aluminum using an electroless plating process.

We have also developed our own passive state treatment technology to form NiF2 films through the reaction of fluorine gas, thus achieving high corrosion and abrasion resistance.
Supercritical Carbon Dioxide (CO₂)

Product Example

The use of supercritical CO₂ enables processes that conventionally needed organic solvents as well as processes not possible with organic solvents.

Our technologies

- Supercritical CO₂ application technology

Features of supercritical CO₂

1. Dissolves organic substances well.
2. Can be dissolved well in resins to reduce their viscosity.
3. Can be discharged as a gas when the pressure is reduced to atmospheric pressure.

Applications of supercritical CO₂

1. Cleaning/drying: Precision removal of even infinitesimal amounts of ingredients
2. Dyeing/impregnation: Transferring effective ingredients to nano-sized spaces
3. Painting: Alternative to a dilution solvent
4. Creating a fine powder: Using the bubbling and cooling effects when sprayed
5. Macromolecular polymerization: Reaction field with no residual solvent
Functional Monomers

Product Example

Polyfunctional secondary thiol compound

Multipurpose isocyanate monomer

Special water-soluble monomer

Our technologies

Molecular structure design technology

To meet the demand for higher performance, we design and provide various functional monomers.

- Improving adhesion
- Improving curing reaction performance
- Providing polymerization ability
- Providing water solubility
- Reducing odor, etc.

Molecular design of organic compounds

- Introducing highly reactive functional groups
- Providing polyfunctionality

Development of an optimal synthesis process

- Minimal step synthesis
- Knowhow to select a reaction catalyst

Establishment of an industrializing process

- Protecting reaction functional groups
- High purification
- Water amount control
HPLC Columns ~Shodex™~

**Product Example**

High-performance liquid chromatography (HPLC) plays an active role in various fields, including:
- Product quality inspection
- Factory process inspection, and
- Environmental analysis.

Analysis of sugar content in apple juice

Sample: Apple juice 5uL
1. Sucrose
2. Glucose
3. Fructose
4. Sorbitol

Column: Shodex SUGAR SC1011
Eluent: H₂O
Flow rate: 0.6mL/min
Detector: RI
Column temp.: 85℃

**Our technologies**

- **Surface modification technology**
- **Gel synthesis technology**

The interaction of each ingredient in the sample and the gel filled in the column causes separation.

**Polymer gel manufacturing technology**

- Gel size control
- Fine pores size control
- Fine pores quantity control
- Surface hydrophobicity control

**Gel synthesis**

- **Monomer selection**
  - Styrene
  - Methacrylate
  - Vinyl alcohol
  - N-vinyl acetamide

**Surface modification**

- **Selection**
  - Alkylation
  - Alkoxylation
  - Halogenation
  - Sulfonation
  - Carboxylation
  - Amination
  - Affinity ligand
Functional Cosmetic Raw Materials

**Product Example**
The products feature functionality and high quality. Both physiological data and prescribing information can be provided together.

- Stabilized vitamin C derivative, amphipathic vitamin C derivative, water-soluble vitamin E derivative, amphipathic carnitine derivative, etc.

These materials are contained in various quasi-drugs and cosmetics both in Japan and abroad and help improve the quality of life of users.

**Our technologies**
- **From chemical compound design to industrial production**
  We can create high functional derivatives from a parent compound with a highly safe physiological active substance.
  We also own the technology to produce such derivatives on an industrial scale.

- **Physiology evaluation**
  We own the technology to evaluate functional cosmetic raw materials created using biochemical techniques based on dermatology.

- **From properties to prescription**
  We offer a range of services, from product property analysis to prescription examination.
Product Example
- **Binder resin for color filters**
  Contributing to realizing high-definition LCD.

Our technologies
- **Polymer design technology**
  Providing photocuring and thermosetting resins with various characteristics
  Developability, heat resistance, solvent resistance, flexibility, high refractive index, adhesion, optical transparency, dispersibility, etc.

