Material for the Explanation Meeting on the Copper Foil and Engineered Powders Business

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

January 12, 2024

Engineered Materials Sector
Mitsui Mining & Smelting Co., Ltd.

MITSUI KINZOKU

Participants in Today's Meeting

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

- Masato Okabe, Managing Director and Senior General Manager of the Engineered Materials Sector

- Tatsuya Sudo, Director of the Copper Foil Division

- Takeshi Miyazono, Executive Officer and Director of the Engineered Powders Division

- Daisaku Kobayashi, President and CEO, Nippon Yttrium Co., Ltd.

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Copper Foil Division

Bases and Production Capacities of the Copper Foil Division

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

The Copper Foil Division supplies our products to the global market mainly through its global network centered on three domestic and overseas production bases.

三井金属

Head Office
(Osaki, Shinagawa-ku, Tokyo)

<Total Production Capacity>
4,200 tons/month
(including MicroThin™: 4,900 km²/month)

Ageo Operation <ACF>
(Ageo-shi, Saitama)

<Production Capacity>
500 tons/month
(including MicroThin™: 2,500 km²/month)

Increased the production capacity for MicroThin™ by 500 km²/month (Announced in the news release dated December 12, 2023)

China network
Mitsui Copper Foil (Hong Kong) Co., Ltd. <Sales base>
Mitsui Copper Foil (Suzhou) Co., Ltd. <Processing base>
Mitsui Kinzoku Trading (Shanghai) Co., Ltd. <Marketing base>
Mitsui Kinzoku Trading (Shanghai) Co., Ltd. Shenzhen Office <Marketing base>

San Jose Office
(CA,,U.S.A.)
<Marketing base>

Oak-Mitsui Technologies LLC
(Frankfort, Kentucky U.S.A.)

Mitsui Mining & Smelting Co., Ltd.
Taiwan Representative Office
<Marketing base>

MITSUI COPPER FOIL (MALAYSIA) SDN. BHD, <MCF>
(Shah Alam, Selangor Darul Ehsan, Malaysia)

<Production Capacity>
2,000 tons/month
(including MicroThin™: 2,400 km²/month)

Taiwan Copper Foil Co., Ltd. <TCF>
(Nantou Hsien, Taiwan, R.O.C.)

<Production Capacity>
1,700 tons/month

Production/sales base
Sales/processing base
Marketing base

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Strengths and Market Share of MicroThin™

MicroThin™, which was developed based on our high technological capability accumulated through more than 20 years of experience in production, has stable quality and we offer an extensive lineup of MicroThin™ products. In addition, coupled with our overwhelming supply capacity and technical service, MicroThin™ has gained more than 95% share of the global market for micro-thin copper foil with a carrier copper film.

Composition of MicroThin™

Cross-section

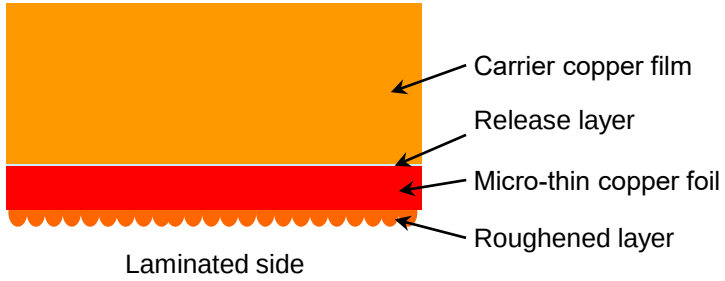
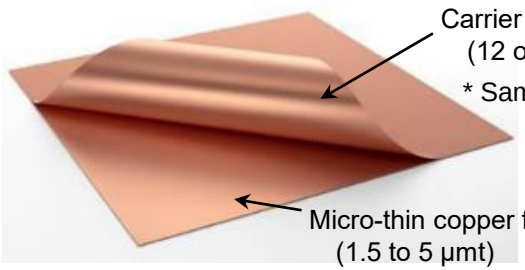
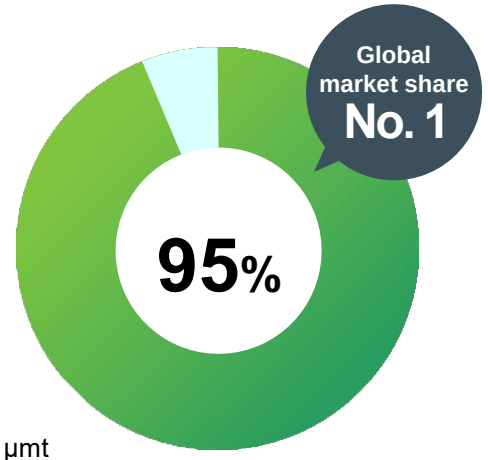


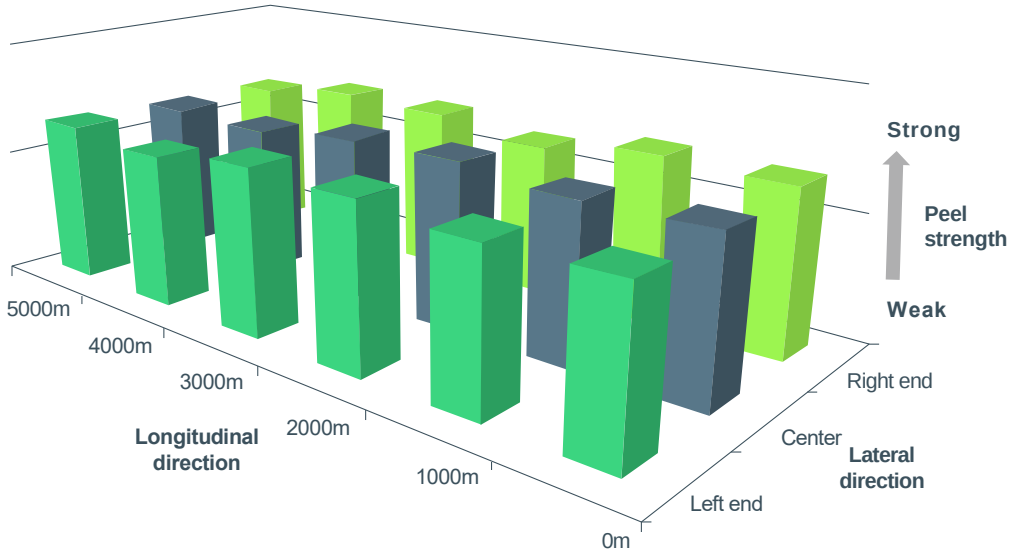
Photo of MicroThin™



Share of our copper foil with a carrier copper film



Distribution of interfacial peel strength between carrier copper film and micro-thin copper foil



● Stable peel strength

Lineup of MicroThin™

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

We offer a wide lineup of MicroThin™ products, including copper foil for forming microcircuits needed in high-tech semiconductor devices, as well as copper foil for high-frequency PCBs, an area that is expected to grow in the future.

Characteristics of MicroThin™ products*1

Product	Characteristics			Target PCB Line/Space (μm)					
	Copper thickness	Laminated side Rz	Peel strength*2	35/35	30/30	25/25	20/20	15/15	10/10
Ex	1.5/2.0 /3.0/5.0 μm	2.0 μm	0.64 kgf/cm						
FL	1.5/2.0 /3.0 μm	1.3 μm	0.65 kgf/cm						
GN	1.5/2.0 /3.0 μm	0.9 μm	0.65 kgf/cm						

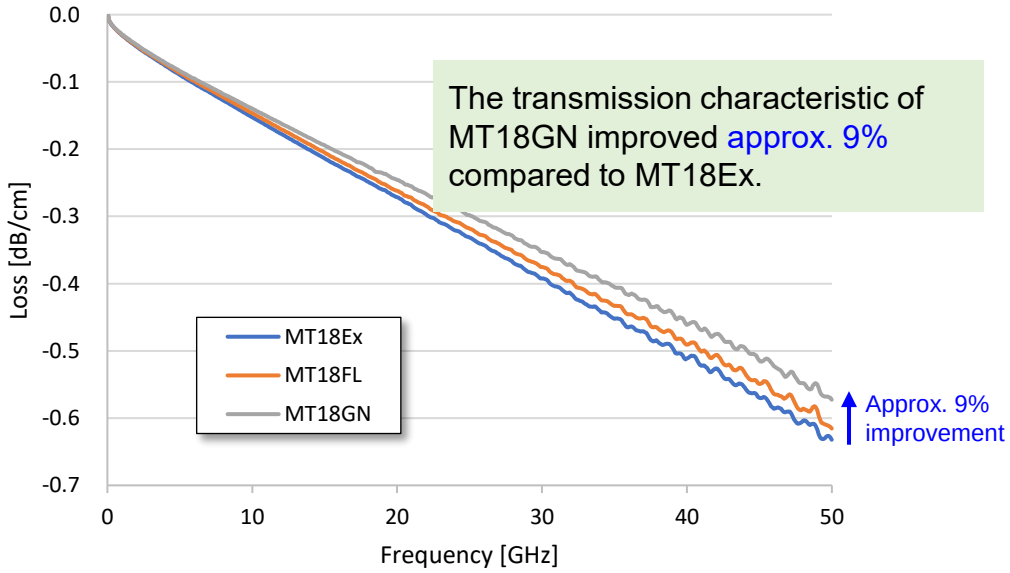
- MicroThin™ GN is copper foil roughened to a lower roughness to make it suitable for forming microcircuits or using in high-frequency PCBs, areas that are expected to grow in the future.

*1: The characteristic values in the table are representative values and not guaranteed.
*2: Peel strength is the peeling strength between a BT PCB and copper foil placed on it and further plated with copper to a thickness of 20 μm.

Transmission characteristics of MicroThin™

Test conditions

- Copper foil: MT18Ex, MT18FL, MT18GN
- PPG: Dk 3.16, Df 0.002 (at 1 GHz)
- Pattern: Microstrip
- Pattern height: 18 um
- Pattern width: 300 um
- Impedance: 50 Ω



The transmission characteristic of MT18GN improved approx. 9% compared to MT18Ex.

