Main Businesses of SHOWA DENKO

- **Petro-chemicals** 26%
- **Chemicals** 19%
- **Electronics** 14%
- **Inorganics** 7%
- **Aluminum** 14%
- **Others** 20%

**2016 Consolidated net sales 671.1 billion JPY**

**Lithium-ion battery (LIB) materials**
- Rolled products (high-purity foils), casted components, and beverage cans, etc.
- Graphite electrodes, and ceramics (alumina, titania and abrasives), etc.

**Olefins (ethylene and propylene) and organic chemicals (ethyl acetate), etc.**

**Electronic chemicals (specialty gases), functional chemicals, industrial gases, and basic chemicals, etc.**

**Hard disks (HDs) and Rare earth magnetic alloys, etc.**
## Inventory/Summary of Technologies

**Strength = Diversified Range of Core Technologies**

### Segment

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### Synthetic Process

| Polymerization Control | ○ | ● | ● | ● |
| Purification | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Micro-particulation | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Film/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

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

- Basic Petrochemicals
- Olefin Derivatives
- Organic Chemicals
- Ethyl Acetate
- Allyl Alcohol Derivatives

Heat-resistant Transparent Film
SHORAYAL™
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.

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 products
Chemicals-1 ~Gas Products~

- High-purity Gases/Solvents for Electronics
  - SOLFINE™
- Electrolysis
  - Chlorine Hydrogen
- Industrial Gases
  - ECOANN™
- Gases for Electronics
  - Fluorine Chemicals
- Specialty Gas Chemicals
  - High Temperature Heat Treatment
- Mixing/Dispersion
  - Supercritical Carbon Dioxide
- Surface Treatment
  - Clean-S™
- Plastic Recycling
  - Abatement System for Specialty gases
- Inorganic Materials Design
  - SHOWA DENKO GAS PRODUCTS CO., LTD.

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High-purity gases/chemicals for electronics ~ for semiconductors ~

Example products

High-purity gases / chemicals are used in the electronic industry for 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

Plant to fill high-purity solvents
Sensitive analysis instrument (ICP-MS)
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

Fluorine compounds are decomposed in plasma and react with materials such as silicon to form vapor materials.

Taking advantage of such characteristics, fluorine chemicals are used for dry etching in semiconductor manufacturing process and dry cleaning of the chambers.
**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 equipment 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.

Supercritical CO₂ painting system

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 ~Karenz™~**

**Product examples**

**Multifunctional secondary thiol compound**

- Improves coating performance

![Molecular structure](image)

**Applications:**
- Epoxy curing agent (cold & rapid curing, low yellowing, hydrolytic stability)
- UV curing additive (higher sensitivity, less oxygen inhibited polymerization, deep curing, adhesion)
- Ene-thiol reaction (high transparency, deeper curing)

**Monomer containing isocyanate groups**

- Useful for synthesizing high performance resin

![Molecular structure](image)

**Applications:**

1. Synthesizing polymers with NCO pendant after reacting unsaturated groups
2. Introducing unsaturated groups after reacting NCO

**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 multifunctionality

**Development of optimal synthesis process**

- Minimal step synthesis
- Knowhow to select a reaction catalyst

**Establishment of industrial process**

- Protecting reactive functional groups
- High purification
- Control of water amount

**Applications:**
- Epoxy curing agent (cold & rapid curing, low yellowing, hydrolytic stability)
- UV curing additive (higher sensitivity, less oxygen inhibited polymerization, deep curing, adhesion)
- Ene-thiol reaction (high transparency, deeper curing)

**Monomer containing isocyanate groups**

- R=Me Karenz MOIT™
- R=H Karenz AOIT™

**Useful for**
- Synthesizing high performance resin

**Applications:**

1. Synthesizing polymers with NCO pendant after reacting unsaturated groups
2. Introducing unsaturated groups after reacting NCO

**Thermosetting resin**

- Crosslinking agent (Example)

**Radically curable resin**

- Example
**Versatile isocyanate monomer ~AOI-VM™~**

**Product example**
Automotive coating (OEM coatings, refinishing, interiors), construction, painting/coating for electronics, adhesive, etc.