Polymer design meeting the required performance

Family of products constituting Ripoxy™ and examples of applications
- Epoxy acrylate resin
  Applications: Solder resist, various paints, dicing tape
- Acrylic resin
  Applications: Color filter resist, semiconductor resist
- Urethane acrylate resin
  Applications: Adhesive for optical use
**Product Example**

- Adhesive for tapes
- Fiber processing resin
- Adhesive for building materials
- Paint binder for exterior materials

**Our technologies**

We optimize the synthetic resin emulsion “Polysol™” to suit various applications.

- Polymer design technology (Acrylic, vinyl acetate, ethylene-vinyl acetate)
- Morphology control technology (Particle diameter, particle shape, heterophase structure)
- Emulsion design
- Modification technology
- Processing technology
Resins for Composite Materials
〜Rigolac™, Ripoxy™〜

Product Example

- Chemical tank
- FRP waterproofing
- Resin concrete
- Pipe lining
- Floor material
- Heat-proof paint

Our technologies

- **Synthesis technology**
  With a focus on unsaturated polyester resin, vinyl ester resin, and urethane-acrylic resin, we own resin synthetic technology meeting such requirements as flexibility, hardness, high strength, and high heat resistance. We can also develop new resin systems.

- **Compounding technology**
  While considering the final usage environment and purpose, we can propose usage methods such as compounding additives, including fillers, curing agents, and accelerators, while also drawing up construction specification proposals, for example.

- **Physical property evaluation**
  We can evaluate the basic properties of products and make various measurements while considering the actual usage conditions.

- **Technical guidance**
  To prevent troubles when the products are used, we can attend and provide technical guidance as required when the products are used. If any trouble arises, we will study countermeasures.
**Molding Compounds**

~Rigolac™ molding compounds~

**Product Example**

- **Head lamp reflector**
- **Body**
- **Motor for HV/EV**
- **Breaker (Heavy electric parts)**
- **Motor for home appliances**

**Our technologies**

- **Formulation technology**
  We provide optimally formulated thermosetting molding materials that meet customers’ requirements.

- **Physical property evaluation technology**
  We can evaluate various physical properties of molded parts in-house, such as mechanical properties, electrical properties, and chemical resistance.

- **Moldability evaluation technology**
  We own various molding machines and can mold prototypes and will propose molding conditions that optimize the physical properties.

**SMC (Sheet Molding Compound)**

**BMC (Bulk Molding Compound)**
Biodegradable Plastics
〜Bionolle™〜

Product Example
Application that utilize the biodegradability of Bionolle™ (PBS: polybutylene succinate), as well as its physical properties similar to those of polyethylene.

Mulch films
No need to collect the films after harvesting

Packaging materials
(Plastic shopping bags, garbage bags, etc.)

In various countries, there are restrictions on the use of non-biodegradable single-use bags to protect the environment.

Our technologies

High molecular weight products
Using our unique polymerization technology, we successfully manufactured high molecular weight PBS. Now, various products can be manufactured using a general machine for polyethylene.

Degradability and flexibility control
Degradability and flexibility can be adjusted according to the application by selecting a raw material monomer and adjusting its formulation.

Blending with starch and polylactic acid
We have established technology to blend starch in a high concentration (>30wt%). We named the product STARCLA™. The biomass ratio not only reduces the cost, but also increases the tear strength significantly.

The biomass feedstock, polylactic acid, which is poor in flexibility, brittle, and hard to mold, as blended with Bionolle™, and established the compound showing good moldability and physical properties. We named the product KIYOYUKI™

Biodegradability in compost
It is not necessary to separate kitchen garbage and garbage bags in composting facilities. Of course, the bags also degrade in nature.

Improvement of processability
Alteration of the molecular structure makes it possible to manufacture the grade suitable for foaming and lamination process.

Bionolle™ has been authorized the international certifications that prove its biodegradability.

Application that utilize the biodegradability of Binolle™ (PBS: polybutylene succinate), as well as its physical properties similar to those of polyethylene.

Bionolle™ has been authorized the international certifications that prove its biodegradability.

Four months later, films have biodegraded into tatters.

