Material for the Explanation Meeting on the Business Creation Sector

We promote the well-being of the world
through a spirit of exploration
and diverse technologies.

April 16, 2024

Business Creation Sector
Mitsui Mining & Smelting Co., Ltd.

Today's Agenda

We promote the well-being of the world through a spirit of exploration and diverse technologies.

Participants and Materials

Participants	Name	Position
	• YASUDA Kiyotaka, Ph.D.	Senior Executive Officer and Senior General Manager of Business Creation Sector
	• YAMAMOTO Takuya	Executive Officer and General Manager of Business Planning Department, Business Creation Sector
	• NAKAHARA Yunosuke, Ph.D.	Director of the R&D Center, Business Creation Sector
	• SUZUOKA Kenji, Ph.D.	General Manager, SE Business Promotion Unit
	• FUJII Joji	General Manager, HRDP Business Promotion Unit
	• ANAI Kei	General Manager, AST Business Promotion Unit
Materials	Topic	Document pages
	• Overview of the Business Creation Sector	PP. 2 to 6
	• [A-SOLiD®], a Solid Electrolyte Business for All-Solid-State Batteries	PP. 7 to 13
	• [HRDP®] Specialty Carrier Business for Next Generation Semiconductor Packaging	PP. 14 to 17
	• Cu Sinter Paste Business	PP. 18 to 19
	• CO_2 Capture and Reuse Business (R&D Center Case Studies)	PP. 20 to 23
	• Owned Media "M-Lab" (Web Marketing & Open Innovation)	P. 24
	• Copyrights and Disclaimer	P. 25

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Positioning of the Business Creation Sector

Company purpose

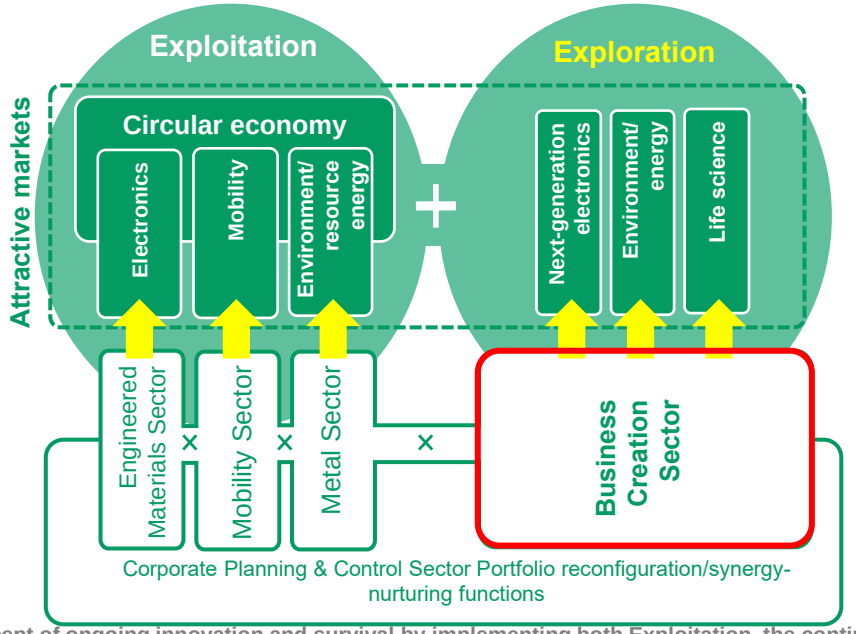
We promote the **well-being of the world** through a spirit of exploration and diverse technologies.

Sector mission

To be a **"source" of the well-being of the world**. Three sentiments behind our mission: (1) Our company is a source of resolving issues to make the earth smile ≈ a starting point; (2) our sector is a source of company-wide businesses; and (3) the foundation of our competitive advantage is the intelligence of the source (material).
This is a sector of **"Exploration"** within Ambidexterity*, with priority allocation of management resources as a **"Value Cultivation"** sector within business portfolios.

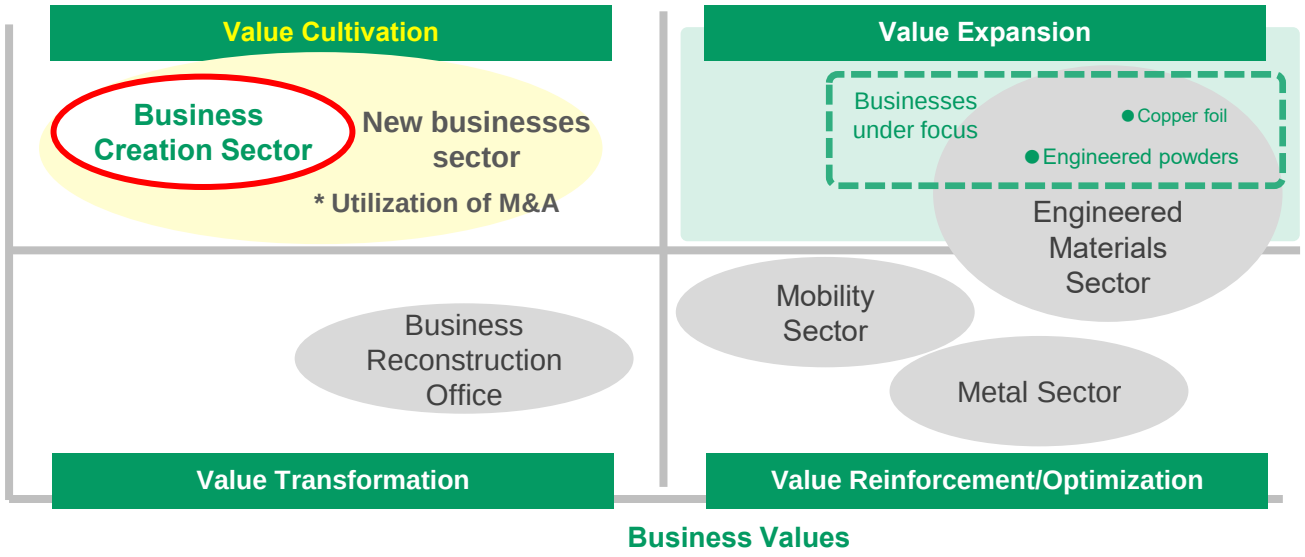
Positioning of the Business Creation Sector

Ambidexterity



* A concept of ongoing innovation and survival by implementing both Exploitation, the continuous pursuit of existing businesses, and Exploration, the development of new businesses.

Business Portfolio Management



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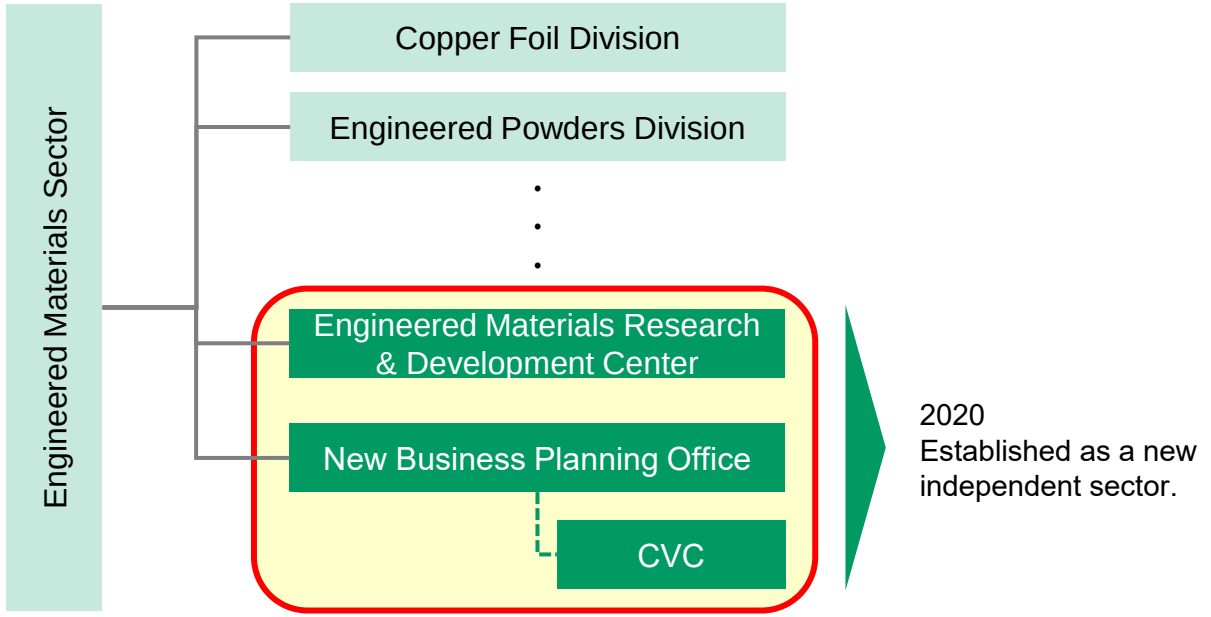
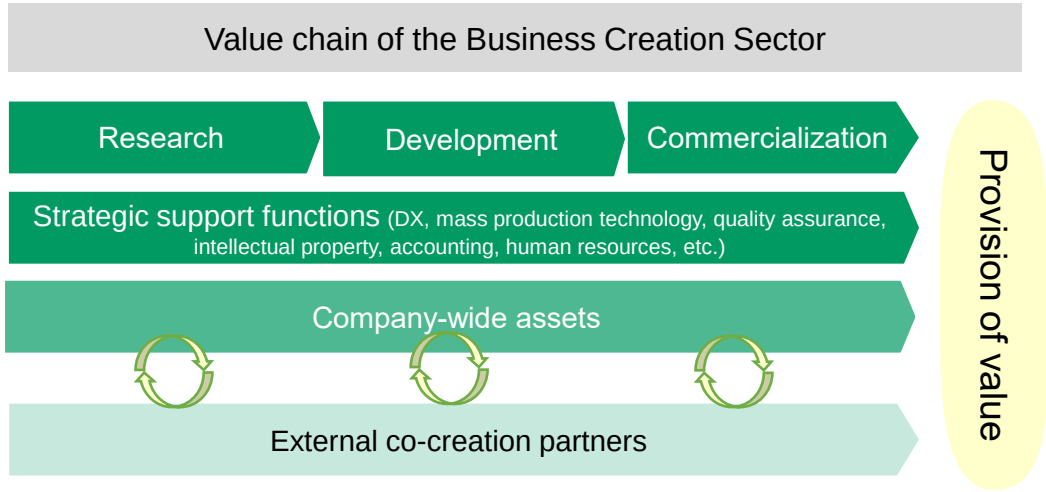
History and Organization of the Business Creation Sector