- **Application: thermosetting resin composites**
  
  ![Chemical structure](image)

  Copolymer using AOI-VM Porohol

- **Add functionality**

  ![Copolymer structure](image)

  Low-temperature thermo curing

  ~60°C or higher

**Our technologies**

- **Production technology**
  Based on the production technology for Karenz, mass production technology for AOI-VM™ using a continuous plant reduces the price.

**Broader customer applications**

- Applicable to versatile paints and coatings, which require low cost

**Providing value**

- The only compound (group) that can synthesize polymers with aliphatic NCO pendant
- Adding functionalities such as low-temperature rapid curing
- Providing a new development approach
Water-soluble monomers, polymers ~NVA, PNVA™~

Product examples

**NVA (N-Vinyl acetamide)**

- Raw material of water-soluble polymers
- Hydrophilization of hydrophobic polymers
- Material of UV curing composites

**PNVATM (Poly-N-Vinyl acetamide)**

- Thickening agent
- Dispersant
- Gelatinizer
- Binder
- Coating agent
- Adhesive, pressure-sensitive adhesive

Our technologies

- **NVA**
  
  NVA is an amphiphilic, nonionic, water-soluble monomer produced commercially by our unique technology.
  - Characteristics as a solubilizer
  - Nonionic
  - Water-soluble, solvent affinity

- **PNVATM**
  
  PNVATM is a water-soluble polymer produced commercially from NVA by our unique technology.
  - Stable thickening over a wide range of pH
  - Thickening of polar organic solvents
  - Thickening of high salt concentration solutions
  - Resistant to acids and alkalis
  - Viscous and adhesive
  - Resistant to heat, UV
  - Nonionic

Applications:
- CMP
- Water-based ink, paint
- Capacitor, secondary battery
- Dispersant for CF, resin kneading
- Thickening agent for acid/alkaline detergent
- Conductive paste
- Emulsion thickening
- Binder for sintering ceramics
- Inkjet ink absorbing layer
- Coating agent for heat exchangers

Hydrogen bonding
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°C

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.

- **Cosmetic raw material**
- **Physiological data**
- **Prescribing information**

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.

  - Parent compound
  - Derivative
  - Functional cosmetic raw materials
  - Chemical compound design, chemical modification
  - Stabilization, water solubilization, improved penetration of skin

- **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.
Chemicals-3 ~Resin Products~

- **Resins for Electronic Materials**
  - Ripoxy™

- **Substrate solder mask**
  - Nippon Polytech Corp.

- **Synthetic Resin Emulsion**
  - Polysol™

- **Chlorinated Polyethylene**
  - Elaslen™

- **Functional Resin Design**

- **Mixing/Dispersion**

- **Molding/Casting**

- **Polymerization Control**

- **Resins for Composite Materials**
  - Unsaturated Polyester Resins Rigolac™, Ripoxy™

- **Molding Compounds**
  - Rigolac™ Molding Material

Nippon Polytech Corp.
Resins for Electronic Materials
〜 Ripoxy™ 〜

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
Synthetic Resin Emulsion  
~ Polysol™ ~

**Product Example**

- Adhesive for building materials
- Adhesive for tapes
- Fiber processing resin
- 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)

**Synthetic resin emulsion**

- Emulsion design
- Modification technology
- Processing technology
- Measuring 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.
**Product Example**

- **BMC (Bulk Molding Compound)**
  - Formulation technology
  - We provide optimally formulated thermosetting molding materials that meet customers’ requirements.

- **SMC (Sheet Molding Compound)**
  - Moldability evaluation technology
  - We own various molding machines and can mold prototypes and will propose molding conditions that optimize the physical properties.

**Our technologies**

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

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

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

- 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/dispersing technology**
  - Dispersed particle size control
  - Contaminant management
  - Stable quality

High-performance insulating ink for COF

Nippon Polytech Corp.
Abrasives ~Sinter MORUNDUM™ SR-1~

Product example

Sinter Morundum™ SR-1

A high-purity alumina sintered body used for heavy polishing heavy grinding stones

Our technologies

- Crushing and classifying technologies
  Since our technologies of crushing and classifying abrasive grains are highly effective, both pulverization and productivity can be achieved.