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No need to collect the films after harvesting

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Solder Mask for Flexible Board

Product Example

Permanent insulating layer for high precision circuits (COF: Chip on Film) mounted with IC driving LCD.

Taking advantage of its excellent insulation reliability and durability, the film improves the image quality of LCD TVs and smartphone LCD panels.

Achieving high resolution, downsizing, long life, and low price

Product Example: insulating film of COF (green part)

COF

LCD panel

IC driving LCD

Printed circuit board

High image quality LCD TV

Our technologies

We can design functional polymers that satisfy various required characteristics according to customers’ demands, and also design ink and paint products that adapt to the customer’s process by using formulation and dispersion technologies.

- Functional resin design technology
  - High insulation properties
  - Flexibility
  - High durability
  - High reliability
  - Reactivity
  - Toughness

- Formulation technology
  - Process compatibility design
  - Printability
  - Curability control

- Mixing/dispersion technology
  - Dispersed particle size control
  - Contaminant management
  - Stable quality

High-performance insulating ink for COF

Nippon Polytech Corp.
Aluminum Hydroxide
〜HIGILITE™〜

Product example
HIGILITE™ is aluminum hydroxide [Al(OH)₃]. Its general characteristics are:
・White powder
・Amphoteric substance
・Contains crystal water → an endothermic reaction occurs when heated.

Taking advantage of these characteristics, HIGILITE™ is used as a raw material of chemicals, flame-resistant fillers, and artificial marble fillers.

Our technologies
We own technology for precipitation from the liquid phase and powder processing technology, and manufacture various kinds of products.

Standard particle aluminum hydroxide

Changing deposition conditions
Particle size/impurity control

Calcination

Breaking/crushing

Fine particle products

Alumina

Blend/classification (Airflow, sifter, etc.)

Products with better workability

Fine particle products

Surface treatment

Products with adjusted particle size distribution

Used as a raw material of aluminum salt and aluminate after reaction with acid and alkali. *Photo: Zeolite Na₂O·Al₂O₃·SiO₂·nH₂O

Used as a fire retardant for wire covering, etc.
We have a lineup of various heat dissipation fillers.

- Low soda alumina (AL)
- Roundish alumina (AS)
- Spherical alumina (ALUNABEADS™ CB)
- Hexagonal boron nitride (SHOBN™ UHP)

**Application example:** Heat-dissipating silicone sheet

Mix and mold with resin.

**Our technologies**

- **High-temperature heat treatment technology**
  We can manufacture various fillers with the particle shape and size controlled through chemical and physical reaction in various kilns and reacting furnaces capable of high-temperature heat treatment.

- **Grinding/classification technology**
  The smashing and classification technology we have cultivated over many years allows us to manufacture fillers with various particle sizes and distributions and to design optimal particle sizes.

- **Compounding/surface treatment technology**
  By compounding fillers and using surface treatment technology suited for various resins, we can provide fillers with a high filling ratio in the resin.

- **Evaluation technology**
  In addition to evaluating the physical properties of fillers, we can also evaluate various thermosetting resin compounds in accordance with customers’ requirements, such as viscosity and heat conductivity.
**Product example**

Taking advantage of its characteristics of high hardness second only to diamond and no reaction with iron, cBN (cubic Boron Nitride) is used as a material of grinding and cutting tools for iron-based high hardness materials.

We manufacture sintered compacts from cBN abrasive grains and offer a range of grades for grinding and cutting various materials.

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**Our technologies**

- **Ultrahigh pressure/temperature technology**
  We own ultrahigh pressure/temperature sintering technology exceeding 5 GPa and 1200°C.

- **Composite sintered compact production technology**
  We own fine particle mixing technology to mix submicron particles together with high dispersion.

- **Sintered compact design/manufacturing technology**
  We not only design and manufacture sintered compacts in accordance with customers’ demands but also manufacture the world’s thickest-class solid cBN sintered compacts.

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**Product example**

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Titanium Oxide
〜 SUPER-TITANIA™ 〜

Product example
SUPER-TITANIA™ is used as a material of multilayer ceramic capacitors (MLCC).

