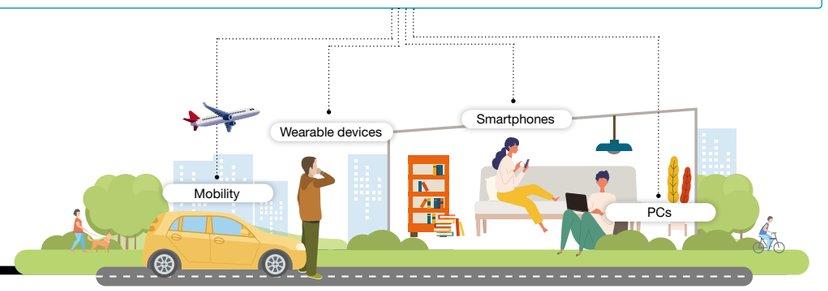
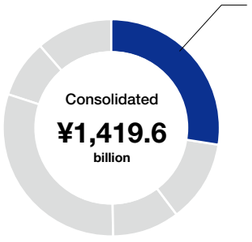
Semiconductor and Electronic Materials

Showa Denko Products in Everyday Life



Fiscal 2021 Net Sales



Semiconductor and Electronic Materials

Net sales
¥391.8 billion

Operating income
¥46.9 billion

Semiconductor materials
Front-end **¥81.2 billion**
Back-end **¥185.3 billion**

Device solutions
¥98.5 billion

Management Target

EBITDA margin
30% or more in 2025

Strategy for Realizing the Long-Term Vision

As a leading global manufacturer, Showa Denko is driving the advancement of semiconductor technologies with its strength in materials. Our front-end and back-end semiconductor materials provide a key technology for contributing to people's happiness while protecting the environment through semiconductor manufacturing processes and end products.

	Results in 2021	Plan for 2022	Vision for the future (2030)
Semiconductor materials Front-end Back-end	• Year-on-year increases in sales and income • Contributions to performance from efforts to build reliable supply structures at bases and bolster production capacity of copper-clad laminates and CMP slurry amid robust demand • Decision to establish an advance package verification platform (JOINT2) comprised of substrate, equipment, and material manufacturers to create a de facto standard for next-generation semiconductor packages	• Construction of growth platforms to become a global leader • Preparation of new sales promotion themes and management of pipelines to achieve growth leading up to 2025 (key account strategies, and enhancement of development capabilities from a medium- to long-term perspective) • Development of a resilient supply chain management system allowing for swift risk detection and stable supply • Flexible investment plan prescribing timely investment and responsive adaptation • Verification and material development of 2.xD, 3D, and other next-generation semiconductor packages through JOINT2 activities	• Goal of becoming a world-leading semiconductor material manufacturer that supports the advancement of a sustainable, digital society • Contribution to the realization of a sustainable society by conserving energy and reducing environmental impacts through the supply of advanced semiconductor materials • Growth outpacing the market
Device solutions (HD)	• Higher demand for large-capacity HD media used in near-line servers for use in data centers; robust demand for HD media employed in PCs due to the spread of teleworking and online learning • Conclusion of a joint development contract of HAMR*1-based next-generation HD media with Seagate • Start of mass production of MAMR*2 HD media for Toshiba • Development of MAS-MAMR*3 HD media as second-generation MAMR media • Expanded aluminum substrate production capacity and improvement of productivity	• Growth of sales centered on media for large-capacity near-line servers, demand for which is rapidly increasing, through industry-leading development and mass production of best-in-class HD media • Maximization of aluminum substrate and media production capacity through improvement of efficiency and operating rates at existing production facilities • Promotion of cost reduction to compensate for increases in fixed costs caused by higher production and sales volumes and rises in raw material prices	• Contribution to storage demand supporting increased data traffic volume and transmission speed as a large-capacity media technology leader • Development and mass production of future media technologies to create 100 TB hard disk drives • Acceleration of integration of digital transformation and automation of production activities and virtual linkage of multiple factories, to be operated as one • Pursuit of sustainability through production activities and recycling of post-sale products
Device solutions (SiC)	• Conclusion of a sales and joint development contract with Infineon Technologies AG • Conclusion of a long-term supply contract with ROHM Co., Ltd. • Conclusion of a long-term supply contract with Toshiba Electronic Devices & Storage Corporation • Significant increase in sales volumes due to long-term supply contracts, allowing for the posting of operating income	• Response to growth in demand centered on automotive and industrial products amid accelerated energy conservation and decarbonization trends • Provision of best-in-class SiC epitaxial wafers with high reliability and low cost for high voltage and high current applications • Timely plans to expand production capacity based on trends in growing markets	• Provision of solutions as SiC epitaxial wafer technology leader in response to rapid growth in demand for SiC power semiconductors amid an accelerated global push for carbon neutrality • Proactive supply of high-value-added products (MOSFETs, high-voltage-resistant Schottky barrier diodes) in response to more sophisticated and specialized quality requirements • Launch and mass production of eight-inch wafers to help reduce costs of SiC power semiconductors