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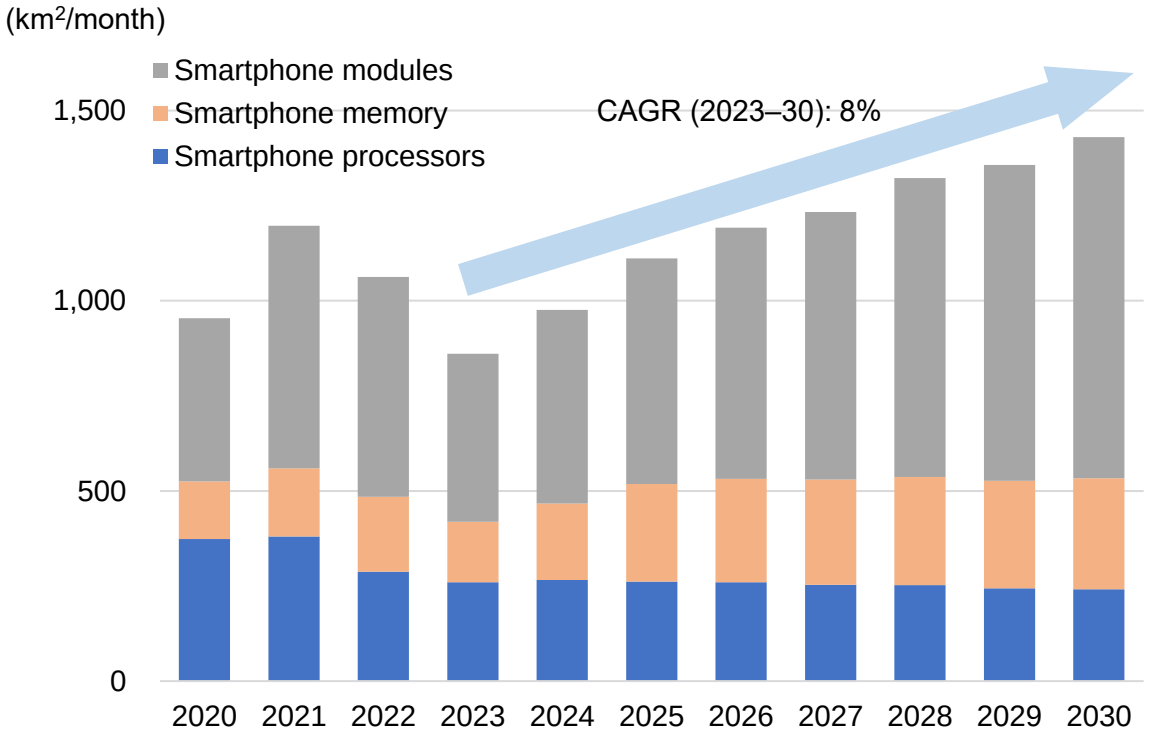
Major Applications and Market Trends of MicroThin™ for Packages (Smartphones)

Although the growth rate of unit sales of smartphones in which MicroThin™ for packages is used has been declining with the maturation of the market, the number of modules mounted on motherboards and the use of MicroThin™ in modules are expected to increase as 5G smartphones gain popularity.

CAGR by smartphone package use



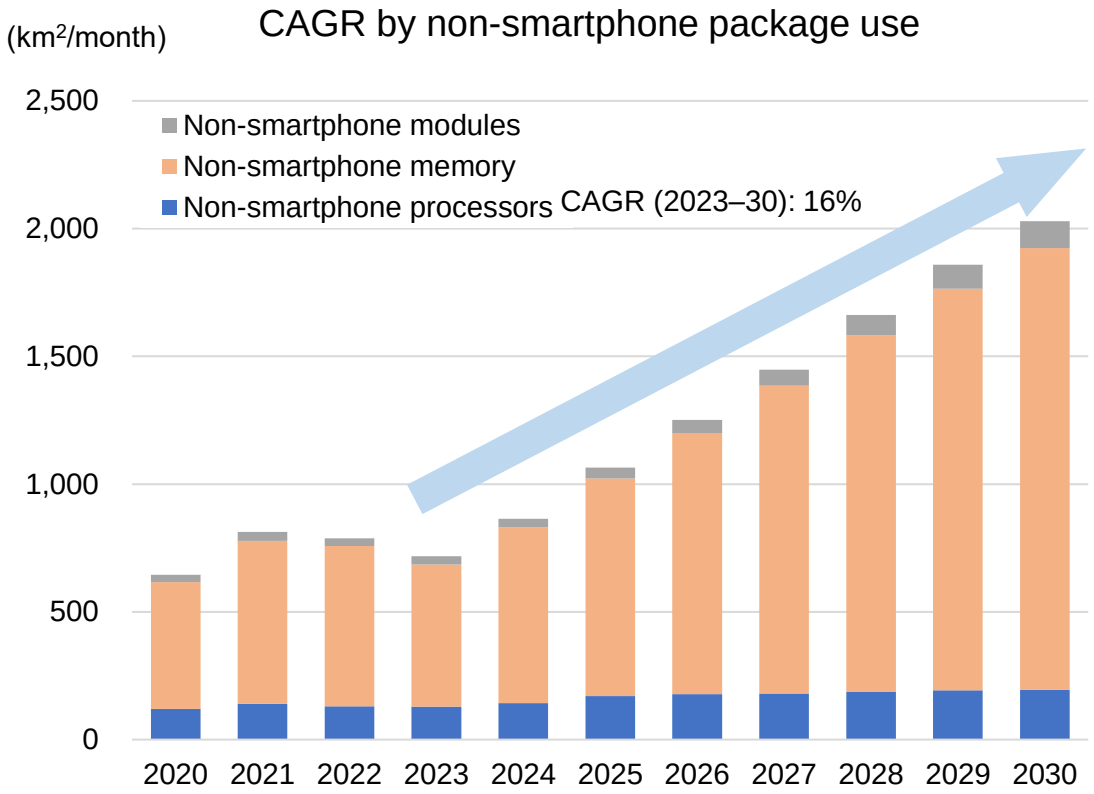
* Based on the results of a survey by a research agency

Usage in modules (CAGR: 11%)	• Usage in modules accounts for more than half of the total demand for MicroThin™ for packages for smartphones and is expected to continue to lead the growth. • Increase in the number of RF modules per smartphone • Increase in the number of camera modules and UWB modules • Increase in the number of 5G mmWave modules with increasing introduction of the technology
Usage in memory (CAGR: 9%)	• Usage in memory accounts for approx. 20% of usage of MicroThin™ in packages for smartphones and is expected to grow. • Adopting use of MSAP for the center layers of three-layer LPDDR*1 substrates • Increase in the number of layers in eMCP*2 substrates (from two layers to three layers)
Usage in processors (CAGR: -1%)	• Due to the sluggish growth of unit sales of smartphones, usage of MicroThin™ in processers is expected to show a slight decline in the future.

*1 Low-Power Double Data Rate: Memory designed specifically to consume less power based on standards derived from SDRAM.
*2 Embedded Multi Chip Package: Memory package designed to reduce mounting area and power consumption

Major Applications and Market Trends of MicroThin™ for Packages (Non-smartphones)

MicroThin™ for packages, which is used as a substrate material for DRAM and NAND, is also increasingly used for packages in a wider range of non-smartphone applications, including data centers, game machines, drones, and on-vehicle applications.



* Based on the results of a survey by a research agency

Usage in modules (CAGR: 18%)	• Although there is originally not much need for MicroThin™ in micro wiring, its implementation in image sensors, ADAS, automatic driving, and other on-vehicle applications is expected to increase. • Owing to the growth of IoT, usage of MicroThin™ in WiFi and other communication modules for industrial equipment is expected to increase.
Usage in memory (CAGR: 18%)	• Usage in memory will account almost entirely for future growth. • Demand for MicroThin™ for data centers and on-vehicle applications has been increasing. • There has been a shift toward DDR5 with a high use rate of MSAP, where MicroThin™ has been increasingly implemented. • There has been a shift in PC and on-vehicle applications from DDR to LPDDR.
Usage in processors (CAGR: 6%)	• Usage of MicroThin™ in processers is mainly in FC-BGA, and its implementation in processors will be limited in the future.

Examples of Application of Our MicroThin™ for Packages

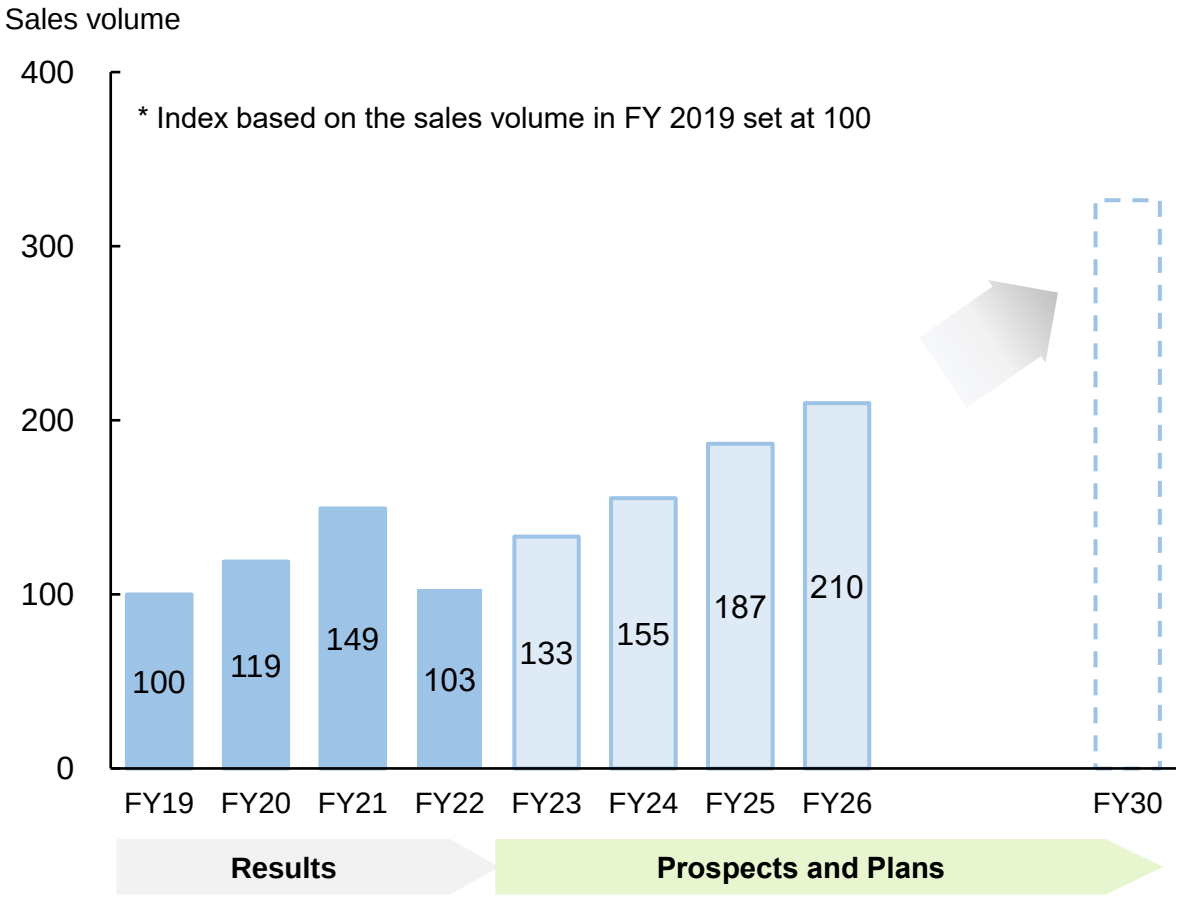
Our MicroThin™ is used for a wide range of applications, mainly in an L/S range of 10/10 to 30/30 µm.

Equipment	Substrate	Target L/S [µm]			Remarks
		>30/30 µm	30/30 to 10/10 µm	10/10 µm>	
Smartphone	SoC	—	○	○	Fine pitch spec models are available.
	DRAM (LPDDR)	—	○	—	–
	Mobile NAND	—	○	—	–
	RF module	—	○	—	–
	mmW antenna and AiP	—	○	—	Used for 5G mmWave transmitting and receiving antennas. MSAP is used to meet demand for low roughness and high circuit accuracy.
Server/PC	CPU	—	—	—	FC-BGA substrate
	GPU	—	—	—	FC-BGA substrate/HBM
	DRAM (DDR)-DIMM	—	○	—	–
	NAND-SSD	—	○	—	–
	Controller-SSD	—	○	○	Same as SoC in smartphones.