Example of MLCC mounted

MLCC

Functions of MLCC
・Stabilizing voltage
・Eliminating noise
・Retrieving necessary signals etc.

Cross section

Dielectric layer (BaTiO₃)

External electrode

Internal electrode

TiO₂ + BaCO₃ → BaTiO₃

The following are required for titanium oxide as a material of MLCC:
・Fine particles with uniform particle diameter
・High purity
・Excellent dispersibility

Our technologies

■ Fine particle synthesis technology
- Gas phase method: We own the technology to synthesize titanium oxide suitable for MLCC by using equipment we have developed.
- Particle size control technology allows us to manufacture multiple grades.
- Liquid phase method: We own the technology to synthesize titanium oxide in which the crystalline properties and dispersibility of fine particles can be better controlled than by the gas phase method.

■ Fine particle facilities technology
- We own the facilities and quality control technology that enables stable production of high-purity fine particles based on almost 30 years of developing gas phase technology.

■ Fine particle evaluation technology
- We own the technology to evaluate and analyze fine particles from various perspectives to meet customers’ requirements. The results are used to improve quality and processes and to develop technologies.

■ Technology evolution
- Taking advantage of our wealth of experience with fine particle synthesis technologies using gas phase and liquid phase methods, we are constantly developing technologies to synthesize characteristic fine particles.
Photocatalytic Titanium Oxide
〜LUMI-RESH™〜

Product example

LUMI-RESH™ is a visible-light-sensitive photocatalyst with excellent antibacterial and antiviral characteristics.

LUMI-RESH™ has been used for photocatalytic indoor-use membrane materials (Taiyo Kogyo), photocatalytic curtains (Lilycolor), antibacterial and antiviral fibers (Shikibo), and others.

Above: Taiyo Kogyo
Product name “Hikari-Protextile”

Right: Lilycolor, Photocatalytic curtain

Our technologies

■ Titanium oxide photocatalyst manufacturing technology

We use our high-purity fine particle titanium oxide “SUPER-TITANIA™” to manufacture high activity visible-light-sensitive photocatalyst materials through, for example, metal modification.

■ Dispersion technology

In response to customer feedback that the catalyst is hard to use in powder form, we have developed slurrying technology. We not only provide the catalyst in a water slurry form but can also disperse the catalyst in an organic solvent if required.

■ Photocatalyst evaluation technology

We can correctly evaluate visible-light-sensitive photocatalysts for:

- VOC decomposition activity
- Antibacterial activity
- Antiviral activity

■ Photocatalyst application technology development

We have a solid track record of joint development with many customers on the practical application of photocatalysts. Please consult us if you have technical problems with particular applications.

We are also conducting joint studies with customers on the application to other products, such as paint, films, fiber processing agents, and decorative sheets. We can also introduce customers of such finished goods.

Above: Taiyo Kogyo
Product name “Hikari-Protextile”

Right: Lilycolor, Photocatalytic curtain
Graphite Electrodes

Product Example

- Graphite electrodes are conductive members of an electric steel-making furnace, which recycles scrap iron to manufacture steel products.
- Since graphite electrodes are used under high temperature and oxidation atmosphere, they require low electric resistivity and thermal shock resistance.
- The product is a large-size pillar-shaped graphite material with a maximum diameter of 800 mm and length of 3,000 mm.

Our technologies

- **High-temperature heat treatment technology**

  Raw materials are extruded, baked and then heat-treated at high temperature in a graphitizing furnace.

  We have the know-how (energization schedule, inter-electrode connection method, protection of the furnace body from high heat, etc.) to control the properties of the final products and heat-treat the materials with good yield.
High-purity Aluminum Foil

Product Example

High-purity aluminum foils are used as electrode foils of aluminum electrolytic capacitors after surface enlargement treatment by customers, thus playing an essential role for electric and electronic products.