In 2020, the Engineered Materials Research & Development Center and the New Business Planning Office under the Engineered Materials Sector were spun off into a new independent sector.
This new organization is autonomous and self-propelled, and handles everything from research and development to commercialization, having the internal strategic support functions necessary for business creation.

History of the Business Creation Sector



Organization Features



(1) An autonomous, self-propelled organization
- Handling of everything from R&D to commercialization
- With strategic support functions for DX, mass production technology, quality assurance, IP, etc.

(2) A “market co-creation-type” business entity
- Creation of new markets with external co-creation partners*
  The sector operates CVC for organic links with external assets.

* Customers, universities, research institutions, suppliers, startups, equipment and complementary goods manufacturers

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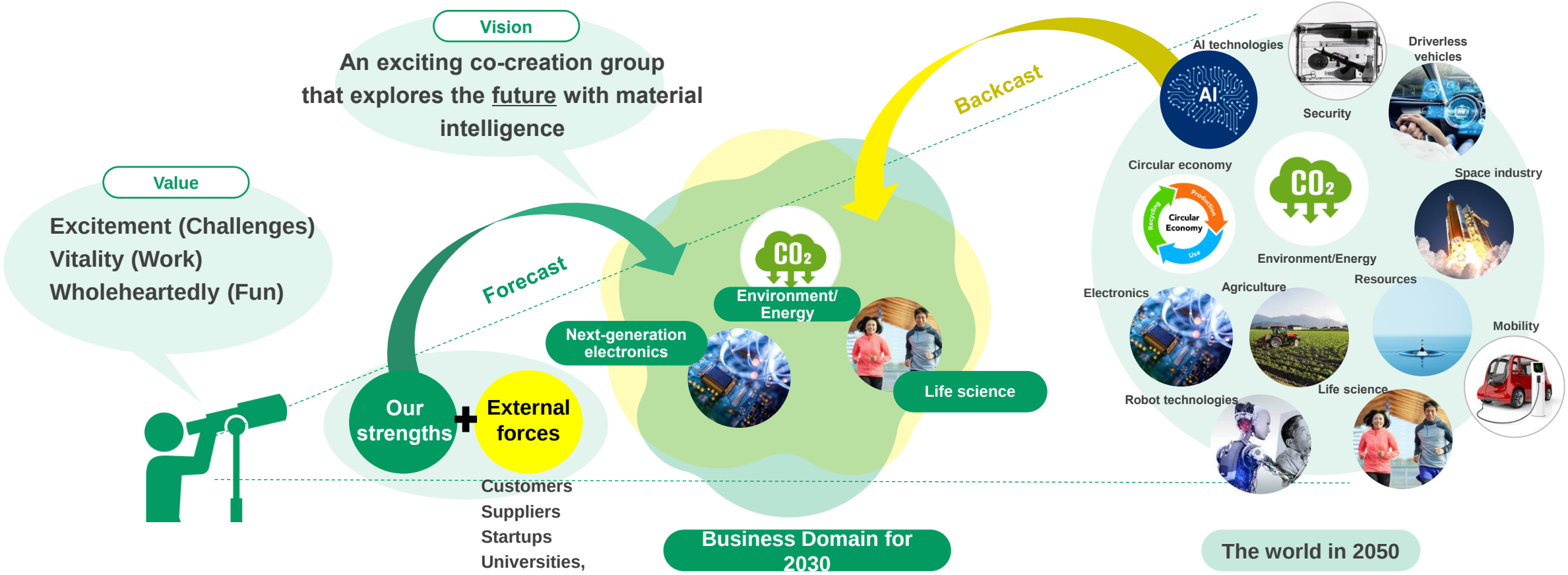
Vision, Value, and Business Domain of the Business Creation Sector

We create markets one after another by leveraging our strengths and external forces.
Our business domain for 2030 are “Environment/Energy,” “Next-generation Electronics,” and “Life Science.”



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Year 2030 Goals and Major Policies of the Business Creation Sector

We will actively invest management resources toward the goal of contributing to profits of 10 billion yen* or more in 2030 from our new business themes.

Major Policies of the Business Creation Sector

Policies

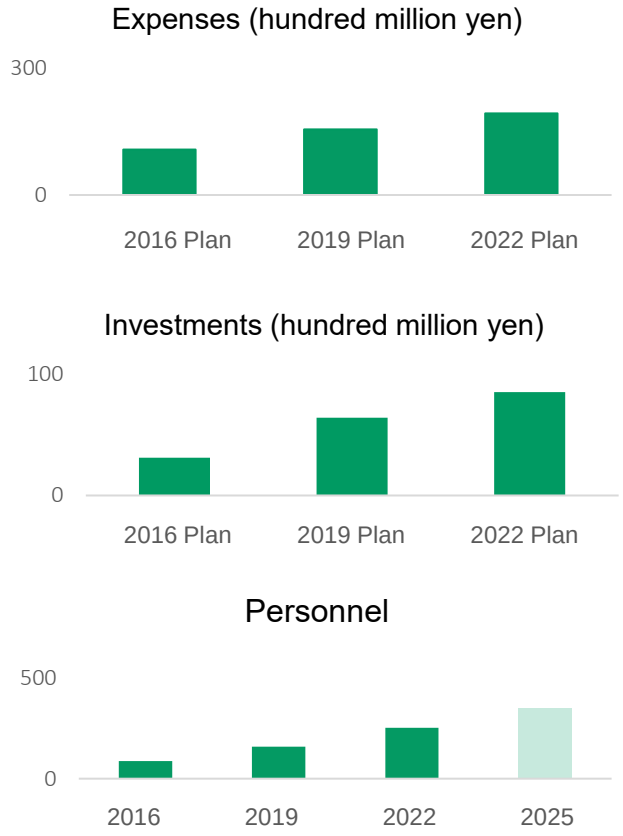
(1) Reinforcement of our R&D strengths
- Increase the number of R&D personnel.
- Promote DX application.
- Promote external collaboration.

(2) Reinforcement of commercialization promotion
- Increase the number of personnel for commercialization promotion.
- Implement strategic investments.

(3) Enhancement of strategic support functions
- Reinforce strategic support functions for production process development, IP, quality assurance, etc.