* To meet demand for further finer pitches, HRDP® is available. For details about HRDP®, refer to the announcement in the following link: News release dated May 15, 2023: Expansion of Facility Manufacturing HRDP®, a Specialty Carrier for Next-Generation Semiconductor Packaging

Sales Performance and Forecast for MicroThin™ for Packages

In FY23, demand for MicroThin™ has almost brought us back to a state where we could receive orders based on actual demand since prolonged inventory adjustment in related supply chains has been gradually coming to an end. We aim to expand the customer base into non-smartphone fields to increase the use of MicroThin™ in the future.



FY22
- Prolonged inventory adjustment in memory-related supply chains

FY23
- Inventory adjustment has been coming to an end, which has brought us back to a state where we could receive orders based on actual demand.

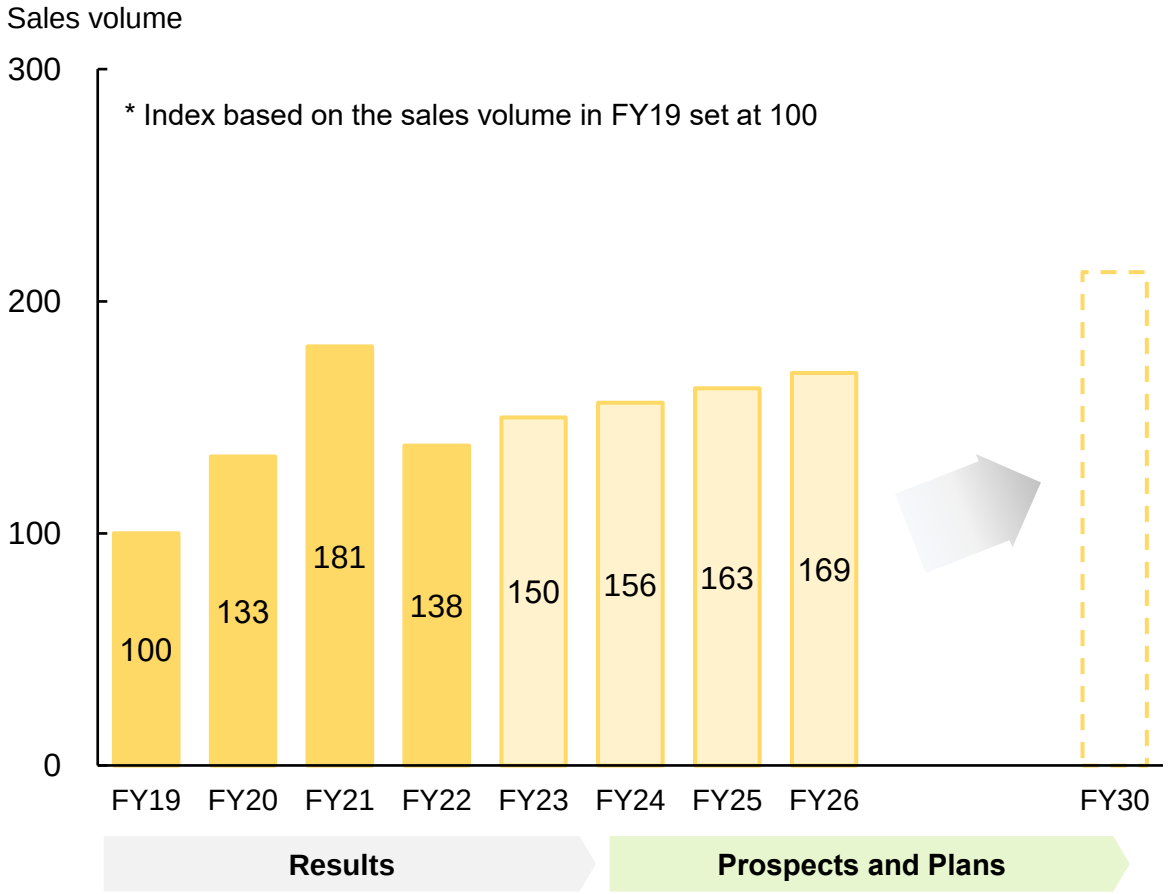
Forecast for FY24 and beyond
- Increase in the number of electronic devices where MicroThin™ is used with the popularization of 5G technologies.
- Expansion in the use of MicroThin™ in servers and installation of other applications

- Reinforcement of marketing to create new businesses
- Speeding up of product development (new installation of a processing machine for development testing)
- Improved productivity through utilization of DX (acceleration of mass production tests by using actual machines)

Sales Performance and Forecast for MicroThin™ for HDI*1

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

In FY23, unit sales of North American brand smartphone remained flat, but demand for MicroThin™ increased slightly. In the future, we will promote the use of MT-FL, which is suitable for finer wiring. We are continuing to promote the use of MSAP to Chinese smartphone manufacturers.



FY22
- Reduction in smartphone production as a result of lockdowns of Chinese cities due to COVID-19

FY23
- Unit sales of smartphones in the North American market remained flat, but demand for MicroThin™ increased slightly.
- Increase in use of MicroThin™ in Chinese smartphones (foldable models)

Forecast for FY24 and beyond
- Increase in the number of electronic devices where MicroThin™ is used with the popularization of 5G technologies
- Expansion of introduction of MicroThin™ in Chinese high-end models

- Promotion of use of MSAP to Chinese smartphone manufacturers
- Reinforcement of the marketing structure in Greater China (use of the marketing bases in the South China region and Taiwan)

*1: High Density Interconnected PCB

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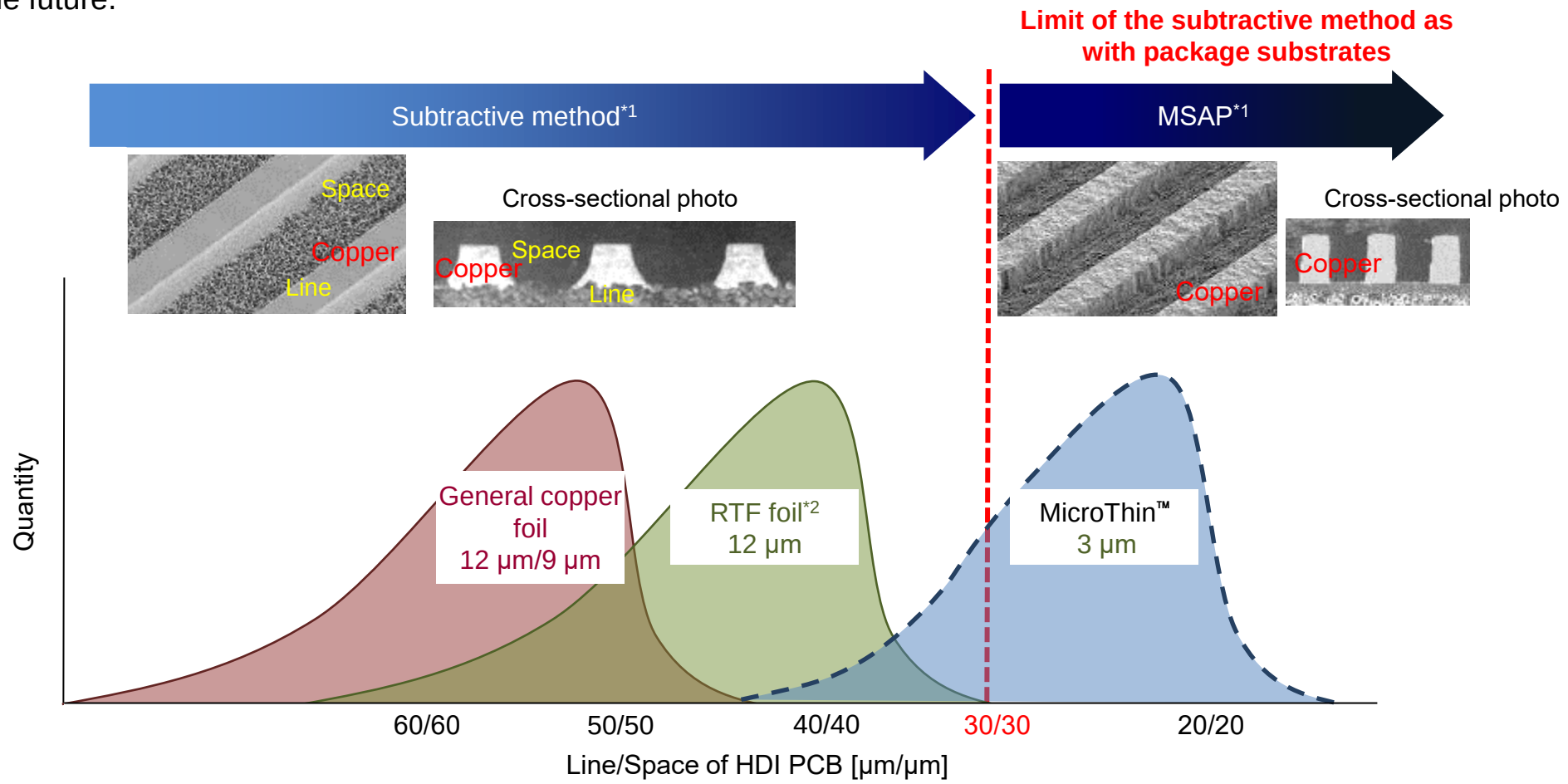
Increasing Density of Components in HDI PCBs and History of Production Processes: The Driver of the Development of Micro-thin Copper Foil

MSAP using micro-thin copper foil is suitable for use with HDI PCBs with a circuit width of 30/30 µm (line/space) or less.
The MSAP method is now used as the production process for some Chinese high-end smartphones, and is expected to be used more widely in the future.

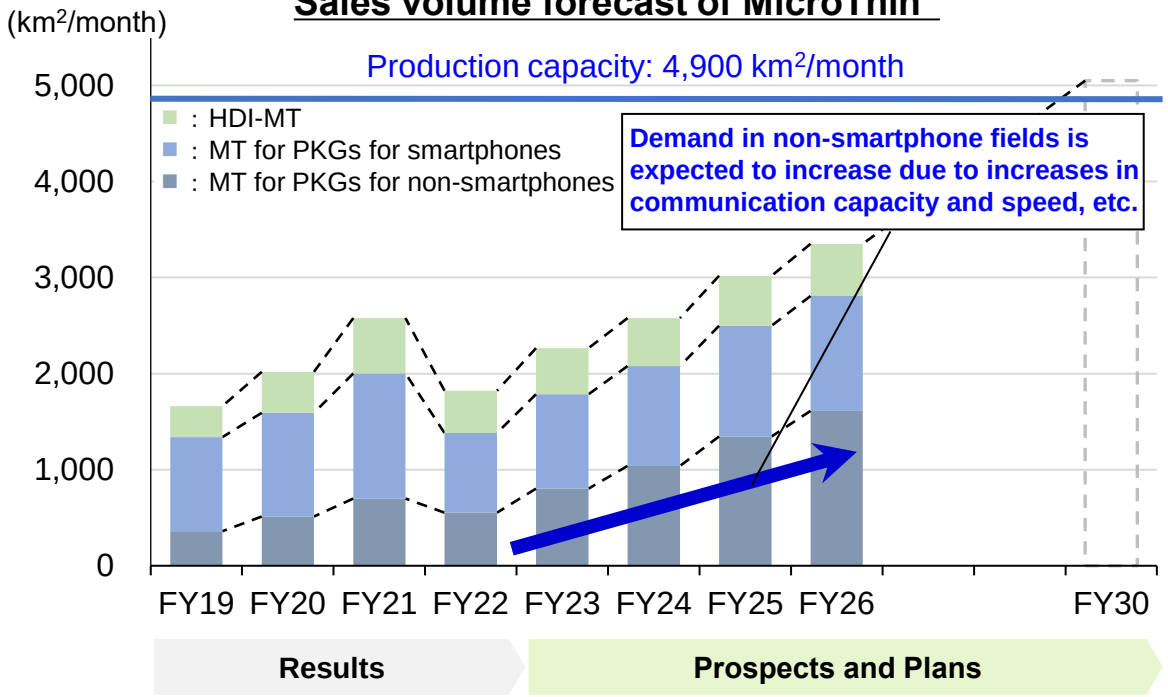


*1: Refer to Appendix 1.
*2: Reverse Treated Foil is copper foil with the shiny surface roughened. It can reduce trailing when forming patterns.