- Kneading and extrusion molding technologies
  We own kneading technology for evenly kneading several kinds of abrasive grains and extrusion molding technology to achieve high yield with specific grain sizes.

- High-temperature sintering technology
  Our high-temperature sintering technology developed over the years produces stable and uniform abrasive grains.

- Evaluation technology
  We evaluate the bonding strength between a resin layer and abrasive grains, the abrasive capacity, and abrasive grain properties.

Heavy grinding is a process for snagging or peeling using grinding stones before the rolling process in iron manufacturing.

Heavy grinding, which is conducted under extremely high load, requires high hardness, high strength, and high heat resistance of abrasive grains.
Glass Polishing Material ~SHOROX™~

**Product example**

**SHOROX™**

SHOROX™ is a CeO₂ abrasive made from rare-earth compounds. There are two types of product: containing fluorine, or without fluorine. It is provided as a dry powder or slurry.

SHOROX™ is used as an abrasive for polishing various glass substrates, such as liquid crystal displays, hard disks, photomasks, optical lenses, and crystal, to a mirror-smooth and highly precise finish.

**Our technologies**

- **Crushing, sintering, classifying technologies**
  
  Our crushing, sintering, and classifying technologies we have developed over the years allow us to produce CeO₂ abrasives with various levels of hardness and particle size distribution, and to design optimal abrasives for glass polishing.

- **Polishing evaluation technology**
  
  Our polishing evaluation technology is used to evaluate the polishing quality of abrasives in accordance with customers’ requirements. We use our experience gained from evaluations for quality improvement, process improvement, and technology development.

- **Technology development**
  
  Customers require high quality in terms of polishing speed, scratches, and slurry state. Using our polishing evaluation capability as well as production knowledge and technology we have developed over the years, we rapidly develop excellent products and stabilize their quality in accordance with customers’ requirements.
Cubic Boron Nitride 〜SBN™〜

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.

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.
Thermal Conductive Fillers
～Alumina, SHOBN™～

Product example
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.

Compounded products with the combination of the above are also under development.
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.

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.
Inorganics-2 ~Carbon~

Graphite Electrodes

Carbon Structure Control

Mixing/Dispersion

High-Temperature Heat Treatment

Purification

Molding

Granular Graphite

Shocaraiser™

Granular-M
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.
Aluminum

High-purity Aluminum Foil

Showa Aluminum Can Corp.

Aluminum Can

Laminate/Printing

Casting/Molding

Purification

High-Temperature Heat Treatment

Metallic Materials

Heating/Cooling Control

Mixing/Dispersion

Continuously Cast Rods

SHOTIC™

Extrusion and Drawing Tubes

Automotive Cooling Devices

Heat Exchangers

Skyve heat sink™

Aluminum plate with high heat conduction and high strength

ST60

Aluminum Can

Aluminum Can with high-purity Aluminum Foil

Showa Aluminum Can Corp.

Extrusion and Drawing Tubes

Automotive Cooling Devices

Heat Exchangers

Skyve heat sink™

Aluminum plate with high heat conduction and high strength

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Aluminum plate with high heat conduction and high strength

ST60
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.

- **Structure 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.

---

**Anode aluminum foil**

**Cathode aluminum foil**

**Electrolytic paper**

**Lead wire (Terminal)**

**Aluminum lead**

**Basic structure of the element**

**Non-cube orientation area**

**Cube orientation area**

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

**Product example**

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

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**
- Skyve heat sink
- Extruded heat sink
- Brazed heat sink
- Heat pipe heat sink
- Roll bond panel type heat pipe container
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

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 joining technologies, such as welding and brazing.
- Thin panels can save space.
- Either an internal fluid LLC or cooling medium can be used.
Aluminum plate with high heat conduction and high strength ~ST60~

**Product examples**

Heat sinks for FPD
- Back panels for PDP and LCD

Heat sinks in electronic devices
- Heat sinks for PCs, car navigation systems, and game machines

Enclosures for mobile devices
- Enclosures for smartphones and tablet devices

**Our technologies**

- **Hardening and aging technologies**
  ST60-HSM® is an aluminum plate with high strength developed using our hardening, aging, and rolling technologies.