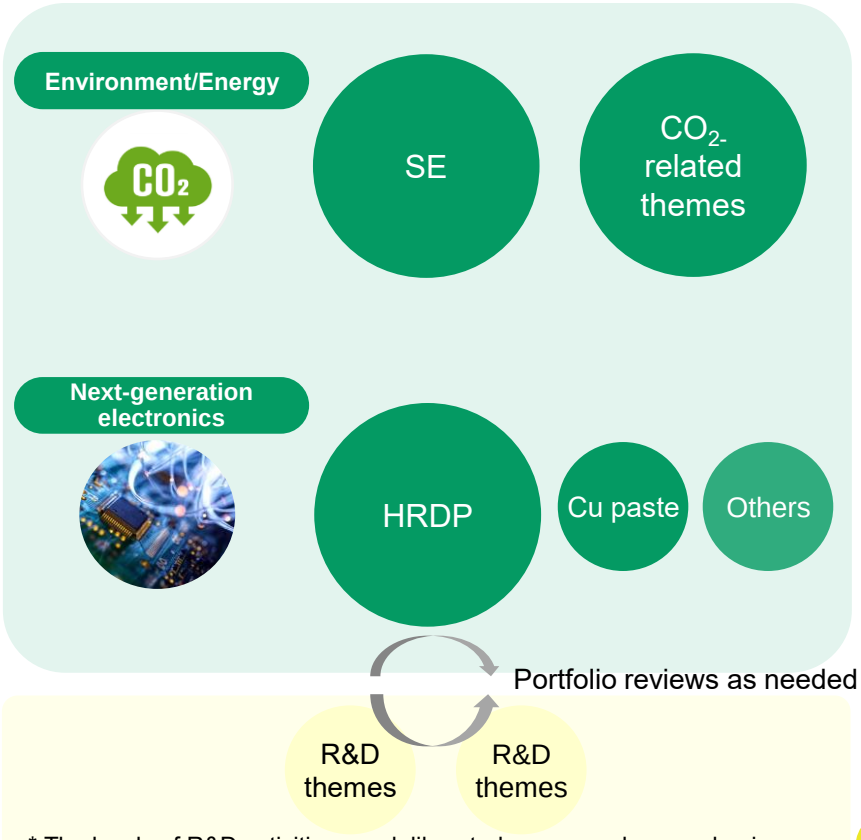
(4) Reinforcement of sector competitiveness
- Promote the spread of MVV.
- Enhance human capital.
  - Boost engagement.
  - Nurture global human resources, etc.

Management Resources



Year 2030 Goals

Profit contribution > 10 billion yen



* The levels of R&D activities are deliberated on a case-by-case basis within the framework of company-wide management asset allocation.

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Concrete Case Studies (Cases Studies in the Environmental/Energy Sector)

To realize the well-being of the world, we are promoting a vast number of themes based on keywords such as a “carbon neutral society,” “recycling-oriented society,” and “society in harmony with nature.”

Excerpt

Blue: Themes to be introduced today

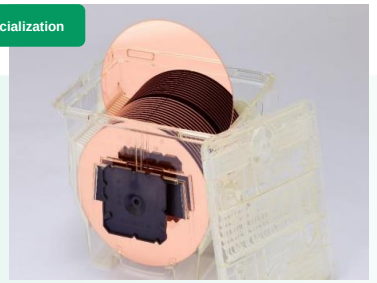
Contribute to a carbon neutral society

- Technologies that facilitate the transition to EVs and FCVs
- Technologies that support a hydrogen society
- Technologies that contribute to the reduction of GHG emissions

Solid electrolyte A-SOLiD®

Commercialization

Commercialization

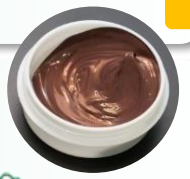


HRDP® Special carrier for next generation semiconductors

Contribute to circular economy

- Technologies that contribute to energy and resource conservation
- Materials that support material recycling and resource circulation

Under development



Cu sinter paste for power semiconductors

Contribute to harmonious coexistence of nature and humans

- Technologies that support the bioeconomy

Methanol generation from CO_2

Collaborating

eSep

Downsizing and energy conservation for chemical processing

Collaborating

CHITOSE

Industrial structure transformation driven by photosynthesis-based technology

Collaborating

Helical Fusion

Commercialization of nuclear fusion technology

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Project Overview

Year 2030 vision

Contribute to realizing a decarbonized society through all-solid-state batteries and become the leading company for solid electrolytes.

Product Overview

Target markets

Next-generation batteries: All-solid-state batteries

Safer and more comfortable electric vehicles (EVs)

Expansion of potential battery uses by increasing environmental adaptability (high/low temperatures, etc.)

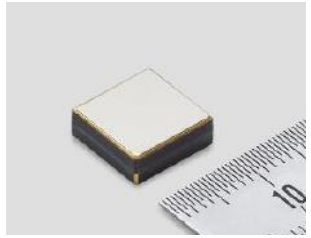


Photo provided by Maxell, Ltd.

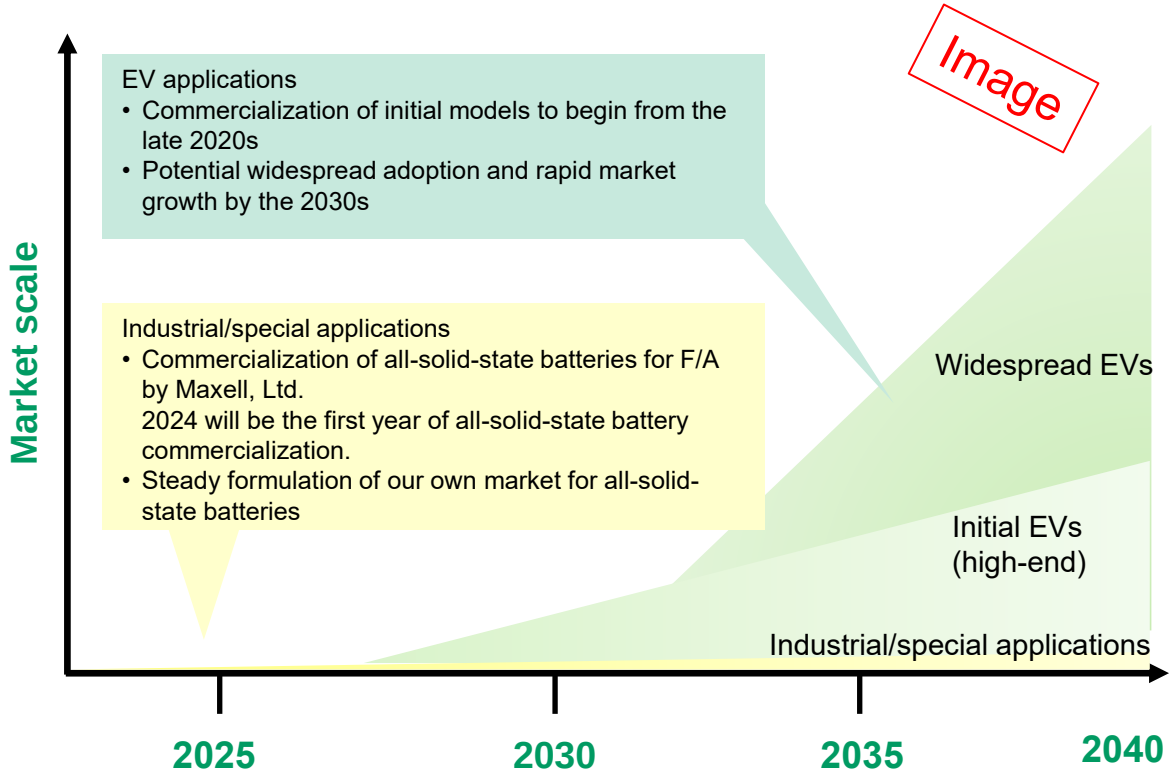
Photo provided by LIBTEC

Value we proposition

A-SOLiD®, a solid electrolyte

- A powder sulfide solid electrolyte necessary for all-solid-state batteries
- Argyrodite-type structure with high ion conductivity and durability, and exhibits excellent properties for use in batteries

Market Scale in the 2030s



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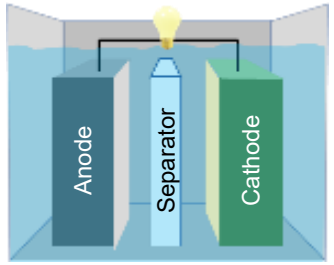
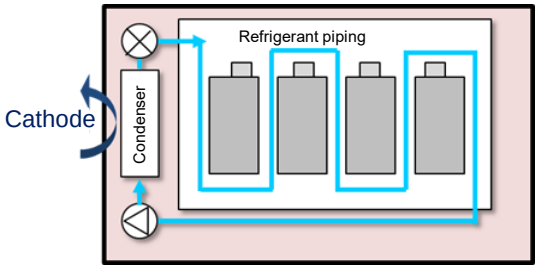
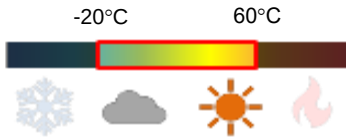
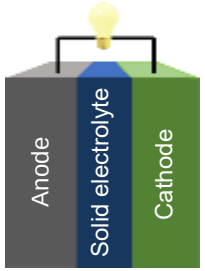
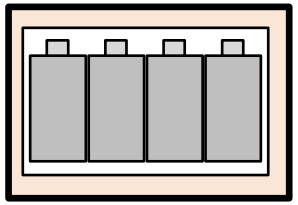
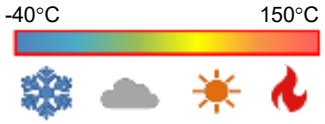
Features and Expected Value of All-solid-state Batteries

Compared to conventional liquid LiBs, all-solid-state LiBs offer a “wide temperature range for use” and “high safety.”
They are expected to provide value in terms of smaller sizes, quicker charging, and higher energy density.