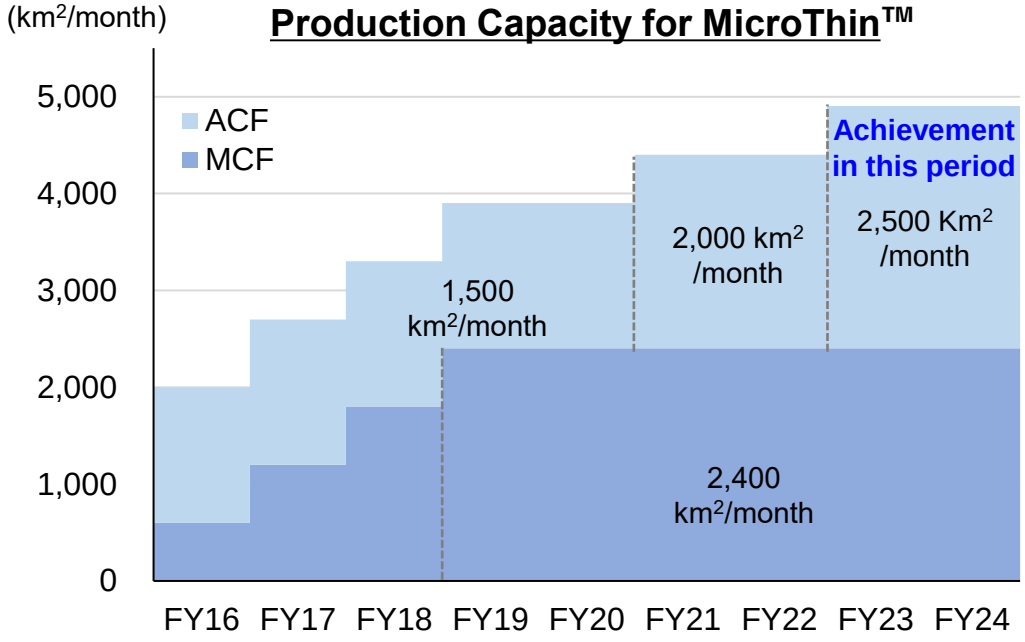
MicroThin™ Sales Volume Forecast and Production Capacity

With high-speed communication technologies being developed, we are working to expand opportunities to increase sales of MicroThin™ in both the smartphone and non-smartphone fields. We had sufficient production capacity to cater to present demand, but we further increased the production capacity by improving productivity in the previous year.

Sales volume forecast of MicroThin™



Production Capacity for MicroThin™



- MicroThin™ for packages
  Demand in non-smartphone fields is expected to expand due to increases in communication capacity and speed, etc.
- MicroThin™ for HDI
  Promotion of use of MSAP to Chinese smartphone manufacturers
  (It is currently used by three manufacturers.)

- By improving work satisfaction for improving labor productivity and introducing DX to improve operation rates, as well as improving yields and other technological factors in ACF, the production capacity was increased to a production of 2.5 million m²/month.
- Continuation and promotion of transfer of production of MicroThin™ for packages to MCF
  (Effective use of both bases)

Product Types of Electro-Deposited Copper Foil

We offer a variety of product series for various purposes, including high-end products for different purposes.

VSP™ series

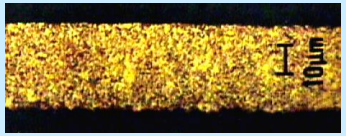
(Produced in Taiwan and Japan)

Both side smooth profile

- Copper foil with the **lowest degree of roughness** in our lineup
- Contributes to **lower transmission loss** in high-speed, high-frequency PCBs.
- Can be used for both rigid PCBs and FPCs.
- Major applications: Base stations, servers, and 5G terminals (FPCs)

VLP™ series

(Produced in Japan)



Very low profile

- The **high tensile force** makes the thin foil easy to handle.
- The thin foil with a low degree of roughness meets **fine pitch requirements**.
- Lineup for rigid PCBs
- Major applications: IC substrates

Super HTE™ series

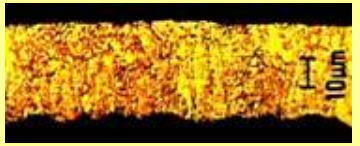
(Produced in Malaysia, Taiwan, and Japan)

Big grain after heating => soften

- **Soft** copper foil (softened by heating)
- **Highly resistant to cracking and flexible**
- Products with a low degree of roughness for high-frequency FPCs are also available.
- Major applications: FPCs for mobile equipment, etc.

Class III series

(Produced in Taiwan, Malaysia, and Japan)



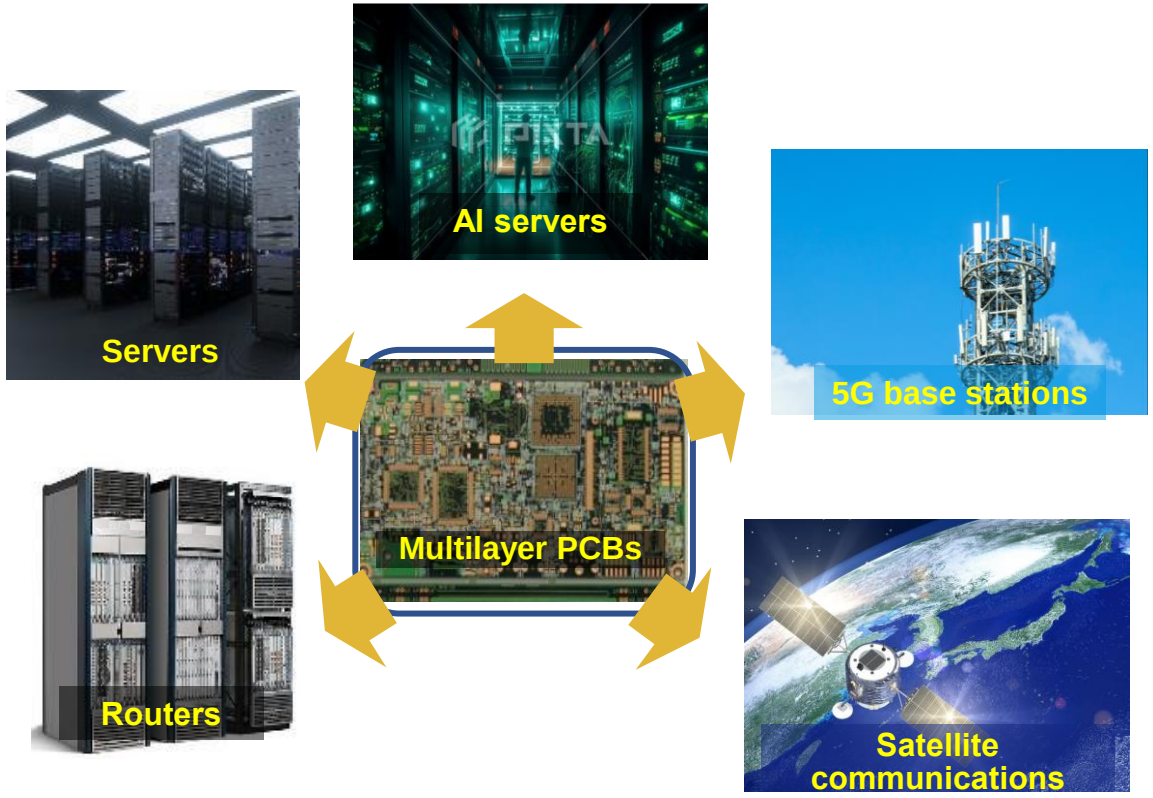
Standard profile

- Our standard copper foil
- Can be used widely in various applications such as rigid PCBs and FPCs.

Trends in the Market of Multilayer PCBs for Information and Communication Infrastructure

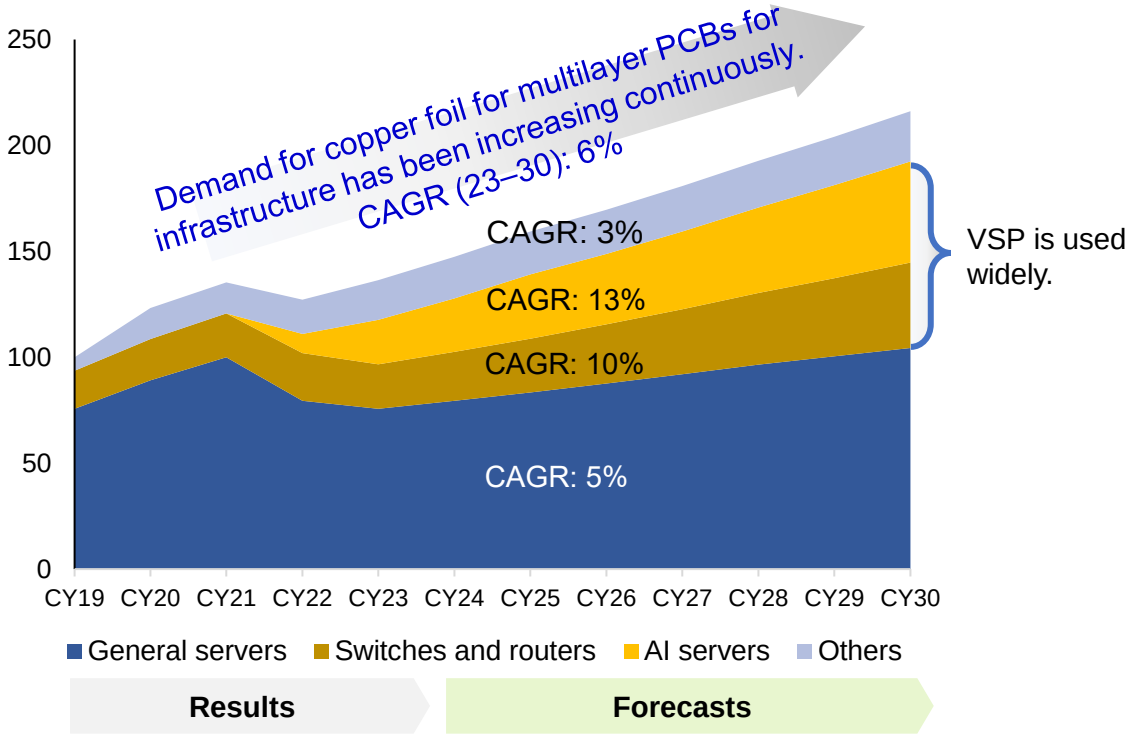
VSP™ is used as a material for multilayer PCBs for information and communication infrastructure, such as high-end servers, routers, and 5G base stations. In particular, the market of high-end servers such as AI servers is growing, so VSP™ is expected to see a growing demand.