*1 HAMR: Heat-assisted magnetic recording
*2 MAMR: Microwave-assisted magnetic recording
*3 MAS-MAMR: Microwave-assisted switching microwave-assisted magnetic recording

Competitive Edge

Operating Environment Outlook and Showa Denko's Strategy

Robust growth in semiconductor demand is anticipated as a result of progress toward a digital society, and it is thus incredibly likely that technological advancement and market growth will continue within a certain scope of technological development. The positions of market participants have already been solidified in this market. While there is some chance that industry reorganization may take place, it is unlikely that an upheaval in the industry structure or the emergence of a significant new player will occur. Based on this outlook, the Semiconductor and Electronic Materials segment will act in accordance with its position as a Core Growth business to develop highly competitive operations with a lineup that encompasses comprehensive solutions and a wide variety of front-end and back-end semiconductor materials.

Risks faced by the Semiconductor and Electronic Materials segment include the potential for increases in raw material, energy, or logistics costs or supply chain disruptions as a result of geopolitical risks. To counter these risks, the segment is developing a resilient supply chain management system designed to facilitate the swift detection of risks and the stable supply of products to customers. As one facet of these efforts, we are constructing a system for integrated management and tracking of semiconductor production and shipment information in Malaysia and other parts of the Indo-Pacific area. This system is scheduled to be implemented in December 2022.

Semiconductor Material Technology Trends

As semiconductors are endowed with more sophisticated functions, there is a rising need for more minutely detailed circuit patterns to be etched through front-end wafer fabrication processes. Meanwhile, in back-end processes, which generally entail mounting chips made from individual wafers onto substrates, the number of components included on chips and in electronic components is increasing at a rapid pace, creating a rising need for new package structures that use 2.xD and 3D mounting technologies to achieve higher mounting density. These trends are boosting demand for Showa Denko's existing highly functional, high-share materials as well as for the new advanced functional materials under development.

In front-end processes, we facilitate customers' development activities with our CMP slurry (nanoceria slurry) capable of creating precise circuit patterns with 2 nm nodes as well as with our precision etching gases and high-purity solvents. At the same time, we assist production activities around the world with back-end process offerings such as photosensitive dry film, copper-clad laminates, and die bonding film supported by superior functionality and strong supply capabilities.

Moreover, Showa Denko is the founding member of the JOINT2 consortium, which is collaborating with regard to substrates, materials, and equipment to help resolve customer issues and accelerate development speeds.