Comparison of LiB Features

	Composition	Form	Working Temperature Range	Battery Design
Liquid type	 ● More than 70% is organic matter ➢ Limited working temperature range ➢ Risks of leakage/combustion			Cathodes: LMO, NCM, LFP Anodes: Graphite, LTO
All-solid-state	 ● No use of electrolyte solutions (Composed of only inorganic matter) ➢ Wider working temperature range ➢ Lower risks of leakage/combustion ➢ Rapid charging becomes possible	 ・Smaller cooling space ・Simplified BMS	 Wider working temperature range and improved heat resistance	Potential of new materials Cathodes: High-voltage cathodes 5V-class LNMO, etc. Anodes: High-capacity anodes Li metal, Si-types, etc.
Provision of value	**High level of safety**	**Smaller and more lightweight**	**Rapid charging becomes possible**	**High energy density**

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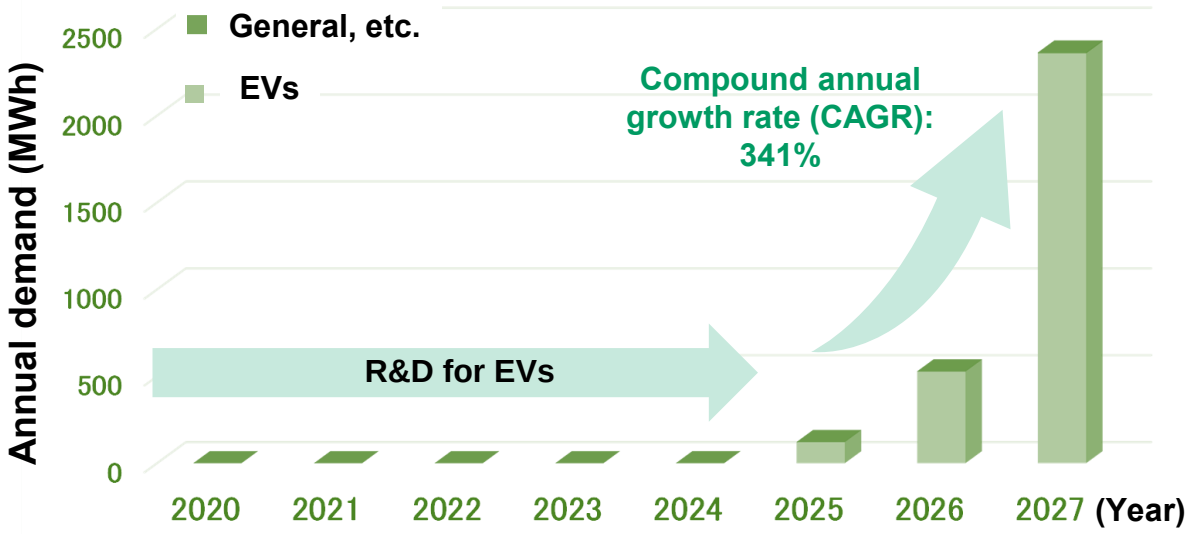
All-solid-state Battery Market Trends

We can expect the market to expand, as there are already practical applications that make the most of the features of all-solid-state batteries. Companies have been actively making efforts to achieve EV commercialization in the latter half of the 2020s.

Market forecast per application for all-solid-state batteries



Data source: Solid-State Battery 2021 | Report | www.yole.fr

General

maxell

Commercialization of high-capacity ceramic packaged all-solid-state batteries

News release (7/25/2022)

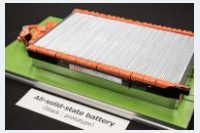
Development of cylindrical all-solid-state batteries for use in main power supplies

News release (10/26/2023)

EVs

TOYOTA

Striving to create an all-solid-state battery-powered vehicle in 2027 to 2028



News release (6/13/2023)

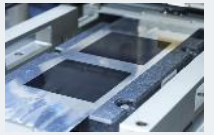
HONDA

Announced 44 billion yen in investments in 2024

Business briefing (4/12/2022)

NISSAN

Announced prototype manufacturing facilities

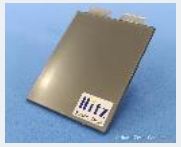


News release (4/8/2022)

Space

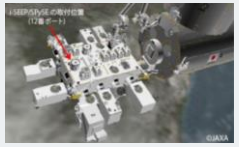
Hitz
Hitachi Zosen

Adopted by a semiconductor equipment manufacturer



News release (2/27/2024)

Discharge/charge functions confirmed in space



News release (8/5/2022)

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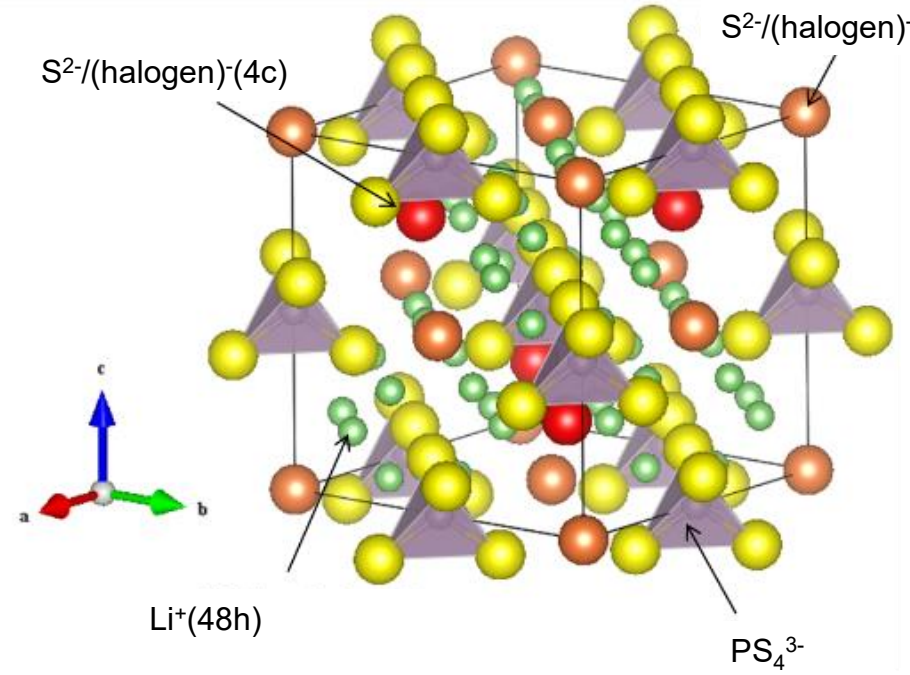
A-SOLiD® Features

A-SOLiD® features high ion conductivity (2 to 10 mS/cm) within processes feasible for mass production.
It has both the characteristics of a powder and ion conductivity and can be used widely as a battery material.

Features of A-SOLiD® (Argyrodite-type Solid Electrolyte)

Crystalline Structure of an Argyrodite-type Sulfide Solid Electrolyte



Use of VESTA: K. Momma and F. Izumi, J. Appl. Crystallogr., 44, 1272–1276 (2011).

Features

- **Achievement of high Li ion conductivity through optimized composition**
  → Optimization of composition to incorporate the lattice space necessary for high diffusion of Li ions
- **Realization of both powder characteristics and ion conductivity**
  → Realization of both particle size control and ion conductivity by employing our powder control technology
- **Crystalline material with excellent mass production properties**
  → Management of crystallization parameters and quantification of control factors
- **Possession of many patents related to argyrodite**

A-SOLiD® Features

A-SOLiD® (sulfide solid electrolyte), which our company has developed, is a material that features high ion conductivity and particle size control compared to other sulfide solid electrolytes, and that has excellent mass production potential.

◎Particularly excellent ○Good △Has issues

Comparison of Various Sulfide Solid Electrolytes

Name	Structure: Typical composition	Ion conductivity	Voltage stability	Moldability (hardness)	Atomization	Mass production feasibility	H_2S generation
Our company A-SOLiD®	Crystal $Li_{7-x}PS_{6-x}Ha_x$	◎	○	○	◎	◎	△
Argyrodite	Crystal Li_6PS_5Cl	○	○	△	○	◎	△
LGPS	Crystal $Li_{10}GeP_2S_{12}$	◎	△ (Ge, Si)	△	○	△	△
Glass ceramic	Glass ceramic LPS+Ha	○	○	◎	△	△ Mechanochemical	△

Created by Mitsui Mining & Smelting Co., Ltd. based on various data.