- **Thermal diffusion evaluation technology**
  Our measurement, evaluation, and simulation technologies are used to evaluate thermal diffusivity.

- **Aluminum rolling technology**
  Our seamless facilities from melting and casting to rolling processes are used to produce various coils and plates.

**Manufacturing process for ST60-HSM™**

- Melting, casting → Hot rolling → Cold rolling → Trimming, reforming → Cutting
- Hardening → Aging → Annealing
Large-sized extrusions

Product examples

- High-precision production of large products using a 7,000-ton press, the largest in Japan

  - Automobile parts
    - A5083 T bar for ships (100 × 300 mm)

  - Vehicle structure (width: 570 mm)

  - Heat sink Tongs ratio: 14

Our technologies

- Alloy design technology
  Technology to optimize alloy compositions and achieve requirements for various applications

- Die technology
  Our abundant design data and advanced design technology allow us to produce various products with complicated cross sections.

- CAE technology
  We use our simulation technology for optimizing the settings and conditions of extrusions and die design, in order to produce products with complicated shapes faster and more precisely.

Example of simulated speed distribution of an extrusion

Vehicle structure (width: 570 mm)

Heat sink Tongs ratio: 14

Fast

Slow
Continuously-cast Rods ~SHOTIC™~

Product Example

- Engine piston
- Valve retainer
- Body of high-pressure pump for direct-injection engine
- OCV sleeve for VVT
- Propeller shaft yoke
- Car air compressor parts
- Upper arm of the suspension
- Brake caliper & piston

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 structure of Al-eutectic Si alloy**

**Proved in replacing iron parts with aluminum**
(Swash plates, suspensions, brake pistons, etc.)
Improving aluminum casting functionality
(Compressor pistons, engine pistons, etc.)
**Product examples**

**Aluminum can body (2-piece can)**
- Applications: Beer/low-malt beer, RTD, drinks (soft, carbonated, retort)
- Size: Slim type (202 dia.): 190 mL/250 mL, Standard type (211 dia.): 250 mL/350 mL/500 mL
- Lid dia.: Slim: up to 200 dia., Standard: up to 204 dia./206 dia.

**Aluminum can lid (stay-on tab)**
- Applications: Beer/low-malt beer, RTD, drinks (soft, carbonated, retort)
- Size: 204 dia. for beer, 206 dia for RTD/drinks, 200 dia. for slim can

**Our technologies**
- **Our high-speed molding technology** for thin walls ensures stable quality. Main molding technologies:
  - Drawing, ironing, trimming, necking, transferring
  - Can manufacturing speed:
    - Can body: up to 2,000 units/min.
    - Lid: up to 8,000 pieces/min.
- **Our various printing technologies** satisfy customers’ requests for precise printing.
- **Our internal coating technology** for food packaging stabilizes the quality of the contents.
- **Our high-speed transfer technology** enables mass production without degradation of appearance.
- **Our high-speed 100% inspection system** prevents the outflow of defective products.
- **IoT technology** that collects and analyzes production conditions and quality data enables timely and stable production management.
- **Our lid seaming technology** contributes to customers’ stable production.
Hard Disks (HD)

Product Example

The annual number of hard disk drives (HDD) shipped worldwide is about 400 million, and about 900 million HD recording media are required.

We lead the world in terms of maximum capacity, and have gained a 23% share (200 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.
High-brightness LED
〜Invisible light in various applications〜

Product example

Wide application area: Infrared LED

Feature 1
High-speed response
- Non-transparent resin (black resin)
- Light-emitting diode
- Transparent resin (white resin)
- Photo transistor
- Frame
- Shaft

Structure of an absolute encoder

High-speed response photo coupler
Encoder

Feature 2
Authentication
- Iris authentication
- Pulse oximeter

Feature 3
Reach Long-distance
- Night vision
- Surveillance camera

Our technologies

- A broad range of LED chip products, from yellow green to infrared light
- The double-junction technology enhances output, especially of infrared LED chips.