Major applications of multilayer PCBs for information and communication infrastructure



Demand forecasts for copper foil for multilayer PCBs for infrastructure*1

Demand for copper foil for switches and routers and AI servers, where VSP is widely used, is expected to increase.



*1: Forecasts based on data presented by a research company. The figures are indexes based on 2019 results set at 100.

Copper Foil for High-Frequency Communication Infrastructure (VSP™/MLS®-G)

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

With increases in data traffic, demand for higher speed communication will further increase in the future. We will develop products to meet market needs and expand our product lineup. We will be required to offer surface treatment technologies that support customers' resin development more than before.

Application	Copper foil category	Transmission loss	Product type	Cross-section image
	HVLP4 HVLP3 HVLP2	Low	Developed products SI-VSP HS2-VSP High-grade VSP	Rz 0.5um Rz 0.8um
	HVLP		HS1-VSP	Rz 1.2um
	RTF2		MLS-G3	Rz 1.3um
	RTF	High	MLS-G	Rz 3.0um

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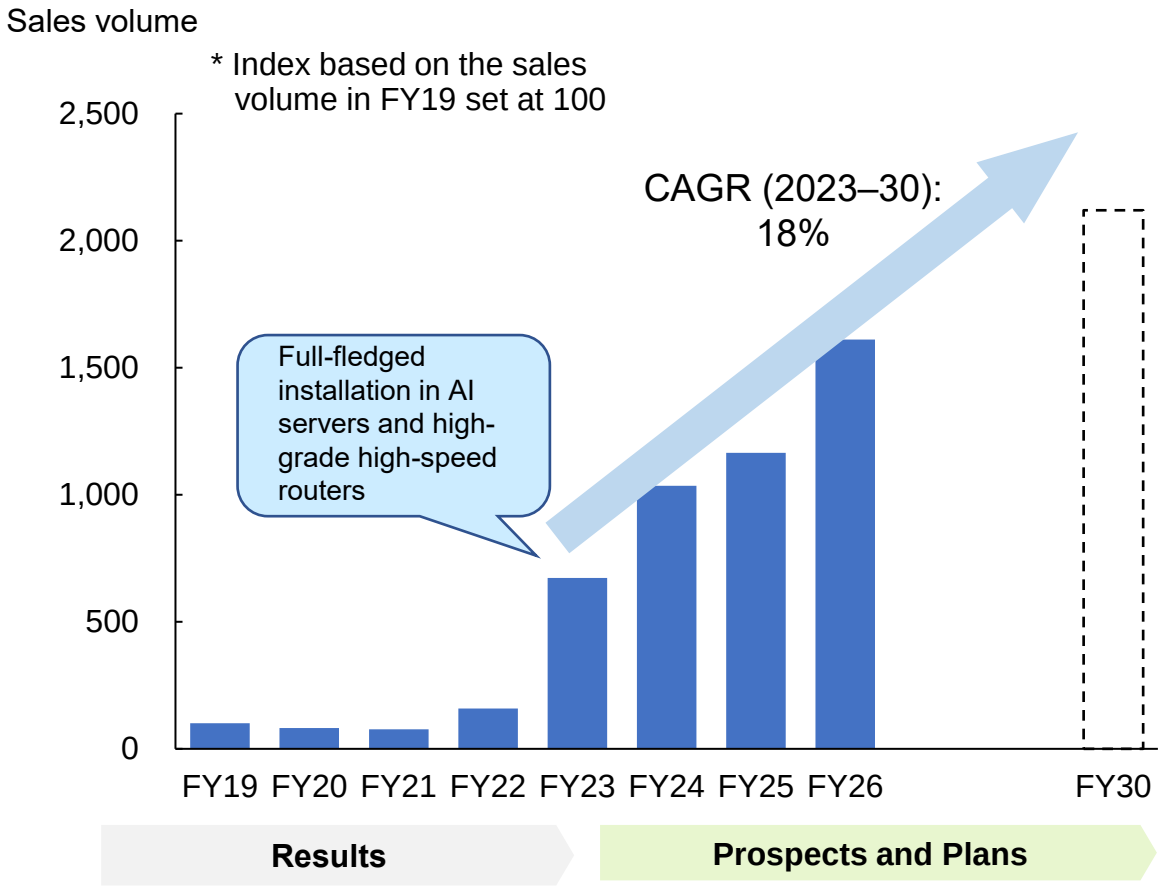
Sales Performance and Forecast for High-Grade VSP™

With the growth of the market of foil products for information and communication infrastructure, demand for high-grade VSP™ foil products (of category H-VLP2 or higher) for high-speed transmission is expected to expand.

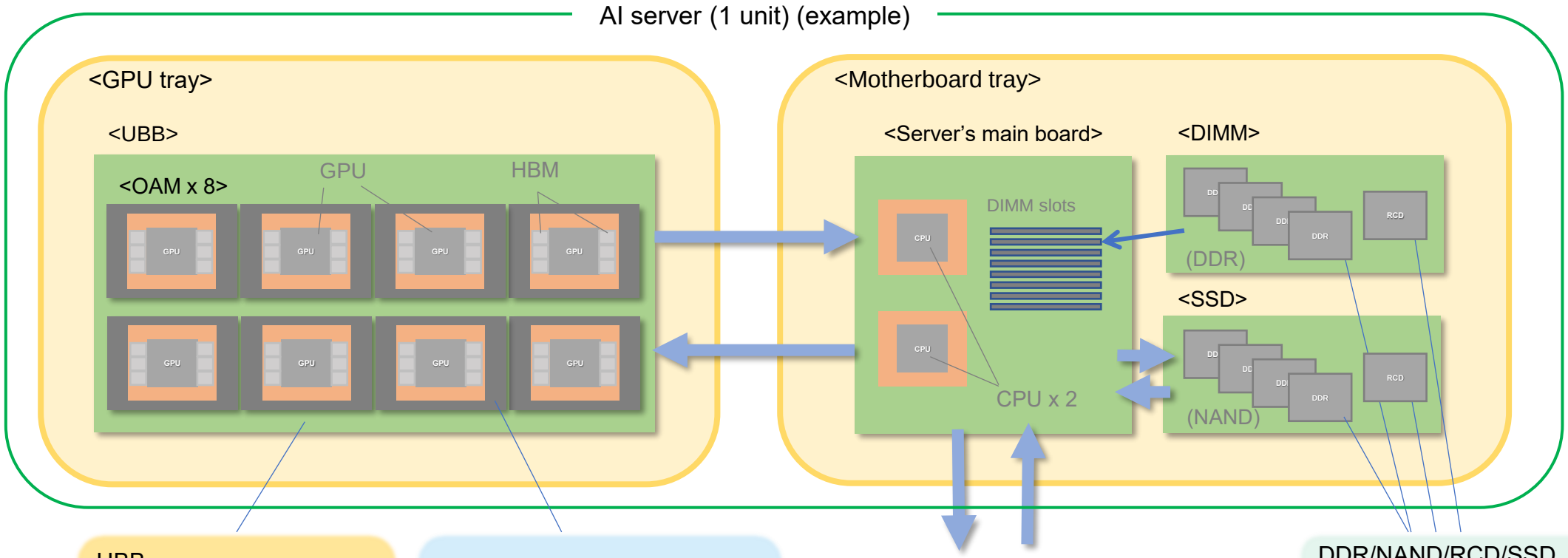


Up to FY22
- Worked to ensure stable supply of standard products.
- Encouraged new customers to introduce high-grade products.

Prospect for FY23
- High-grade products would come to be used in AI servers, high-speed routers, etc., and put into mass production.

Forecast for FY24 and beyond
- As the market/share of high-grade products expands, we expect to see long-term growth.

Image of an AI Server and Examples of Where Our Copper Foil is Used



UBB
High multilayer PCB (up to 30 layers)
Copper foil: HVLP3 (SI-VSP)

OAM
HDI PCB (16 or more layers)
Copper foil: RTF to RTF2 (MLS-G2, MLS-G3)

Connected to external devices

DDR/NAND/RCD/SSD controller substrate
Micro-thin copper foil: MT18Ex

UBB: Universal Base Board
OAM: OCP Accelerator Module
OCP: Open Compute Project
DIMM: Dual Inline Memory Module
SSD: Solid State Drive
RCD: Registered Clock Driver

PCB
FC-BGA substrate

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Reinforcement of the Product Development Structure

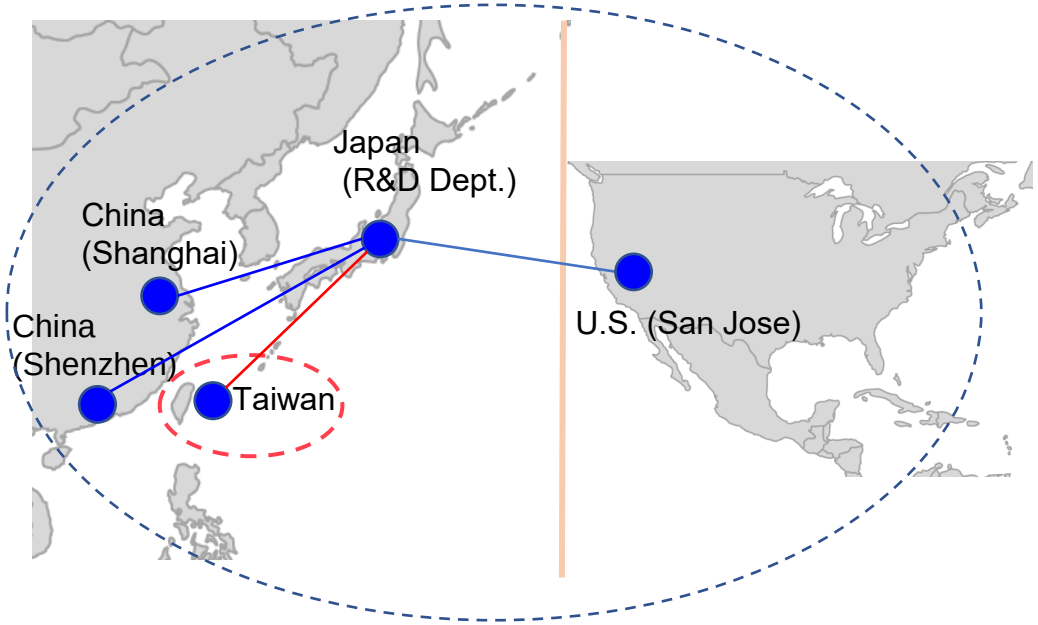
We will speed up product development by installing a processing machine for development tests and reinforce marketing in Greater China to further leap forward and develop the copper foil business.

Speeding up of product development

New installation of a processing machine for development tests (news release on January 10, 2023)	
Installation location	Ageo Operation
Expected completion	End of FY23
Characteristics	• Adopting a design which drastically enhances the testing flexibility, acquiring capability to execute various kinds of tests ⇒ Development of high-end copper foil with additional functions • Early delivery of copper foil in sizes that facilitate evaluation by customers themselves ⇒ Speeding up of evaluations by customers
Major products to be developed	• Copper foil for semiconductor package substrates • Copper foil for high-frequency, high-speed PCBs • Copper foil for module substrates • Copper foil for fields other than circuit materials

Development of new businesses and deepening of existing businesses with environmentally friendly products catering to social needs

Global marketing structure



A Taiwan base has been established. We collect OEM information from Japan. U.S., China, and Taiwan to take action quickly.