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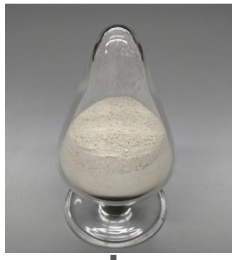
Initiatives to Promote SE Projects

In November 2021, we started supply from test facilities for mass production. We decided to increase production capacities in February 2023 and again in January 2024.
A-SOLiD® will contribute to the realization and widespread adoption of all-solid-state batteries.

2016 — Development of a sulfide solid electrolyte

(11/24/2016 News release)

- Developed an argyrodite-type sulfide solid electrolyte with excellent mass production capabilities.



2019 — Decision to introduce mass production testing facilities

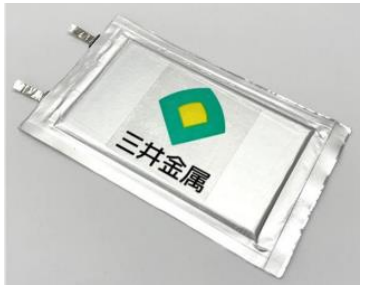
(12/4/2019 News release)

- Started verification towards commercialization of all-solid-state batteries with facilities that have an annual production capacity of several dozens of tons.

2021 — Start of supply from A-SOLiD® mass production testing facilities

(11/11/2021 News release)

- Developed an argyrodite-type sulfide solid electrolyte with excellent mass production capabilities.



2023 — Production capacity increased for mass production facilities

(2/7/2023 News release)

- Decided to increase the production capacity for argyrodite-type sulfide solid electrolyte.

2024 — Decision to invest in expanding secondary production capabilities

(1/26/2024 News release)

- Decided to invest to triple the current production capacity.

A-SOLiD® mass-production testing facility building

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Initiatives toward 2030

Roadmap

*1 Small Volume Manufacturing
*2 High Volume Manufacturing

R&D → Preparations for commercialization → SVM*1 → HVM*2

2015 2020 2025 2030

Developed solid electrolytes.

Decided to introduce a mass-production testing facility.

Started to supply samples.

EV uses

Accelerate R&D with customers. → Commercialization

Industrial uses

Commercialization → Expanded applications

Decided to triple production capacity in response to soaring demand for samples from companies in Japan and overseas. (January 26, 2024)

A-SOLiD™ mass-production testing facility building (Ageo City, Saitama Prefecture)

2024

With the acceleration in development towards commercialization at companies, there has been a rapid increase in the number of inquiries.

➡ We are deliberating additional investments to increase production.

Future Key Policies

EV uses

Environment

- Development is accelerating at companies to achieve commercialization in the late 2020s, and the number of inquiries has been increasing rapidly.

Measures

- Reinforce mass production testing facilities to address customer demand.
- Co-create an EV market by providing high-quality solid electrolytes.
- Develop processes for HVM and make efforts to lower costs.
- Assess market trends to invest at optimal timings.

Industrial uses

Environment

- Maxell's high-temperature range and long-life batteries started receiving orders from Nikon in FY2024, so commercialization of all-solid-state batteries starts this year.

Measures

- Ensure delivery of solid electrolytes of consistent quality.
- Expand the product lineup according to customer requirements.
- Collaborate with partners who develop materials that cater to customer/market needs to expand applications and markets.

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Project Overview

Year 2030 vision

Achieve a de facto standard for next-generation semiconductor packaging device platforms

Product Overview

Target markets

Specialty carrier for the next-generation semiconductor PKG

Contribute to the advancement of technologies for high-speed communication, high-speed processing, self-driving, medical procedures, etc.

Reduce power consumption and improve energy efficiency.

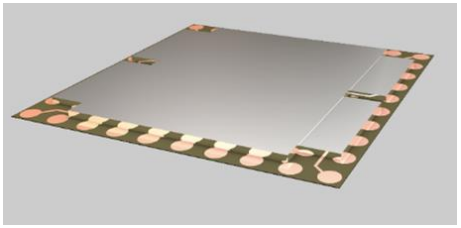
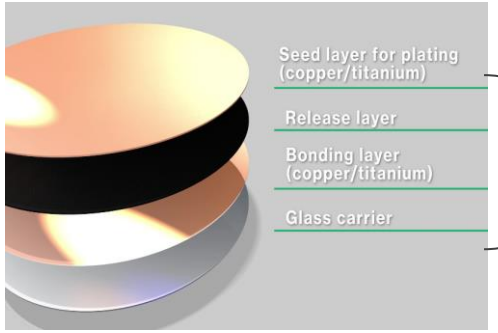


Image of a next-generation semiconductor package

Value we proposition

HRDP®

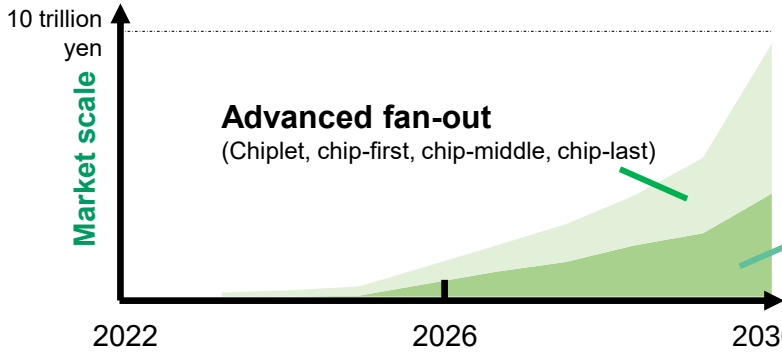


Functional layer thickness: 0.65 μm

- Specialty carrier for high production efficiency of next-generation semiconductor packaging
- Contribution to customers' process yield maximization in next-generation semiconductor package manufacturing

Market Scale in the 2030s

The advanced packaging that HRDP® aims for is advanced fan-out and advanced flip-chip.



The advanced packaging market scale that HRDP® aims for is forecast to expand to 9.4 trillion yen by 2030.

Created by Mitsui Mining & Smelting Co., Ltd. based on information from Advanced Packaging 2023, Yole.

Status of Customer* HRDP® Assessments and Production Application Plans

15 major semiconductor supply chain companies have entered the mass production assessment phase, and one of these companies is in the final stages before mass production.

Customer segment	2024	2025	2026	2027・・・
Innovators 2 companies	SVM*1		HVM*2	
Early adopters 3 companies	Development	SVM	HVM	
Early majority 12 companies	Development		SVM	HVM
Late majority 9 companies	Development			SVM HVM

*1 Semiconductor packaging supply chain; IDM, fabless companies, packaging manufacturers, and board manufacturers
*2 Small Volume Manufacturing
*3 High Volume Manufacturing

Created on information current as of March 2023.

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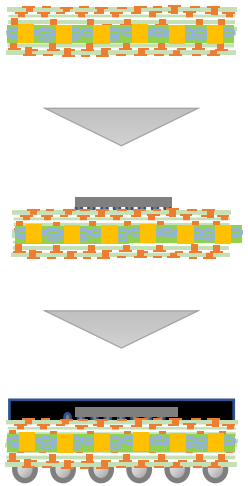
HRDP® Targeting

Merits of Carrier Application

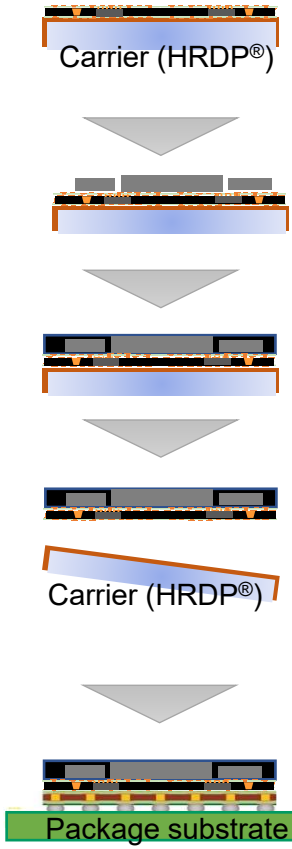
Conventional Structure



Thick (device thickness)

FC-CSP/FC-BGA

Next-generation Package Structure



Ultra-high-density RDL including smaller than LS2/2um circuitry design.