Our technologies

- **Refining technology**
  “Cojunal method” is a refining technology utilizing the segregated solidification principle, which we were the first in the world to commercialize successfully.
  Refining ability: 99.9% Al → 99.998% Al

- **Molten metal treatment technology**
The “GBF method” is an excellent molten metal treatment technology, whereby inert gas is blown into molten metal as ultrafine bubbles to efficiently remove hydrogen and non-metal inclusions in the molten metal.

- **Organization control technology**
In the case of, for example, high-voltage capacitor anode foil, since surface enlargement treatment is applied using cube orientation, cube texture control is needed.

Etching photo of the non-cube orientation and cube orientation areas (Cross section)
Heat Exchangers

Product example

Refrigerator evaporator
  • Evaporator for household/industrial use refrigerator-freezer

Industrial use oil cooler
  • Lubricant oil cooler and compressed air cooler for various industrial machines

High-precision heat sink
  • Heat sink for cooling control panels of various industrial machines

Our technologies

- The use of aluminum for all components minimizes weight.
- We own aluminum rolling/extruding technology.
- We can design excellent heat-exchange performance. (Highly heat-conductive oil circuit and cooling fin structure)
- We own junction technologies, such as welding and brazing. (Strength, airtightness)
- We use the potential difference of materials to achieve high-corrosion resistance in material design.
- We can perform integrated manufacturing from heat design and material production to assembly.
- We have the manufacturing ability to ensure no complaints arise in the market.
- We can design the structure and specifications suitable for the customer’s usage environment. (Hydrophilic surface treatment, low frost formation structure, etc.)

Examples of high-precision heat sinks

Wide/light/thin
  - Skyve heat sink
  - Extruded heat sink

Large size/low cost
  - Roll bond panel type heat pipe container

High design freedom
  - Heat pipe heat sink
Automotive Cooling Devices

Product Example

Vehicle-installed inverter cooling device
Direct cooling type cold plate

PCU (Power control unit)

IGBT element

Ceramic insulating substrate

Vehicle-installed secondary battery cooling device
Water-cooled LLC or air conditioning cooling medium

LiB battery

RB (roll bond) panel aluminum

Our technologies

- We own the technology of aluminum bulk brazing of the ceramic insulating substrate and the heat sink.
- We own aluminum forming technology, i.e., extrusion, rolling, forging, and press method.
- Down-sizing and space-saving can be achieved thanks to the improved performance.

- We own aluminum rolling/extrusion molding technologies.
- We own joining technologies, such as welding and brazing.
- Thin panels can save space.
- Either an internal fluid LLC or cooling medium can be used.
Continuously-cast Rods 〜SHOTIC™〜

Product Example

Engine piston

Car air compressor parts

Upper arm of the suspension

Brake caliper & piston

Valve retainer

Body of high-pressure pump for direct-injection engine

OCV sleeve for VVT

Propeller shaft yoke

Our technologies

- Gas-pressurized hot-top continuous casting process
- Gas-pressurized completely horizontal continuous casting process

The gas-pressurized completely horizontal continuous casting process has evolved from the gas-pressurized hot-top continuous casting process to produce thinner SHOTIC™ rods with higher productivity. Our technological capability is world-leading.

Microscopic organization of Al-eutectic Si alloy

Comparison materials

Eutectic Si

Eutectic Si

ADC12 die cast

AC8A casting

Track record of replacing iron parts with aluminum (Swash plates, suspensions, brake pistons, etc.)

Track record of improving aluminum casting functionality (Compressor pistons, engine pistons, etc.)
Hard Disks (HD)

Product Example
The annual number of hard disk drives (HDD) shipped worldwide is about 500 million, and about one billion HD recording media are required. We lead the world in terms of maximum capacity, and have gained a 25% share (250 million units) as a specialized manufacturer of HDD recording media ranging from those for PCs to those for data centers.

Our technologies
- Ultra-thin film formation technology
We produce hard disks by growing epitaxial crystals at the atomic level while forming over ten layers of ultra-thin films with a total film thickness of no more than 0.1 um at high speed (2000 pcs/hr) with Angstrom accuracy.

- Ultra-smooth substrate polishing technology
The flying height of HDD read/write heads is 10 nm or less and so the presence of foreign particles of this height is not allowed. In addition, ultra-smoothness of $Ra \approx 2\text{Å}$ or less is required for the surface roughness.