Website for Seeking Potential Partners to Create New Applications

We opened a website designed to let customers in non-PCB fields know our copper foil technologies that we have accumulated for over 50 years and contact us as potential partners who will create new markets together.
This website introduces our technologies, which give us an edge, and their use cases. You can download materials to find more detailed information.

Beyond together. Copper Foil Division, Mitsui Mining & Smelting Co., Ltd. (mitsui-kinzoku.com)

URL QR code

https://em.mitsui-kinzoku.com/douhaku

Engineered Powders Division and Nippon Yttrium Co., Ltd.

Strength of the Engineered Powders Division – Utilization of Powder Control Technologies in New Product Development

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

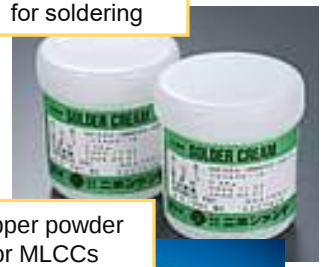
We are utilizing our various powder control technologies and development capability based on them to develop new products. We aim to improve our own technologies and work together with partner companies to create and introduce new products and businesses that contribute to the future.

Our strengths accumulated by developing existing products

- ◇ Purification
- ◇ Composition design
- ◇ Particle size control
- ◇ Surface modification
- ◇ Shape control
- ◇ Dispersion technology
- ◇ Structure control
- ◇ Manufacturing technology

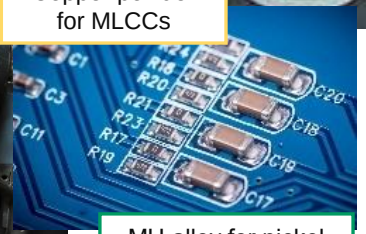
Tantalum oxide and niobium oxide for optical lenses

Solder powder for soldering

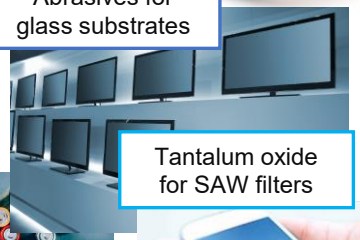


Tantalum carbide and niobium carbide for carbide tools

Copper powder for MLCCs



Abrasives for glass substrates



Materials for dry batteries

Tantalum oxide for SAW filters

Copper powder and copper alloy powders for powder metallurgy

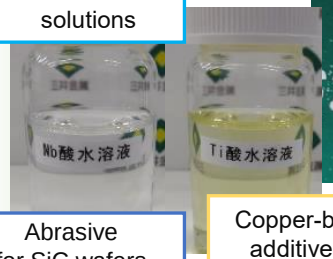
MH alloy for nickel hydride batteries

Past to present

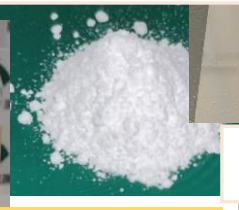
New products for the 2030 growth target

Target: 2 to 3 billion yen of profit in 2030

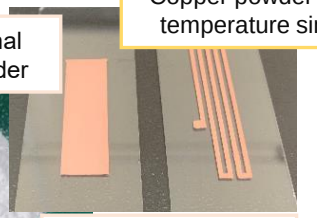
Minor metal solutions



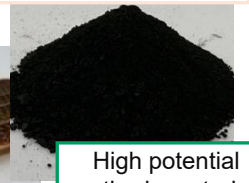
Negative thermal expansion powder



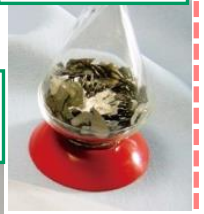
Copper powder for low-temperature sintering



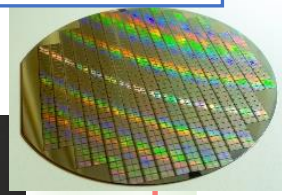
NIR transmitting black powder



MH alloy for hydrogen storage

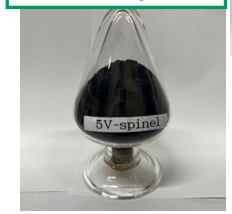


Abrasive for SiC wafers NANOBIX™



Copper-based powder for additive manufacturing

High potential cathode material LNMO



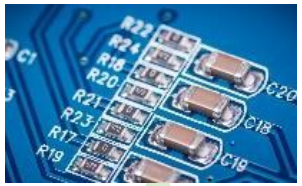
Combine powder control technologies with marketing to develop new products

MITSUI KINZOKU

Major Applications of Copper Powder for Electronic Materials: Market Trends for Multi Layer Ceramic Capacitors (MLCCs)

In the previous forecast made in 2020 and 2021, when sales exceeded actual demand, both the actual demand and growth rates were overestimated. This time, the MLCC market trends were reviewed and we will continue to test hypotheses about actual demand.

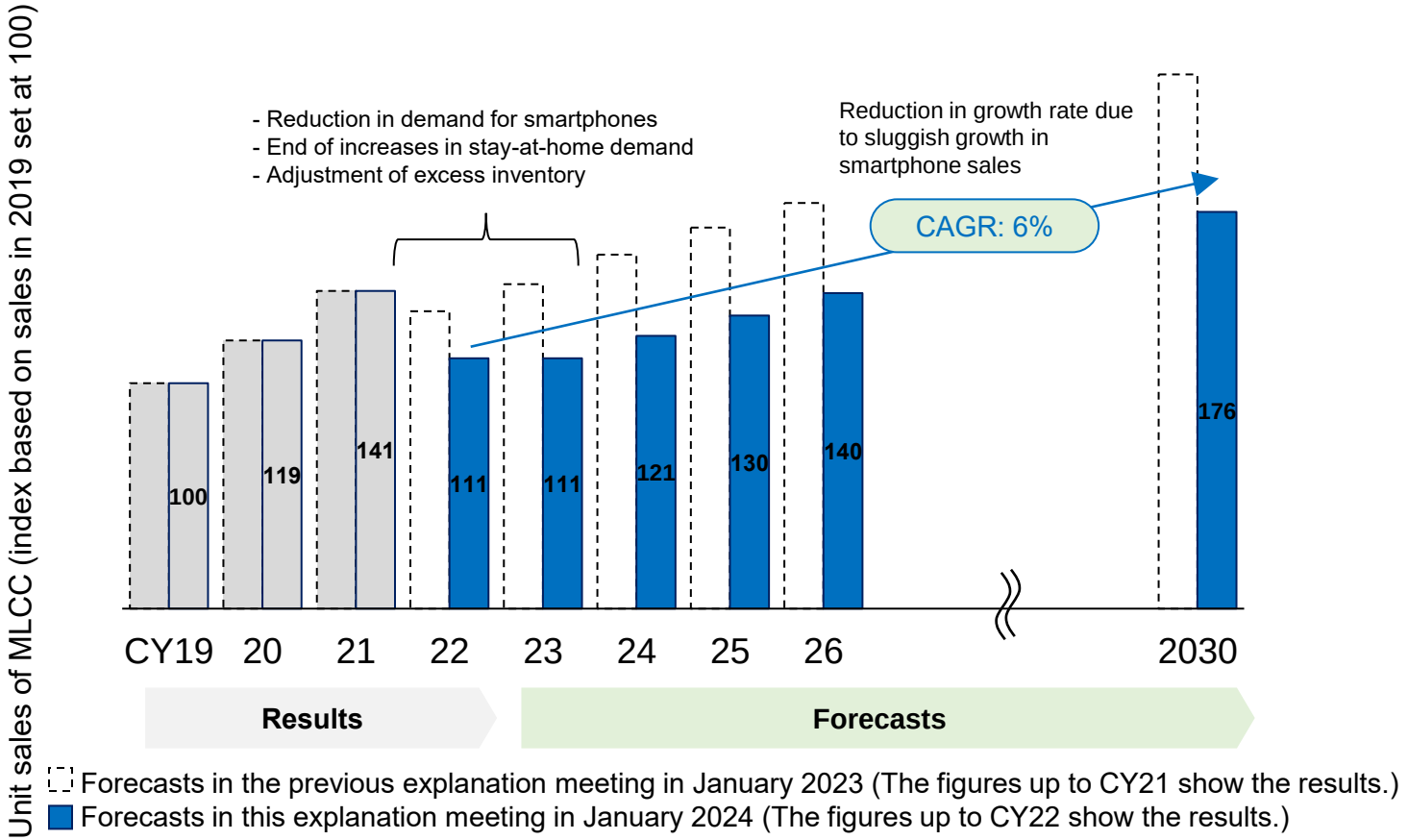
Major applications of copper powder



MLCC
(Multi Layer Ceramic Capacitors)

Other applications include PCs and tablets, monitors, copying machines and printers (including multifunction printers), brown goods and white goods, and industrial equipment.

