Main Businesses of SHOWA DENKO

- Petrochemicals: 29% (Consolidated net sales 780.9 billion yen)
- Chemicals: 17%
- Electronics: 17%
- Inorganics: 7%
- Aluminum: 11%
- Others: 19%

- Olefins (ethylene and propylene) and organic chemicals (ethyl acetate), etc.
- Lithium-ion battery (LIB) materials, building products, and general trading, 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**

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### Technology Classification

#### Core Technologies
- High-performance Catalysts
- Specialty Gas Chemicals
- Molecular Structure
- Functional Resins
- Metallic Materials
- Inorganic Materials
- Carbon Structure

#### Material Design
- Polymerization Control
- Purification
- Micro-particulation
- Membrane/Crystal Growth

#### Synthetic 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**
Petrochemicals

- Material Design Technologies
- Synthetic Process Technologies
- Manufacturing Process Technologies

Common Technologies: Center
Peculiar Technologies: Next to the Products

High-performance Catalysts
Polymerization Control
Molding/Casting
Surface Treatment

Purification
Molecular Structure Design

Basic Petrochemicals
Olefin Derivatives

Organic Chemicals
Ethyl Acetate, Allyl Alcohol Derivatives

Heat-resistant Transparent Film
SHORAYAL™
**Chemicals-1**

**Gas Products**

- **High-purity Gases/Solvents for Electronics**
- **High Corrosion Resistant Plating**
- **Surface Treatment**
- **Clean-S™**
- **Fluorine Chemicals**

- **SOLFINE™**
- **Mixing/Dispersion**
- **Specialty Gas Chemicals**
- **High-heat Processing**
- **Plastic recycling**

- **Supercritical Carbon Dioxide (CO₂)**

**SHOWA DENKO GAS PRODUCTS**

- **Industrial Gases**

- **ECOANN™**

**Showcase of Materials**

- **Silicon Semiconductors**
  - N₂O, CH₃F, C₂F₆
  - CH₂F₂, C₃F₈, c-C₄F₈
  - C₄F₆, HBr, PETa
  - CHF₃, BCl₃

- **Compound Semiconductors**
  - HCl, NF₃, NH₃
  - CF₄, Cl₂, SF₆

- **Solar Batteries**
  - H₂Se

**Liquid crystals**
Chemicals-3 ~Resin Products~

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

- Thermal Conductive Fillers
  - Alumina SHOBN™
- Surface Treatment
- High-heat Processing
- Micro-particulation
- Abrasive
  - SBN™
  - MORUNDUM™ SHOROX™
- Purification
- Molecular Structure Design
- Photocatalytic Titanium Oxide
  - LUMI-RESH™
- Aluminum Hydroxide
  - HIGILITE™
- Titanium Oxide
  - SUPER-TITANIA™
- Cubic Boron Nitride
  - SBN™
  - SHOBN™

SHOWA DENKO
昭和電工株式会社
Aluminum

- High-purity Aluminum Foil
- Metallic Materials
- Purification
- High-heat Processing
- Extrusion and Drawing Tubes
- High-heat Processing
- Heating/Cooling Control
- Casting/Molding
- Mixing/Dispersion
- Aluminum Cans
- Heat Exchangers
- Skyve heat sink™
- Automotive Cooling Devices
- SHOTIC™ SU610 AHS™

Automotive Cooling Devices
Continuously-Cast Rods
Mixing/Dispersion
Casting/Molding
Heating/Cooling Control
High-heat Processing
Purification
Metallic Materials
High-purity Aluminum Foil
Aluminum Cans
Electronics

- Hard Disks (HD)
- Specialty Gas Chemicals
- Metallic Materials
- Mixing/Dispersion
- Membrane/Crystal Growth
- Purification
- Surface Treatment
- Molecular Structure Design
- Charge-dissipating Agent for Electron Beam Lithography
- ESPACER™
- Rare Earth Magnetic Alloys
- Nd-Fe-B alloy
- Molecular Structure Design
- Heating/Cooling Control
- High-brightness LED
- AlInGaP LED
- AlGaAs LED
- GaP LED
- GaAs LED
- Speciality Gas Chemicals
- Mixing/Dispersion
- Rare Earth Magnetic Alloys
- Nd-Fe-B alloy
R&D

- Functional Resin Design
- Molecular Structure
- Printed Electronics
- Membrane/Crystal Growth
- Polymerization Control
- Metallic Materials
- Mixing/Dispersion
- Micro-Particulation
- Laminate/Printing
- High-heat Processing
- Ag Nanowire
- (Printing performance) Line/Space = 110/70μm

Ag Nanowire Ink

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

For inquiries, contact
Inoue, Corporate R&D Department, Showa Denko K.K.
Inoue.hirofumi.xhlne@showadenko.com
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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)
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

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 \( (2\text{HF} \rightarrow \text{F}_2 + \text{H}_2) \)
- 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 used for dry-cleaning, whereby the dirt adhering to the reactor of semiconductor manufacturing devices is converted into gaseous substances to clean the devices.