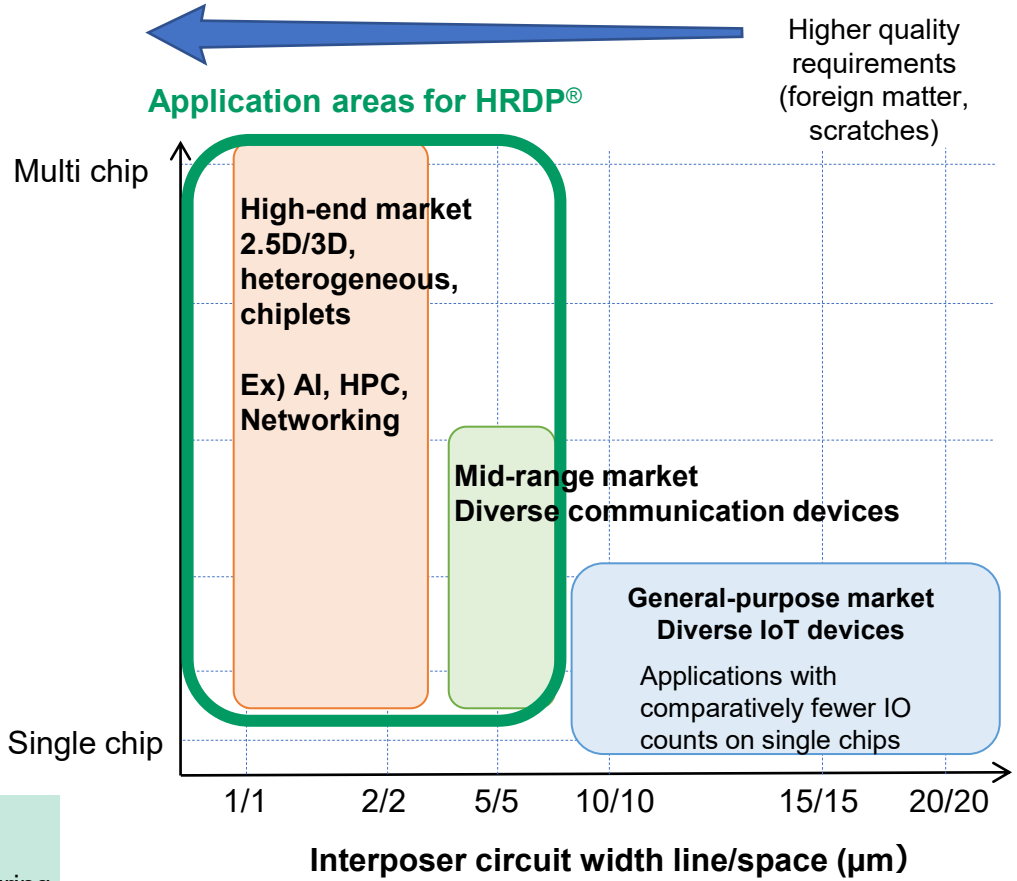
Improved productivity by minimizing warpage of packaging device work-in-progress.

Realization of Ultra-thin devices

- Simplification of high density chip assembly process
- Realization of high yield manufacturing for the 2.5D/3D chip-lets structures

Application Areas for HRDP®

Development of devices with specifications enabled by applying HRDP®



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Initiatives toward 2030

Roadmap

*1 Small Volume Manufacturing
*2 High Volume Manufacturing

R&D → Preparations for commercialization → SVM*1 → HVM*2

2018 — 2020 — 2025 — 2030

- 2018: Developed HRDP®. Established mass production technologies with GEOMATEC Co., Ltd.
- 2020: Started mass production. (Domestic composite chip module manufacturers)
- 2020: Started mass production. (IC-chip packaging device manufacturers overseas)
- 2020: Started operation of the DOE*3 facility.
- 2025: Expand production capacity (install a second line). Enhance the DOE facility.
- 2025–2030: Expanded adoption

Automatic release mechanism for HRDP® (part of the DOE facility)

*3 DOE: Design of Experiments. This methodology is applied to build a development facility for identifying and resolving issues in advance by verifying customer designs.

Future Key Policies

Environment

- Increase in the number of inquiries for next-generation semiconductor packaging geared toward 5G/6G, AI, and high-performance computing
- Increase in the number of development projects from mainstream customers due to production efficiency (panelization and cycle time reduction) with HRDP® application

Measures

- Reinforcement of marketing activities to end-manufacturers who are utilizing DOE facilities
- Expansion of the product lineup according to customer requirements
- Second line to start operation as planned in 2025

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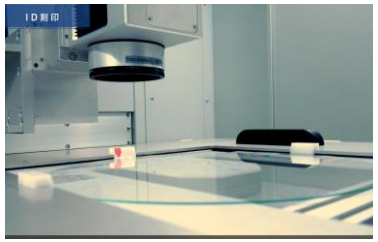
Initiatives toward 2030

At present, the first line within the GEOMATEC Co., Ltd. Ako Factory has been conducting mass production, and the second line is planned to start operation in 2025.*1
We will make capital investments informed by market expansion towards the year 2030.

Manufacturing Process



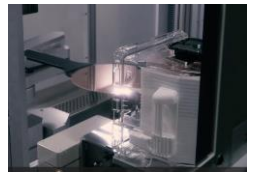
Printing

Glass cleaning

Deposition of functional layer*2

Clean transport

Product inspection



Packaging/shipping

HRDP® production capacity

2023	2024	2025 to 2027	2028 onward
40,000 m²/year	110,000 m²/year (Partial automation of the first line)	170,000 m²/year (Start of operation of the second line*1)	Securing of the required production capacity

*1 May 15, 2023, news release
*2 Excerpted from the GEOMATEC Co., Ltd. website.

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Project Overview

Year 2030 vision

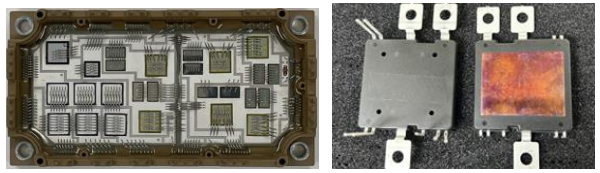
Reach the No. 1 position and performance as a copper bonding material manufacturer to contribute to improving the global environment through widespread adaptation of power electronics.

Product Overview

Target markets

Next-generation power semiconductors

Promote the spread of power semiconductors as key devices for decarbonization and energy conservation.



- EVs/PHEVs
- Renewable energy (wind/solar power)
- Industrial equipment (base stations, etc.) and more

Value proposition

Cu sinter*1 paste for power semiconductors

Characteristics

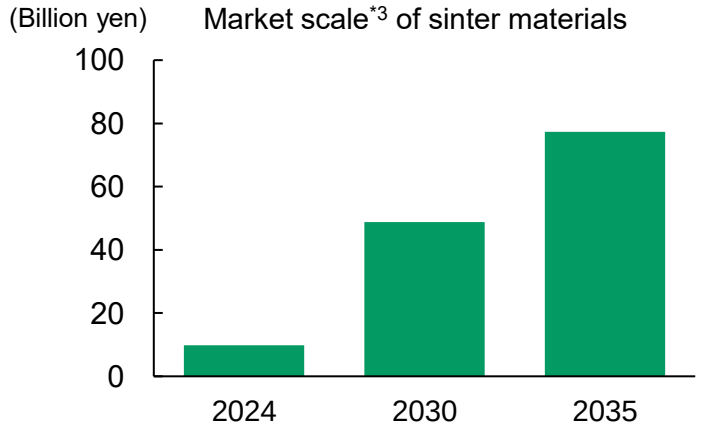
- Bonding material with high heat dissipation and high heat resistance, which are essential properties for next-generation power devices (SiC/GaN)
- A performance level equivalent to that of Ag sinter paste, which is taking the lead in the market

Competitive advantage

- Integrated in-house design/development/production from copper particles to paste to achieve a cost advantage over competitors (Cu/Ag sinter materials)

Market Scale in the 2030s

- The sinter materials market is also expected to see sustainable growth due to the rapid popularization of EVs and wider implementation of SiC power modules.
- Adoption of sinter materials, including die-attach and substrate-attach*2, will continue to grow to a market scale of 50 billion yen in 2030, and will expand thereafter as well.



*1 Technology that creates metal bonds at a junction interface through heat and pressure of materials to be bonded and the paste
*2 E.g., bonding between a semiconductor package and a heat sink
*3 Created by Mitsui Mining & Smelting Co., Ltd. based on the “Current Status and Future Prospects of Next-generation Power Device & Power Electronics-related Equipment Market for 2024” by FUJI KEIZAI CO., LTD.

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Initiatives toward 2030

Roadmap

*1 Small Volume Manufacturing
*2 High Volume Manufacturing

R&D → Preparations for commercialization → SVM*1 → HVM*2

2015 2020 2025 2030

Developed Cu sinter paste.

Started operations of DOE*3 facilities/small-scale mass production facilities.

Markets by area

Europe and America: Accelerate R&D with customers. → Expand adoption/applications.

Asia: Accelerate R&D with customers. → Expand adoption/applications.

— DOE functions —

Equipment for process testing and evaluation

Sintering equipment for mass production

Future Key Policies

Environment

- Full-scale adoption of SiC is ongoing focused on EVs and PHEVs, and solder is being replaced with Ag sinter to improve performance.
- Meanwhile, customers have strong needs to reduce costs, and less expensive Cu paste is expected to reduce costs in the back-end process*4 for widespread adoption of SiC power modules.