Results and forecasts of MLCC sales*1



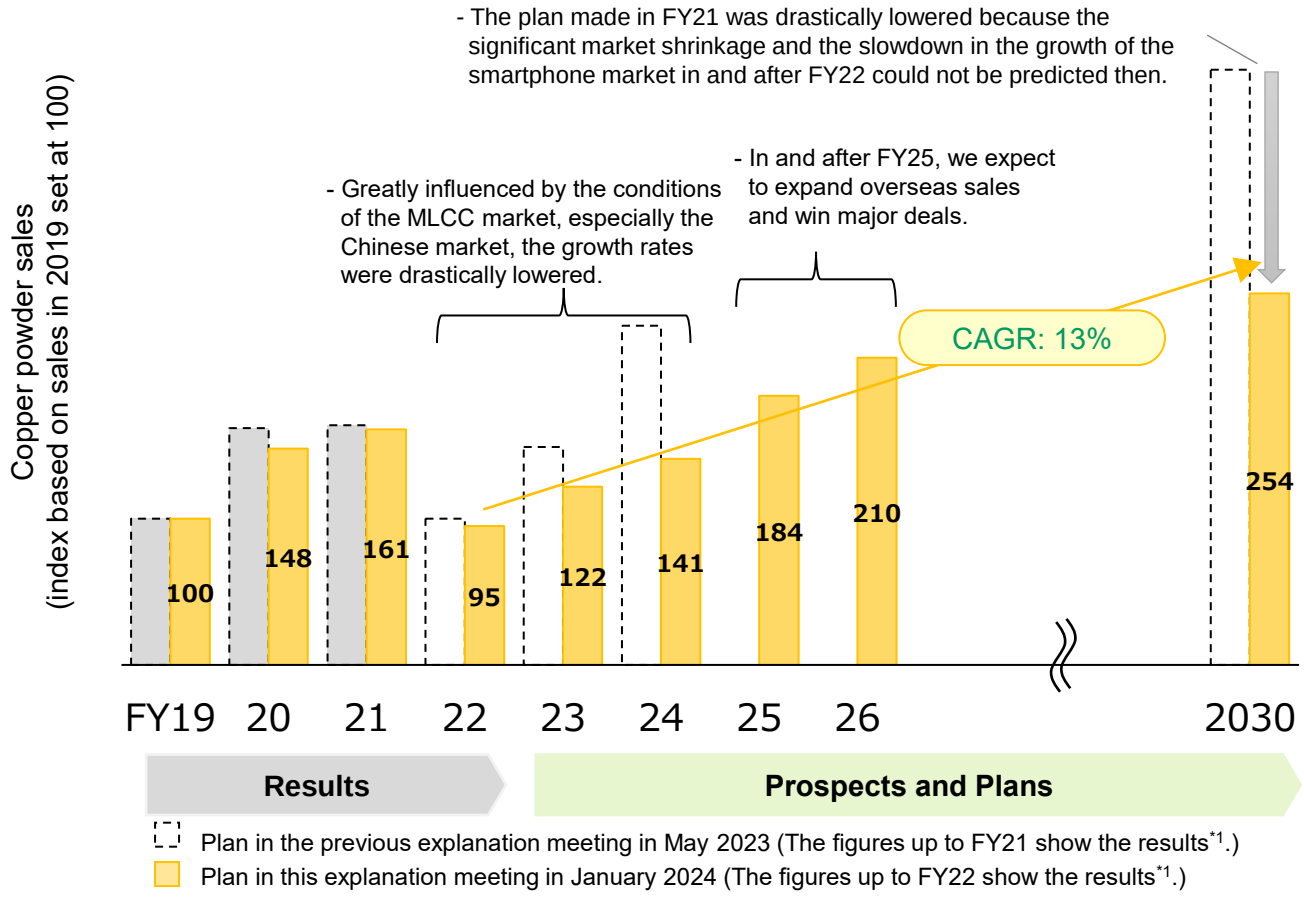
*1: Our own estimates

MITSUI KINZOKU

Sales Performance and Forecast for Our Copper Powder for Electronic Materials

We reviewed the forecasts of the growth of the MLCC market and then reviewed the sales prospects for copper powder accordingly. The plan for 2030 was drastically corrected in view of great uncertainty about the demand in the smartphone market and other markets. However, since we have secured a footing for expanding overseas sales, we expect sales to grow more than the market.

Results and plans of copper powder sales



*1: The sales between group companies were corrected this time.

Market's and our company's conditions

■Up to FY22

[Market] Large-scale production cutbacks by MLCC manufacturers due to the slowdown in the Chinese market
Prolonged inventory adjustment due to the backlash of accumulated MLCC inventory in FY21

[Our company] Delay in commercialization of products in major development projects

■Prospect for FY23

[Market] The MLCC market would go into a recovery period after having bottomed out.

[Our company] Prepare for regrowth of the MLCC market
- Acquire new overseas customers and have them introduce our products.
- Enhance our production technological capability to improve our competitiveness.

■Forecast for FY24 and beyond

[Market] The MLCC market will enter a full-fledged recovery and regrowth period.

[Our company] Keep pace with the growth of the MLCC market and expand our market share
- Commercialize products in major development projects
- Expand sales to existing Chinese customers
- Expand our market share by taking advantage of our technological capability
- Expansion of demand in on-vehicle applications

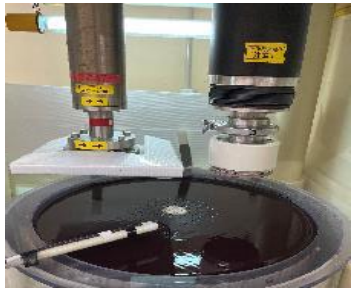
Expand applications in other markets

Flagship Next-Generation Development Items

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

The following are examples from the development of next-generation products prioritized in the 2022 Medium Term Business Plan. We will aggressively promote efforts to develop and commercialize a variety of engineered powders.

Abrasive for SiC wafers NANOBIX™



[Needs]
High-precision processing
Damage free

- SiC wafers for power devices

Adopted by domestic and overseas customers
Strengthening efforts to expand overseas

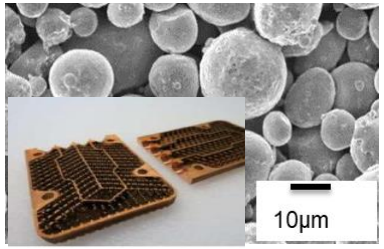
Minor metal solutions

[Needs]
Longer life

- Carbon materials of all kinds
- Electrode components

Sold to two companies for TaC coating applications
Plans to enter the coating business

Copper powder for additive manufacturing

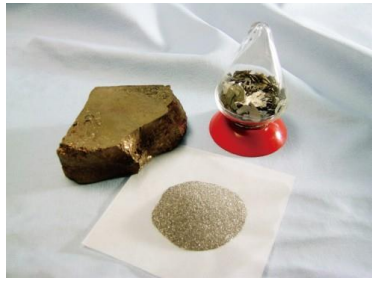


[Needs]
Complex modeling with Cu-based materials

- Induction coils
- Rocket chambers
- Cold plates

Reached certain level for both materials and modeling technics
Strengthening marketing efforts with partner companies

MH alloy for hydrogen storage



[Needs]
Energy storage
Safety

- Stationary hydrogen storage
- Ships

Finding customers through marketing overseas, especially in Europe
Customizable to suit customers' needs

Negative thermal expansion powder

[Needs]
Zero expansion

- Sealers for semiconductors
- Other precision components

Customer-verified effect of inhibiting thermal expansion confirmed
About to be adopted by some customers

NIR transmitting black powder

[Needs]
Wavelength selectivity
Resistance to UV rays

- Filters for LiDAR
- Outdoor sensors

Utilizing exhibitions to win potential customers
Being customized to suit customers' needs

Developed Product (1): NANOBIX™, SiC Wafer Abrasive

This is SiC wafer abrasive capable of low-damage grinding. We will contribute to popularizing SiC power devices by reinforcing the production capacity and achieving a stable supply of NANOBIX™.

Overview of the developed product

Nature of product

- A two-pack abrasive consisting of manganese oxide base abrasive slurry and oxidant liquid for SiC wafers.

Characteristics

Compared to existing silica abrasives/alumina abrasives:
- More capable of grinding SiC wafers faster with less damage (invisible deformations or blind scratches can be removed).
- Easier to remove the abrasive particles after grinding SiC wafers (because it can be cleaned not with hydrofluoric acid, which imposes a high environmental load, but with sulfuric acid/hydrogen peroxide mixture).

SiC wafer observation images (SICA)

Applications

SiC wafer abrasives

Electric vehicle (inverters, chargers)

Photovoltaic power generation (inverters, converters)

Market size/competitive materials/progress

[Market size]

<Market of abrasives for SiC wafers*1>
- $170 million/year in 2029
- CAGR (CY23/CY29): 21%

[Competitive materials]
- SiO_2 slurry, Al_2O_3 slurry, etc.

[Progress]
- Japan: NANOBIX™ has been adopted by three companies. Other customers are hastening their evaluations for its implementation.
- China: NANOBIX™ has been adopted by a company. We aim to further expand sales by utilizing different sales routes.
- Europe and U.S.: NANOBIX™ has been introduced to leading manufacturers, who are in the process of evaluating it.
- Our company: Completed the design to achieve a production capacity of 50 t/year, which is expected to be completed in September 2024.

*1: Source: QYResearch/GII

News Release dated January 10, 2023: Decision to Enhance Production Capacity of SiC Wafer Abrasives

MITSUI KINZOKU

Developed Product (2): Minor Metal Solutions

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

Water-based solvent solutions to dissolve minor metals that are typically difficult to dissolve in water. We will focus on developing new markets through open innovation by utilizing exhibitions, presentations at conferences, and other opportunities.

Overview of the developed product

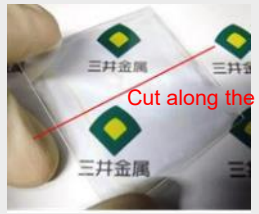
Nature of product

- Water-based solvent solutions to dissolve minor metals that are typically difficult to dissolve in water.
  (Types of metal elements: Nb, Ta, Mo, Ti, etc.)

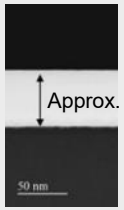
Photos of prototypes (Examples)

Characteristics

Compared to existing minor metal solutions:
- Our rare metal solutions have enhanced safety and better handling because they do not include strongly acidic chemicals such as hydrofluoric acid, etc.
- They offer excellent reactivity, forming a uniform thin film coating on various materials.



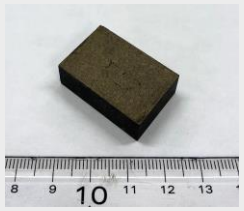
Niobium coated glass



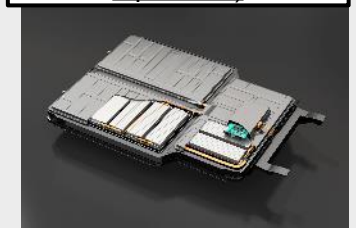
Coating thickness (Cross-sectional photo)

Applications

Extension of lives of carbon materials (Various kinds of carbon materials)



Field of batteries (All-solid-state batteries, liquid LIB)



Field of corrosion protection coatings (Various plants)

Progress

[Progress]
- We are working to promote the commercialization of these products in collaboration with more than eight downstream companies, many of which are domestic customers.
  → In addition to selling these solutions in a conventional manner, we started TaC coating as a processing-on-commission business on a trial basis. This business has started to produce revenue.

- We are considering further expanding the market and applications together with coating manufacturers.

☞ Projects expected to produce an annual revenue of 1 billion yen or more in 2030 in total are in progress.

MITSUI KINZOKU

Developed Product (3): Copper Powder for Additive Manufacturing

Our innovative copper powder enabled additive manufacturing*1 with copper, which was previously considered difficult.
We will aggressively promote efforts to increase earnings by developing products jointly with customers, acquiring new customers at domestic and overseas exhibitions, and taking other measures.

Overview of the developed product

Nature of product

- This copper powder enabled additive manufacturing with copper, which was previously considered difficult.

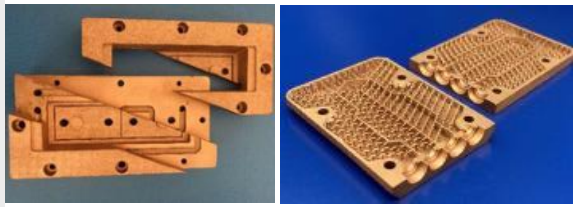
Photos of the copper powder

Characteristics

Compared to similar copper powders for additive manufacturing:

- Our copper powder for additive manufacturing is superior in its capability to create final products with a high level of conductivity, strength, and heat radiation.
- It can be used with a general-purpose laser to achieve fine 3D modeling.

Photos of final products (metallic molds, heat sinks, etc.)



Applications

Rockets (engine chambers)

Data centers (heat sinks)

Electric vehicles (components around the motor)

Market size and progress

[Market size]

<Market for **metal powder** for additive manufacturing*2>

- $6.6 billion/year in 2027

<Market for **copper powder** for additive manufacturing>

- $140 million/year in 2027*3
- CAGR (CY18/CY27): 51%

[Progress]

- We have been appealing to end users in collaboration with modeling equipment manufacturers (3D Systems and Morf3D).
- We have been working to find new applications and customers by proactively participating in overseas exhibitions (especially those in Europe).
- We have been accelerating development by introducing 3D modeling equipment.