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.
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.
**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
**Product Example**

**Polyfunctional secondary thiol compound**

- Contributing to coating performance improvement (curability, adhesion)

**Multipurpose isocyanate monomer**

- Useful to synthesize high performance resins

**Special water-soluble monomer**

- Raw material for our original resin, PNVA

---

**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

---

**Product Example**

**Coatings**
- UV ink
- Resist ink

**For films and coating materials**

- NVA (N-vinylacetamide)
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
**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.
Resins for Electronic Materials
～Ripoxy™～

Product Example
- **Binder resin for color filters**
  Contributing to realizing high-definition LCD.

Example of color filter manufacturing process using photocuring reaction.

1. Black matrix formation
2. Apply resist ink.
   (The figure shows red ink.)
3. Place mask and the part exposed to light irradiation is cured.
4. Remove the part not cured for patterning.
5. Repeat steps (2) to (4) for green and blue ink to complete the manufacturing process.

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.

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 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)

Synthetic resin emulsion

- 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

- Body
- Head lamp reflector
- 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.

- **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.

SMC (Sheet Molding Compound)
BMC (Bulk Molding Compound)
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
- COF
- 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.

Used as a raw material of aluminum salt and aluminates after reaction with acid and alkali *Photo: Zeolite Na_2O•Al_2O_3•SiO_2•nH_2O

Used as a fire retardant for wire covering, etc.

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
- Breaking/crushing
- Surface treatment
- Blend/classification (Airflow, sifter, etc.)
- Products with better workability
- Products with adjusted particle size distribution
- Calcination
- Fine particle products
- High-purity products
- Alumina

In addition, we possess technologies for powder transportation, filtration, and drying during processing.
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)

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

**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.

Mix and mold with resin.

Application example: Heat-dissipating silicone sheet
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.

SEM image of CBN sintered compacts

World’s largest-class special solid cBN
**Titanium Oxide ~ SUPER-TITANIA™ ~**

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

**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.

**Example of MLCC mounted**

**MLCC**

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

**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
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.
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)](image)
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.)

Product example

- Wide/light/thin
- Large size/low cost
- High design freedom

Examples of skyve heat sinks

- Skyve heat sink
- Extruded heat sink
- Brazed 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

LiB battery

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

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
- 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 $Ra \approx 2 \AA$ or less is required for the surface roughness.
  We produce hard disks using advanced substrate polishing and cleaning technologies.

Product Example

Period from April to June, 2014 @IDEMA JAPAN
**Rare Earth Magnetic Alloys**

〜 Nd-Fe-B sintered magnet 〜

### Product example

- Nd-Fe-B sintered magnet
  - IT devices: Hard disk, Mobile phone
  - Automobiles: Motor, dynamo, 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 〜SCMG™〜

Product example

Lithium ion secondary battery negative-electrode material SCMG™ (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

Our technologies

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

Heat treatment facilities
Fine particles with carbon structure controlled

For mobile phones

Battery capacity/residual ratio (%)
Charge/discharge cycles

Before cycles
After 300 cycles

SCMG™
Natural graphite

For EV, PHEV, HEV, ESS

Soft carbon
Hard carbon

Artificial graphite
Mesoscopic graphite

Charge/discharge cycle characteristics

Charge/discharge cycle characteristics

Capacity

SCMG™
Natural graphite

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

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

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

![SEM photo](image)

**SDX™**

You can view this text in Showa Denko Packaging website.

Pouch LiB
2,000 mAh

![Gravure printing](image)

Quoted from Showa Denko Packaging website.
LiB Packaging Materials

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 Co., Ltd.

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.

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

Product example

LED plant growth facilities, Cultivation systems

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
  - Increase of varieties
  - Quality improvement
  - Higher functionality

Product example

SDK High-brightness LED

Conventional fluorescent lighting

SHIGYO Method

SHIGYO™ Unit

SHIGYO™ Unit Mini
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.

**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 various inks suitable for photo curing technology and the most advanced printing technology.
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**

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**Product example**

<table>
<thead>
<tr>
<th>Voltage (V)</th>
<th>Capacity (%)</th>
<th>Characteristic change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usual graphite</td>
<td>3.5</td>
<td>80</td>
</tr>
<tr>
<td>Modified graphite</td>
<td>3.2</td>
<td>90</td>
</tr>
</tbody>
</table>

**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.

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**Our technologies**

- Inorganic chemical analysis
- Organic chemical analysis
- Structure analysis

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**Various non-atmospheric exposure analyses**

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

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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.