Technological Requirements and Showa Denko's Products

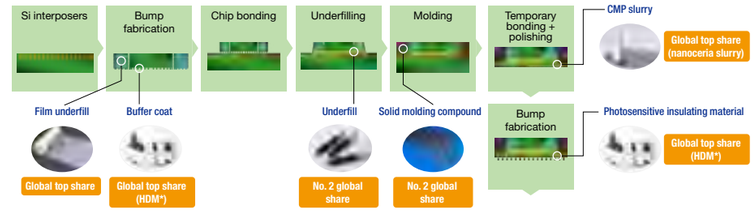
Front-end semiconductor materials

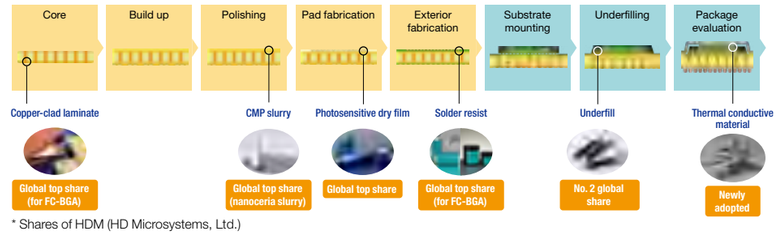
Technological requirements	Requirement-satisfying products
Precision polishing	CMP slurry (nanoceria slurry)
Precision processing (etching)	High-purity gases for electronic materials
Higher-quality solvents	High-purity solvents

Back-end semiconductor materials

Technological requirements	Requirement-satisfying products
Close connection, resolution	Photosensitive dry film
High conductivity, low warping	Copper-clad laminates
Reliability	Die bonding materials

Showa Denko's Lineup of 2.xD and 3D Mounting Products and Associated Market Shares





* Shares of HDM (HD Microsystems, Ltd.)
Note: The above global share figures for products are based on Showa Denko's estimates.

Semiconductor and Electronic Materials

Initiatives for Resolving Social Issues as a “Co-creative Chemical Company”

Contributions to the Realization of a Sophisticated Digital Society Characterized by Popularization of Teleworking and 5G and IoT Technologies

Showa Denko Develops HD Media for MAS-MAMR Technology

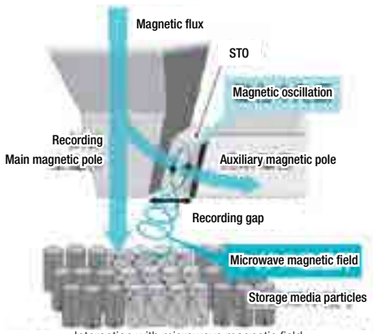
Showa Denko has developed hard disk (HD) media for hard disk drives (HDDs) that support data recording with microwave assisted switching-microwave assisted magnetic recording (MAS-MAMR) technology, which is a next-generation data recording technology based on a new data recording principle suggested by the Toshiba Corporate Research & Development Center and Toshiba Electronic Devices & Storage Corporation (hereinafter collectively called Toshiba).

MAS-MAMR is a next-generation data recording method that can achieve a further increase in the data-storage capacity of HDDs. At present, MAMR is a leading-edge data recording technology that has already been put into practical use. The newly developed MAS-MAMR technology makes possible a data recording track on the surface of HD media that is drastically narrower than that of MAMR-technology-based HD media, through utilization of the strong magnetic oscillation effect of the MAS effect*, thereby increasing the data storage capacity of HDDs.

Aiming to put this new data-recording technology into practical use, Showa Denko has been developing HD media supporting MAS-MAMR in collaboration with Toshiba and TDK Corporation, which is a manufacturer of read/write heads for HDDs. In this joint development program, Showa Denko, Toshiba, and TDK have cooperatively proved for the first time in the world that HDD, as a combination of read/write head equipped with a dual spin-injection-layer (developed by TDK) and HD media equipped with a new-type magnetic layer (developed by SDK), can substantially increase HDDs’ data storage capacity through the MAS effect.

On the basis of the results of the technology development program mentioned above, and aiming to realize large-capacity near-line HDDs with storage capacity of more than 30 TB, Showa Denko will accelerate development of HD media supporting MAS-MAMR, which Toshiba aims to put to practical use as the second-generation MAMR.

Showa Denko will accelerate two-way development of HD media supporting MAS-MAMR and heat assisted magnetic recording (HAMR) in accordance with its motto of “Best in class,” thereby developing the best HD media in the world.