Measures

- Aim to replace Ag sinter by providing products according to application*5 at competitive prices, by taking advantage of our strength in integrated internal development from copper particles to paste and in-house DOE functions.

*3 DOE: Design of Experiments. This methodology is applied to build a development facility for identifying and resolving issues in advance by verifying customer designs.
*4 Back-end process: Processes for bonding diced semiconductor chips and substrates, wiring, and resin encapsulation to finish products
*5 Example applications: Clip attach (bonding between the top side of a semiconductor chip and a lead frame)
Substrate attach (bonding between a semiconductor package and a heat sink)

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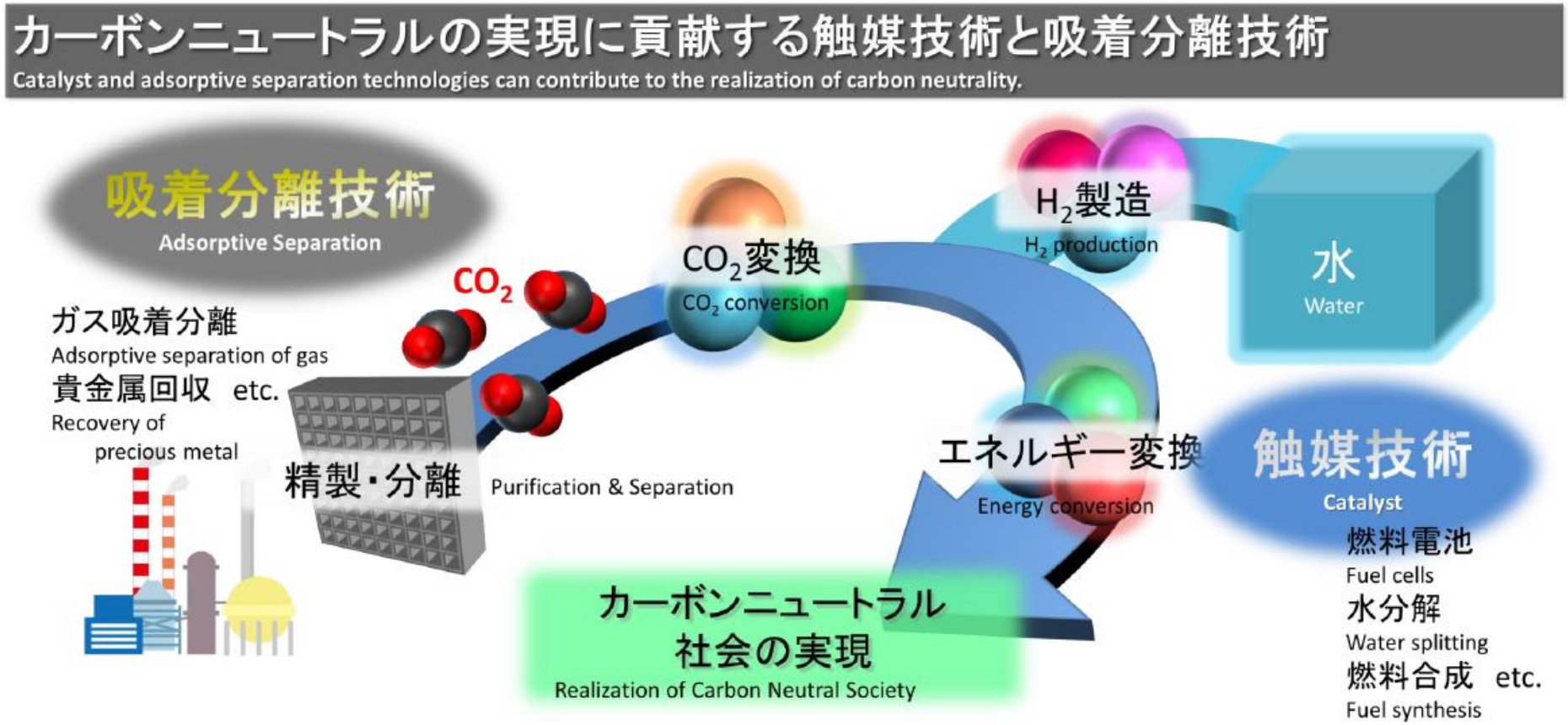
Key Technologies for Decarbonization

We have set **adsorption separation** and **catalysts** as key technologies for creating new businesses related to decarbonization at our company.
We encourage external collaboration to refine technologies and promote initiatives focused on CO_2 capture and conversion as well as related fields.



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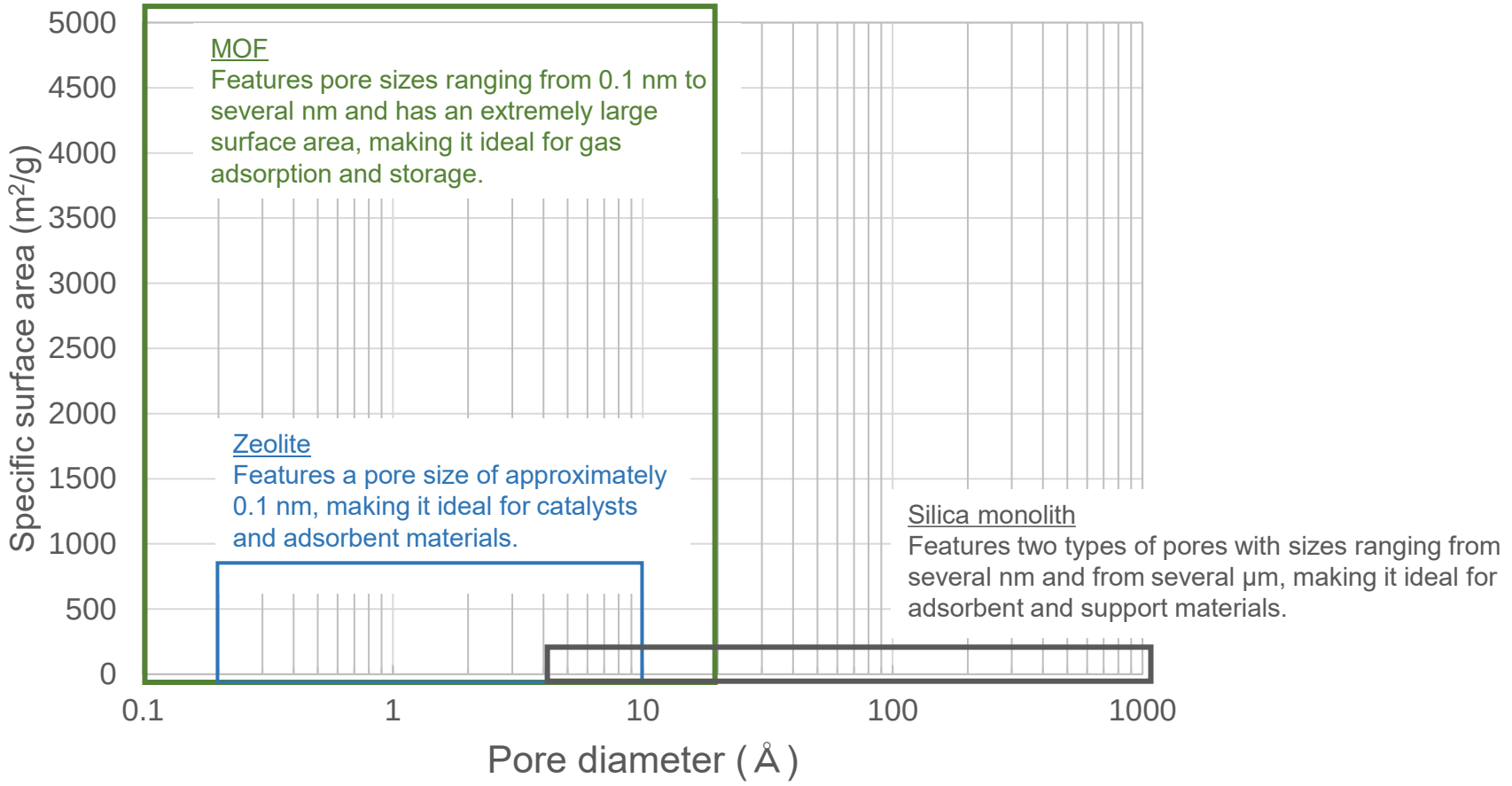
Key Materials for Decarbonization

With distinctive materials (zeolite, silica, MOF/porous materials) and related technologies that can be applied as key elements in the era of decarbonization, we aim to create new value with adsorption/separation and catalytic functions.