We produce hard disks using advanced substrate polishing and cleaning technologies.
Product example

Nd-Fe-B sintered magnet

IT devices

Motor, dynamo

Automobiles

Hard disk

Mobile phone

Electric power steering

Others

MRI

Our technologies

Composition design technology

We own technology for designing the composition of Nd-Fe-B sintered magnets.

We design the composition of rare earth materials and other metallic constituents to satisfy the magnetic strength (magnetization intensity/maximum energy product) and heat resistance (coercivity) required by customers.
Anode Material for Lithium Ion Secondary Batteries

**Product example**

Lithium ion secondary battery negative-electrode material SCMG™ (Structure Controlled Micro Graphite)

- **For EV, PHEV, HEV, ESS**
  - Soft carbon
  - Hard carbon
  - Artificial graphite
  - SCMG™
  - BH
  - XR-s

**Our technologies**

- **Fine particle treatment technology**
  - Technology to control the particle size in accordance with various materials

- **Heat treatment technology**
  - Our original technology developed for manufacturing graphite electrodes
  - Primary calcination technology with atmospheric control
  - Secondary calcination technology to control the carbon structure

**Charge/discharge cycle characteristics**

- Battery capacity residual ratio (%)
  - SCMG™
  - Natural graphite

**Capacity**

- 0 100 200 300 charge/discharge cycles
- 100 80 60 40

**Before cycles**

- SCMG™
- Natural graphite

**After 300 cycles**

- We provide a negative-electrode carbon material that suffers no degradation by charge-discharge cycles.

**Heat treatment facilities**

**Fine particles with carbon structure controlled**

We provide a negative-electrode carbon material that suffers no degradation by charge-discharge cycles.
Carbon Coated Foil ~ SDX™ ~

**Product example**

Current collector for Lithium ion & battery electric double-layer capacitor

- Current collector with high-conductivity carbon particles and binder coated on aluminum foil

- Various patterns printable (Continuous coating, intermittent coating)

- Design providing an anchor effect (Film thickness < 1 μm, Amount of coating < 1 g/m²)

- Significant reduction of the interface resistance between the active material layer and current collector achieves lower resistance, fast charge/discharge, and longer life.

**Our technologies**

- **Material design technology**
  Optimum design of aluminum foil, carbon particle, and binder resin
  ⇒ Products that integrate metals, inorganics, and organics

- **Paint-making technology**
  Optimization of mixing and dispersion treatment of materials
  ⇒ Viscosity control, sedimentation prevention, measures to deal with coarse particles

- **Printing technology**
  Thin-film, uniform, and high-speed gravure printing technology
  ⇒ High quality, mass-production, cost competitive

- **Battery production/evaluation technology**
  Comprehensive evaluation of not only carbon coated foils but also batteries
  ⇒ Proposal of recipes to customers, resolution of technical issues

**DC resistance of lithium-ion battery**

<table>
<thead>
<tr>
<th>Amount of conductivity aid (%)</th>
<th>Aluminum foil only</th>
<th>SDX™ used</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1500</td>
<td>450</td>
</tr>
<tr>
<td>5</td>
<td>1200</td>
<td>300</td>
</tr>
<tr>
<td>10</td>
<td>1000</td>
<td>150</td>
</tr>
<tr>
<td>15</td>
<td>800</td>
<td>100</td>
</tr>
</tbody>
</table>

Positive electrode: LFP
Negative electrode: SCMG™
Separator: PP
Electrolyte: EC/EMC
LIPF₆
Capacity: 100 mAh
Cell: Laminate-type

**Pouch LiB**

2,000 mAh

**Gravure printing**

Quoted from Showa Denko Packaging website
**Product example**

Example of SPALF™ constituents:
- ONY (Nylon film)
- Adhesive
- Substrate treating agent
- Aluminum foil
- Substrate treating agent
- Adhesive
- CPP (Sealant film)