Interaction with microwave magnetic field (strong magnetic oscillation)

MAS-MAMR method

* The MAS effect denotes the microwave assisted switching effect. The MAS effect is an effect of strong magnetic oscillation between a spin torque oscillator (STO) and magnetic recording media. This strong magnetic oscillation enables an HDD manufacturer to record digital data on the surface of HD media with a recording track narrower than those of HDDs equipped with conventional magnetic recording technologies.

Initiatives for Resolving Social Issues as a “Co-creative Chemical Company”

Contributions to Energy-Conserving, High-Efficiency, Compact Power Modules

Showa Denko Launches Mass Production of six-inch SiC Single Crystal Wafers

Showa Denko has launched mass production of silicon carbide single crystal wafers (SiC wafers) with a diameter of six inches (150 mm), which are used as materials for SiC epitaxial wafers*1 to be processed and installed into SiC-based power semiconductors (SiC power semiconductors). SiC power semiconductors have excellent heat resistance and high withstanding voltage, much better than those of conventional silicon-based power semiconductors, which are currently the mainstream of power semiconductors. SiC power semiconductors contribute to improvement in a power module’s energy efficiency and downsizing. Accordingly, the demand for SiC power semiconductors is increasing rapidly in various fields, especially those for use in electrified vehicles, railcars, and industrial equipment.

As an independent supplier of SiC epitaxial wafers, Showa Denko has the global top share in the market, and has been providing power-device manufacturers with best-in-class SiC epitaxial wafers. Showa Denko’s SiC epitaxial wafers are thus highly acclaimed by power device manufacturers both in and outside Japan.

We have even been examining the possibility of starting independent production of SiC wafers. From 2010 to 2015, Showa Denko took part in the Novel Semiconductor Power Electronics Project Realizing Low Carbon Emission Society,*2 which was organized and outsourced by the Ministry of Economy, Trade and Industry (METI) and the New Energy and Industrial Technology Development Organization (NEDO). This is just one of the co-creative venues through which we have been developing mass production technologies.

Showa Denko decided to launch in-house mass production of six-inch SiC wafers because plural customers have adopted the Company’s SiC epitaxial wafers made from its in-house produced six-inch SiC wafers. On the other hand, the Company will continue purchasing SiC wafers from its partners to respond to rapidly growing demand for SiC epitaxial wafers for power semiconductors. In this way, Showa Denko will diversify the sources of SiC wafers, thereby establishing a stable supply chain for SiC epitaxial wafers.

Six-inch single crystal wafer for SiC power semiconductors

*1 SiC epitaxial wafers are a material for semiconductors made from SiC wafers by depositing a thin layer of epitaxial SiC on the surface of the wafer.

*2 The Novel Semiconductor Power Electronics Project Realizing Low Carbon Emission Society is a project aiming to establish technology to realize a stable supply of SiC wafers with large diameters. In 2010 the project was started and entrusted by METI, and in 2011 control of the project was transferred to NEDO.

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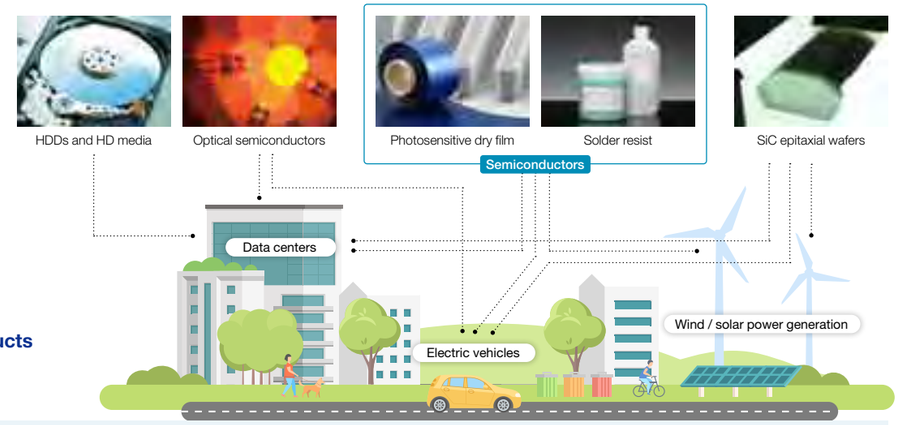