MOF: Metal Organic Framework

Examples of CO_2 Capture Technology Initiatives

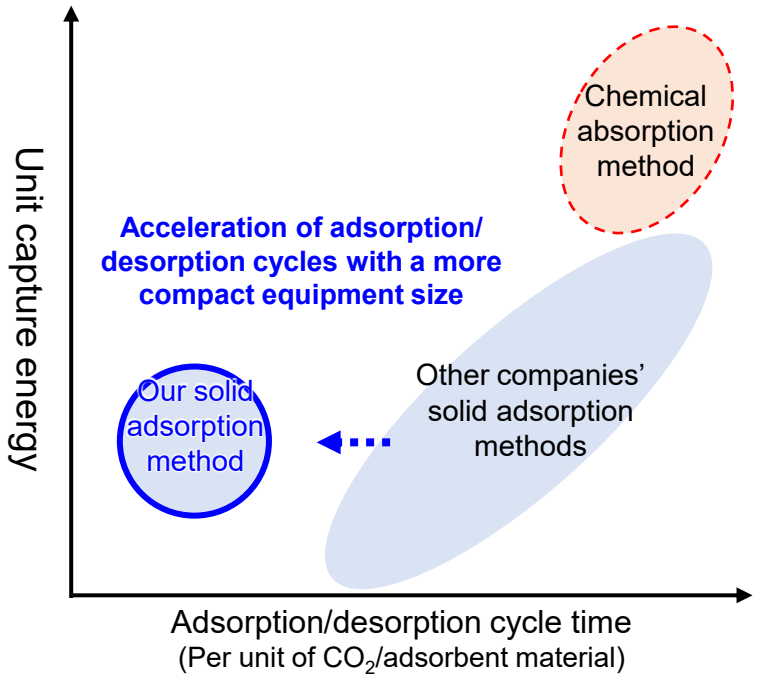
Panels/actual exhibits | Under development | Collaboration between sectors

We promote the well-being of the world through a spirit of exploration and diverse technologies.

By utilizing newly developed CO_2 capture materials, we are making efforts to realize new businesses that widely contribute to the company as well as decarbonization.

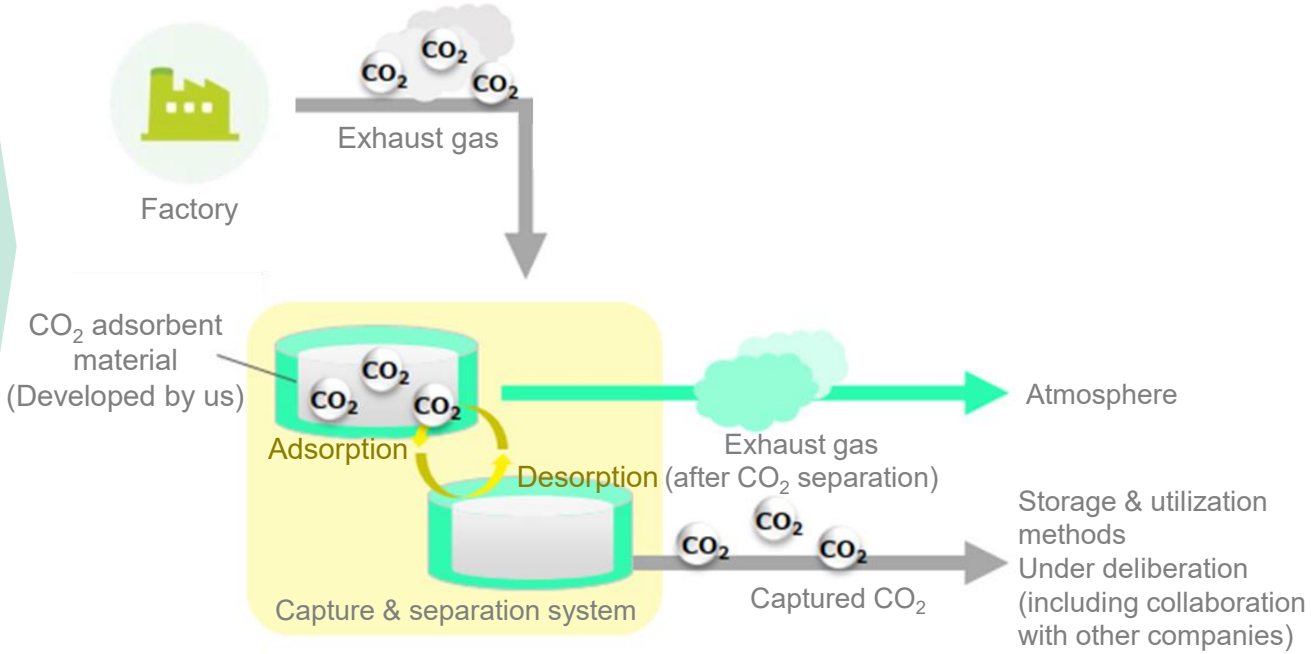
Differential Hypothesis

Development of CO_2 capture materials with a fast cycle time and low capture energy by utilizing our material technologies



CO_2 Capture System Proposal

Rapid extraction of issues within CO_2 capture materials and the system, along with acceleration of practical applications by using our factory for demonstrations



Examples of CO_2 Utilization Technology Initiatives

Under development | Open innovation with startups

We promote the well-being of the world through a spirit of exploration and diverse technologies.

We are accelerating joint development with eSep to provide better value for membrane reactors, which combine separation membranes and catalysts.

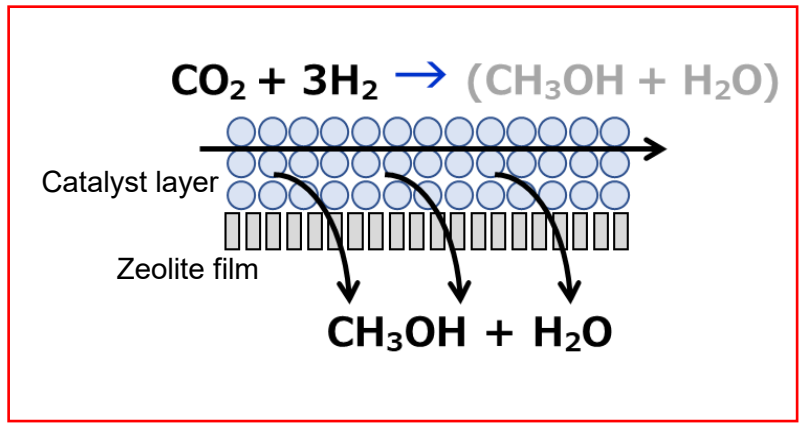
Methanol Generation from CO_2 with a Membrane Reactor

CO_2-methanol synthesis reaction

$$CO_2 + 3H_2 \rightleftarrows CH_3OH + H_2O$$

Theoretical yield of CH_3OH = approx. 20% (250℃,5MPa)

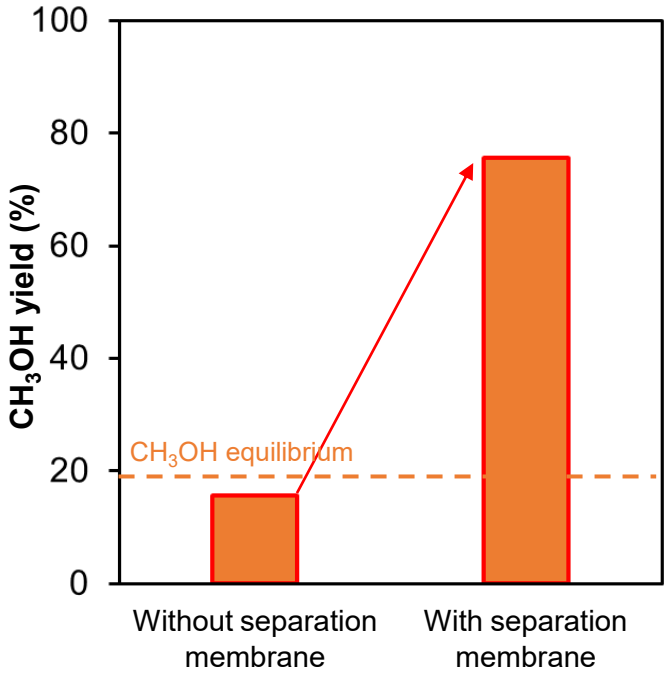
Membrane reactor mechanism



Selective separation of product materials promotes reactions.

Laboratory Scale Test Results

We confirmed the possibility of exceeding the theoretical yield with membrane separation.*



* Already announced at the CerSJ 36th Fall Meeting of the Ceramic Society of Japan.

Business Creation Sector's Owned Media " M Lab"

We relaunched the owned media "M Lab" in March 2023 for web marketing and open innovation (search for co-creation partners.)

www.mitsui-kinzoku.co.jp/mlab/

Exhibition product information

Push-type information transmission

Pull-type information transmission

Stories per theme, etc.

- Customers
- Suppliers
- Startups
- Universities, research institutions, etc.

Solicit product inquiries, development project requests, inquiries for collaboration, etc.

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