- High-purity crystal growth technology enables various wavelengths based on optimal elemental compositions.
- Lattice parameters and band gaps are independently controlled.

- Film thickness control technology of Angstrom order

Band gap [eV]
Wavelength [nm]
Lattice parameter [Å]

TEM cross-sectional image

- Dark-colored layer: 150 Å
- Light-colored layer: 450 Å
Rare Earth Magnetic Alloys
〜 Nd-Fe-B sintered magnet 〜

Product example

Nd-Fe-B sintered magnet

IT devices

Hard disk

Automobiles

Motor, dynamo

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.

Graph showing heat resistance and maximum energy product (BH)max vs. coercivity (μ0Hc) for various applications like HDD, ABS, OA/FA Motors, Servo motors, Air-conditioning motors, Generators, Motors for robots, EV/HEV.
Advanced Battery Materials

Artificial Graphite Anode Materials

SCMG™

Micro-particulation

High-Temperature Heat Treatment

Carbon Structure Control

Mixing/Dispersion

Laminate/Printing

Casting/Molding

Separators

Carbon Coated Foil

Vapor-grown Carbon Fiber

VGCF™

Film/Crystal Growth

150nm

LIB Packing Materials

SPALF™

Showa Denko Packaging Co., Ltd.
Anode Material for Lithium Ion Secondary Batteries

**Product example**

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

- **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

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

**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

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

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

**DC resistance of lithium-ion battery**

- Positive electrode: LFP
- Negative electrode: SCMG™
- Separator: PP
- Electrolyte: EC/EMC
- LiPF₆
- Capacity: 100 mAh
- Cell: Laminate-type

**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

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

<table>
<thead>
<tr>
<th>Constituent Materials</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONY (Nylon film)</td>
<td></td>
</tr>
<tr>
<td>Adhesive</td>
<td></td>
</tr>
<tr>
<td>Substrate treating agent</td>
<td></td>
</tr>
<tr>
<td>Aluminum foil</td>
<td></td>
</tr>
<tr>
<td>Substrate treating agent</td>
<td></td>
</tr>
<tr>
<td>Adhesive</td>
<td></td>
</tr>
<tr>
<td>CPP (Sealant film)</td>
<td></td>
</tr>
</tbody>
</table>

**Development of Pouch LiB Application**

- 2000
- 2015

**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

**Dry laminator/coater**

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 Wafers

High Grade Epi (HGE)

Surface Treatment

Specialty Gas Chemicals

High-Temperature Heat Treatment

Film/Crystal Growth

LED Technology

Plant Growth Facilities

Fast Cultivation: S Method Cultivation Unit

Casting/Molding

Aluminum Technology

Fast Cultivation: S Method Cultivation Unit
SiC Epitaxial Wafer

Product example

Using the epitaxial method, SiC thin film is formed on the SiC substrate wafer for power semiconductor applications.

Wafer size: 4 inch, 6 inch

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. We can reduce basal plane dislocation that lose reliability of MOSFET.

- **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

Final applications:
- Server power supply
- Solar battery power inverter
- Electric railway vehicle inverter
- Automotive inverter

Distribution of basal plane dislocation after epitaxial growth

**Conventional**
- Defect density 30/cm²

**High Grade**
- Defect density 0/cm²
Plant Growth Facilities

Product example

Through the combination of technologies and products of SHOWA DENKO, we provide various products and materials for closed-type plant growth facilities.

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 S method (S500)
  - Increase of varieties
  - Quality improvement
  - Higher functionality
Strategic technology ~Carbon material~

Product examples

**Fullerene**

- Sports gear: Golf clubs, rackets, etc.
- Semiconductors: Nano lithography, material for lower films
- Energy: Organic photovoltaic panels, fuel cells
- Lubricants: Additive to lubricants, waxes, etc.
- Other industrial uses: Additives to polymers, rubber, and metal; hard carbon films

Our technologies

- High-temperature reaction control technology
- Separation and refinement technologies
- Organic synthesis technology
- Vacuum processing technology
- Fine particle treatment technology
- Crystallization technology
- Dispersion technology
- Measurement and evaluation technologies
- Surface analysis technology
- Chemical reaction simulation technology

Frontier Carbon Corporation

Mitsubishi Corporation

Showa Denko K.K.