Open Innovation of Semiconductor Package Materials and Processes

Co-creation through JOINT2

JOINT2 Consortium for Developing Next-Generation Semiconductor Packaging Technologies

Overview

- Development of evaluation technologies, substrates, materials, and devices by utilizing an evaluation platform (the Packaging Solution Center in Kawasaki City, Kanagawa Prefecture, is a principal base for these activities)
- Facilitation of integrated trial manufacture and evaluation of 2.xD and 3D semiconductor package by utilizing fine-wiring with stepper and laser dicing

Tracking of customer needs with superior testing technologies, incorporation of findings into composite and other materials

Composite and other materials → Processing, shaping, assembly → Evaluation, simulation → Marketing

Evaluation of optimal package structures using advanced composite materials

Proposal of package materials based on optimal process and equipment

Aims

- Resolution of technical issues in production of next-generation semiconductor packages through coordination of materials and devices of member companies
- Proposal of optimal one-stop solutions for customers and establishment of predominant position by combining not only our own materials but also other member companies’ materials and technologies

Members:
Ajinomoto Fine-Techno Co., Inc.
C. Uyemura & Co., Ltd.
EBARA CORPORATION
SHINKO ELECTRIC INDUSTRIES CO., LTD.
Dai Nippon Printing Co., Ltd.
DISCO Corporation
TOKYO OHKA KOGYO CO., LTD.
NAMICS Corporation
Panasonic Smart Factory Solutions Co., Ltd.
MEC COMPANY LTD.
Yamaha Robotics Holdings Co., Ltd.
Showa Denko Materials Co., Ltd.

The commercial deployment of 5G mobile communication systems is moving forward. It can therefore be expected that we will see the proliferation of post-5G systems featuring ultralow latency*1 and the capacity for multiple simultaneous connection*2 in fields such as autonomous driving and telemedicine. In the past, functions such as logic and memory were installed in different IC chips on substrates. However, accommodating post-5G systems will require an increased density of IC chips and other components to prevent signal latency. Accordingly, there is a need for technologies that allow for high-density packaging of differing chips within a single semiconductor package.

JOINT2, a consortium of 12 companies involved in the development of semiconductor mounting materials, substrates, and equipment, was established in October 2021 with the goal of developing the 2.xD, 3D, and next-generation semiconductor mounting technologies necessary for telecommunications systems compatible with post-5G systems.

Member companies of JOINT2 have formed multiple working groups through which they share technologies and information via open innovation. In this manner, these companies are teaming up to develop precision bump jointing technologies*3 and precision circuit fabrication technologies*4 along with the high-reliability, large-scale substrate technologies necessary for mounting multiple components in order to achieve higher levels of component density on next-generation semiconductors.

*1 Low time lag in communications
*2 Ability for a single substation to accommodate simultaneous connections from multiple devices
*3 Technologies for connecting IC chips and other components in a perpendicular direction using densely fabricated metal protrusions
*4 Technologies for connecting IC chips and other components in a parallel direction using densely fabricated metal protrusions

Japanese companies hold large shares of the global markets for semiconductor materials, substrates, and equipment. However, maintaining our technological edge in these markets will require a platform through which engineers can discuss and evaluate cutting-edge packages. It was this belief that prompted me to propose JOINT2. Private-sector consortiums are rare in this industry, and we therefore face a lot of difficulties as a leading member of the organization. Still, I cannot deny the fact that we are already seeing experiments through JOINT2 produce results more quickly than could have been accomplished alone. I look forward to an even faster pace once we build additional cleanrooms.

Hidenori Abe
General Manager, Packaging Solution Center