**Our technologies**

- **Paint (Coating technology)**
  - Thin film coating technology

- **Laminate (Lamination technology)**
  - Lamination technology suitable for constituent materials

- **Create (Molding technology)**
  - Die design technology to realize product shape
  - Adhesive evaluation technology suitable for product applications

**Characteristics of SPALF™**
- Light weight
- Unrestricted product shape
- Good formability
- Insulation properties

**Development of Pouch LiB Application**

2000 → 2015

**Showa Denko Packaging (SPA) Corporate Philosophy:** We can offer products created by “paint, laminate, create” technology to the world, and contribute to the development of society.
SiC Epitaxial Wafer

Product example
Using the epitaxial method, SiC thin film is formed on the SiC substrate of wafers for power semiconductor applications.

Our technologies

- **Epitaxial technology**
  We own the technology to uniformly form SiC thin film using Si material gas and C material gas at high temperatures of 1,500 to 1,600°C.

- **Evaluation technology**
  We own the following technologies to deliver the best products to device manufacturers:
  - Optical surface inspection technology
  - Film thickness and carrier concentration measurement technology
  - Surface contamination inspection technology

- **Simulation technology**
  We own the technology to simulate the temperature distribution, gas flow speed, and other items to overcome the difficulty of in-situ measurement at high temperatures of 1,500 to 1,600°C.
Plant Growth Facilities

**Product example**

- LED plant growth facilities, Cultivation systems
  - SHIGYO™ Unit

- SHIGYO™ Unit Mini

- SDK High-brightness LED

**Our technologies**

- **LED-related technology**
  - Wavelength control
  - High luminance
  - Lighting design

- **Aluminum fabrication technology**
  - Structure design
  - Fabrication & assembly
  - Seismic-resistant design
  - Antibacterial alumite

- **Cultivation technology**
  - Fast cultivation
  - Increase of varieties
  - Quality improvement
  - Higher functionality

Through the combination of technologies and products of SHOWA DENKO, we provide various products and materials for closed-type plant growth facilities.
Utilizing our accumulated metallic, inorganic, and organic material technologies, we can offer functional raw materials to meet customers’ demands. Moreover, in cooperation with external organizations, we can provide various inks suitable for photo curing technology and the most advanced printing technology.

Using Ag nanowire ink, transparent patterned wiring and sensors can be formed by the conventional printing process. Using Ag nanoparticle ink, ultra-thin film with low-resistance can be printed. Cu-Ag composite ink is suitable for the highly-reliable conductive circuits.
Using various computational science technologies, we can enhance and accelerate product development and rapidly produce characteristic products.

- Quantum chemistry calculation
- First-principles calculation
- Molecular dynamics calculation
- Thermal stress analysis
- Fluid analysis
- Micromagnetic simulation
- Chemical reaction simulation
- Lighting design analysis
- Electromagnetic wave simulation
- Electron transport calculation
- Heat transfer analysis
- Image analysis
Analysis & Physical Properties Center

Example of evaluation: LiB anode material

Product example

- **Low-temperature cycle characteristics**
  - Usual graphite
  - Modification treatment method A
  - Modification treatment method B
  - Modification treatment method C

- **Characteristic change**

Usual graphite

Modified graphite

- **Inorganic chemical analysis**
  - Trace impurity analysis, High-precision principal component analysis
  - Equipment owned: ICP-OES, ICP-MS, etc.

- **Organic chemical analysis**
  - Molecular structure analysis, Separation analysis, Thermal analysis
  - Equipment owned: FT-IR, NMR, GC-MS, etc.

- **Structure analysis**
  - Microstructural (μm to nm) analysis, Composition analysis
  - Equipment owned: TEM, SEM, XRD, XPS, etc.

Our technologies

Various non-atmospheric exposure analyses

- Raman
- Solvent extraction
- LC-MS
- FIB-STEM
- XPS

Confirmation of the correlation of SEI (degraded material coating) with battery characteristics
We test and investigate the effect of products developed by Showa Denko Group on human health and environmental organisms in order to provide basic data for risk evaluation, thus helping customers to use our products safely.