- World-class sales and marketing capabilities
- Nano carbon technology
- Able to develop, produce, and supply new products satisfying customers’ requirements
**Product example**

**Catalyst for Ethyl acetate**

Using the supported heteropoly acid catalyst jointly developed with a university, we have produced ethyl acetate from ethylene and acetic acid in one stage.

\[
\text{CH}_2\text{=CH}_2 + \text{CH}_3\text{COOH} \rightarrow \text{CH}_3\text{COOCH}_2\text{CH}_3
\]

Since few by-products are generated during this reaction, the production method is eco-friendly, resource saving and energy efficient.

**Our technologies**

**Acetyl catalyst technology**

We have technologies for catalyst design, catalyst analysis, catalyst performance evaluation, and plant operation for the following reaction processes:

- Ethylene + Oxygen $\rightarrow$ Acetic acid*
- Ethylene + Acetic acid $\rightarrow$ Ethyl acetate*
- Ethylene + Acetic acid + Oxygen $\rightarrow$ Vinyl acetate
- Propylene + Acetic acid + Oxygen $\rightarrow$ Allyl acetate
- Allyl acetate + Hydrogen $\rightarrow$ N-Propyl acetate

* Received the Minister of Economy, Trade and Industry prize of the Green & Sustainable Chemistry (GSC) Award (2007)

**Porous coordination polymer (PCP)**

PCP is a porous crystalline material formed by coordination bonds, and PCP with a flexible structure can be used for gas separation. We are developing a wide range of technologies from ligand synthesis to formation, with a view to commercialization in the PSA process.
Research and Development

- Functional Resin Design
- Mixing/Dispersion
- Film/Crystal Growth
- Polymerization Control
- Casting/Molding
- Molecular Structure
- Metallic Materials
- Carbon Structure Control
- Functional Resin Design
- Redox Flow Battery
Our technologies

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 Ag nanowire TCF.

Characteristics of Ag nanowire TCF

- Optical (High transparency, Low-Haze)
- Electrical (Low resistivity)
- Adhesion
- Robust (humidity, heat, light)
- Decorative forming
- Bendable etc.

Product Example

Using Ag nanowire transparent conductive film (TCF), transparent wiring and sensors can be formed.

Ag nanowire TCF

Display Device

Touch sensor
Research and development
〜Redox flow battery (RFB)〜

Product example

A battery that charges/discharges through the oxidation-reduction reaction of vanadium ions

Principle of RFB

Our technologies
- Integrating traditional technologies into new business -
  ■ VGCF™
  Developed sheet-type electrodes made of VGCF™
  ■ Bipolar plate
  Achieved lower resistance by developing a special electrode structure making full use of VGCF™
  ■ Cell stack
  Applied cell stack technology we have developed in the electrolysis business for 70 years
  ■ Vanadium recovery
  Achieved low cost by developing technology to recover vanadium from ash from power plants
Fundamental Technology & Business Assistance

Computational Science and Technology Information Center

Fundamental Technology Assistance

Chemical Analysis/Structure Analysis

Analysis & Physical Properties Center

Computing Science

Safety Evaluation

Business Assistance

Safety Evaluation Center
Product example

Petrochemicals, high-function chemicals

Magnet alloys

Power semiconductors

Plant growth facilities/LED

Our technologies

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

Usual graphite

Modified graphite

Low-temperature cycle characteristics

Voltage (V)

Capacity (%)

Characteristic change

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.

Various non-atmospheric exposure analyses
Raman
Solvent extraction
LC-MS
FIB-STEM
XPS

Our technologies

Graphite

Low-temperature cycle characteristics

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.
Ideas, hopes and dreams for your happily ever after.

For inquiries, contact
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