*1: Additive manufacturing can produce components with complex shapes and a wide variety of products in small quantities.
*2: (Source) Our own estimate *3: (Source) SmarTech ANALYSIS

News release dated February 7, 2023: Mitsui Kinzoku Announces 3D Systems has Added Copper Chromium Alloy Powder to Materials Portfolio
News release dated April 26, 2023: Initiation of Collaboration with Morf3D to Qualify Copper Chromium Alloy Powder for Additive Manufacturing of Aerospace Applications

Outline of Nippon Yttrium Co., Ltd. (NYC)

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

Nippon Yttrium is a **comprehensive manufacturer of rare earths**, supplying a variety of rare earths of various compositions (oxides, fluorides, salts, and metals) in various forms (powders, granules, and liquids).

Outline

- ○ Established: April 23, 1966
- ○ Capital: 400 million yen
- ○ Stockholders: Mitsui Mining & Smelting 70%, Tokin 30%
- ○ Number of employees: 92 (as of December 1, 2023)

Nippon Yttrium Co., Ltd.

Lines of business

○ **Rare earth oxides / compounds**
- High-purity rare earth oxides / compounds (up to 99.999%)
- Fine powders (primary particle diameter: up to a few dozen nm)
- Granules (30 to 60 μm)

○ **Metal products**
- In the form of powders, chunks, foils, plates, etc.

○ **Rare earth salts / sintered bodies**
- Rare earth solutions (nitrate, etc.)
- Fluoride, oxalate, sulfate, acetate, nitrate, etc.
- Rare earth oxide/complex oxide sintered bulks, etc.

Major applications

* Protective materials for semiconductor production equipment
* Additives for electronic materials (MLCCs, Ceramics, etc.)
* Materials for medical devices (scintillators, etc.)
* Others (additives for Solid Oxide Fuel Cells, Super-Kamiokande, etc.)

Product Development in Nippon Yttrium: Protective Coating Materials for Semiconductor Production Equipment

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

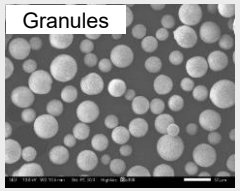
We are engaged in the production and development of protective coating materials that are essential to the state-of-the-art semiconductor production processes. These coatings protect the inner walls of etching equipment from plasma gas. They suppress particle generation, contributing to improving semiconductor device yields.

Overview of the developed product

Nature of product

- Yttrium oxyfluoride: YOF

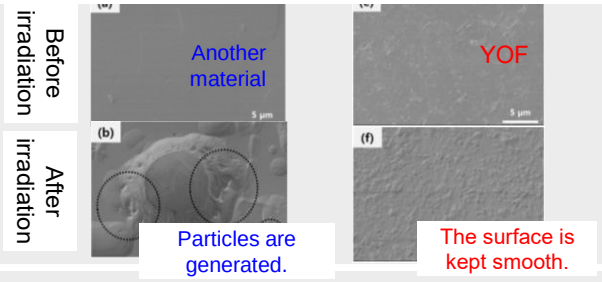
- Composite oxide of yttrium and aluminum: YAG (**Y**ttrium **A**luminum **G**arnet)



Characteristics

- YOF
  ⇒ Exhibits excellent corrosion resistance to fluorine-based plasma gas.
- YAG
  ⇒ Exhibits excellent corrosion resistance to chlorine-based plasma gas.

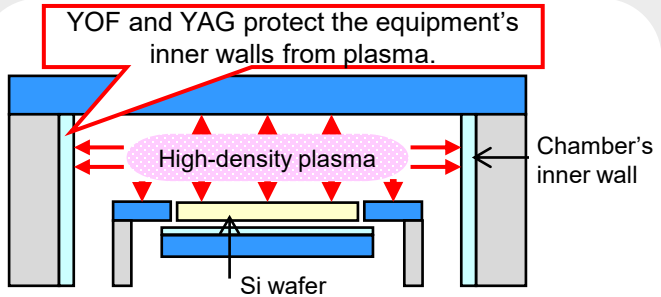
Surface image examples before and after plasma gas irradiation



Applications

Protects the inner walls of etching equipment from plasma gas in semiconductor production processes.

Suppresses particle generation due to damage of inner walls and contributes to improving yields.



Schematic view of dry etching equipment

Market size and progress

[Market size]

Market of protective coating materials for semiconductor production equipment
2025: 7 billion yen, 2030: 10 billion yen
* The materials they developed are used in advanced equipment in this market. The advanced material market accounts for approx. 20% of the entire market.

[Competitive materials]

Currently, there is no competitive material in the advanced material market. (Both the YOF and YAG products have been patented for this purpose.)

[Progress]

- YOF has been used in existing state-of-the-art production lines.
  Evaluation is underway to develop next-generation products.
- A leading semiconductor equipment manufacturer has decided to use YAG (from December 2023).

MITSUI KINZOKU

Technology Development in Nippon Yttrium: Recycling of Rare Earths

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

We use advanced separation and refinement technologies to recycle scarce rare earths. We have been participating in a JOGMEC project (highly efficient solvent extraction PJ) since FY22.

Overview of the development

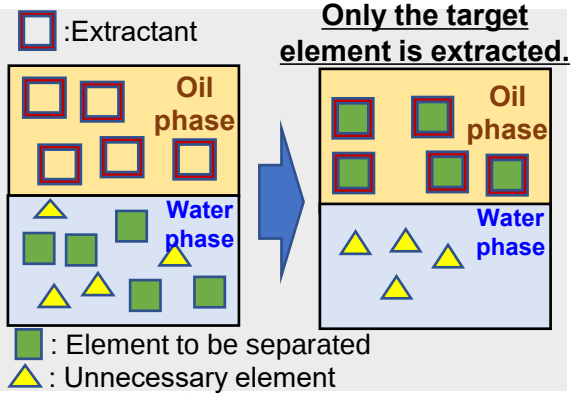
Nature of development

- They recycle the following heavy rare earths, which are scarce and important elements of the 17 rare earths:
  Gd, Tb, Dy, and Lu

Characteristics

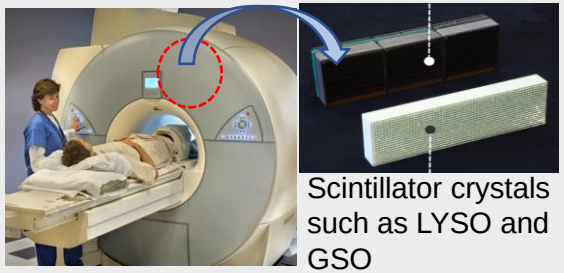
The solvent extraction method is the process of mixing an aqueous solution in which various elements are dissolved with an organic solvent (oil) containing an extractant in order to extract certain elements.

Certain rare earth elements can be separated and refined to a high purity.



Applications

Gd
Lu

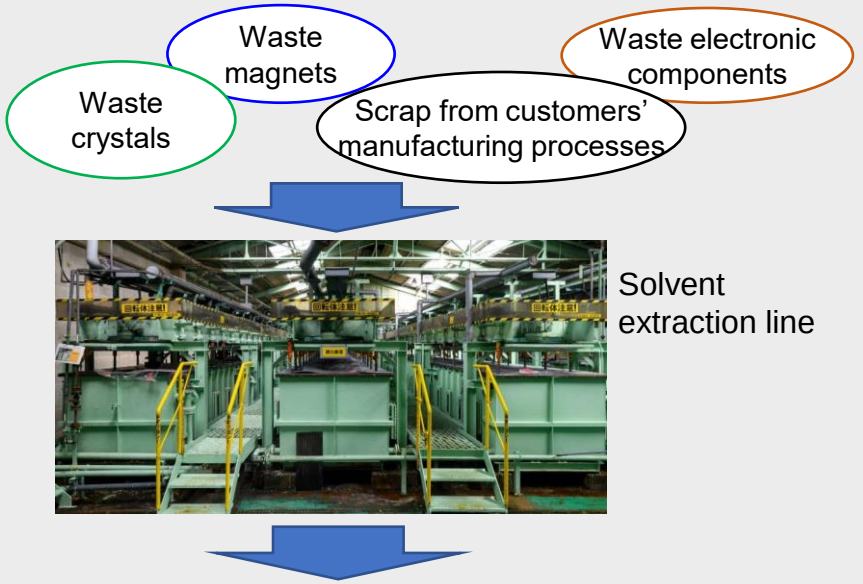


Scintillator crystals such as LYSO and GSO

Tb
Dy

By adding Tb or Dy as an additive to high performance magnets (Nd-Fe-B), they can become heat resistant.

Efforts to build a recycle supply chain



Solvent extraction line

High-purity rare earths (Gd, Tb, Dy, and Lu)

- They are recycling Gd and Lu collaborating with customers.

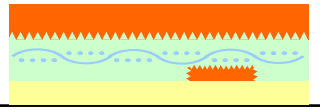
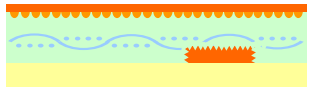
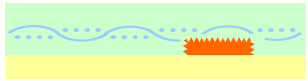
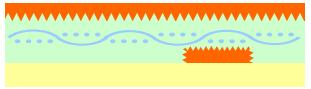
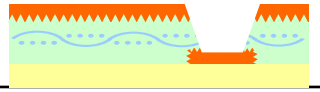
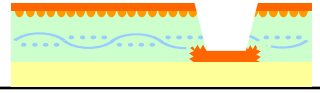
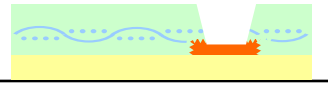
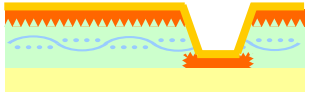
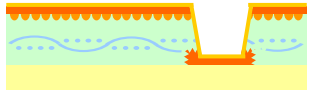
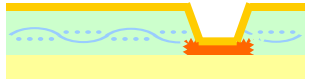
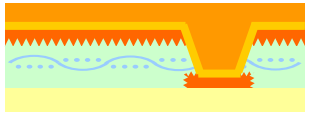
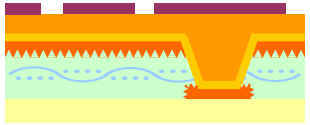
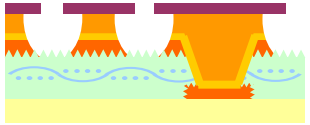
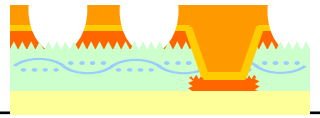
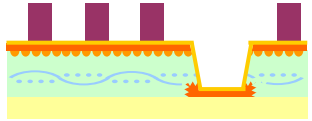
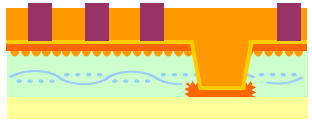
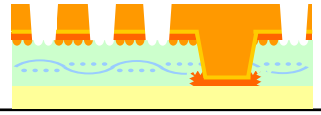
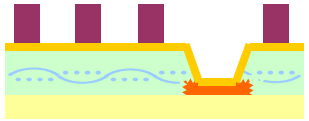
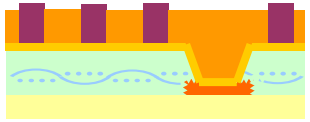
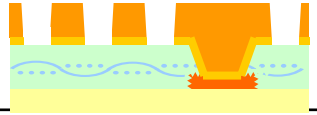
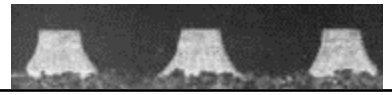
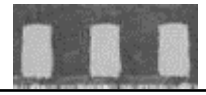
To recycle these elements on a larger scale, they are planning to:

- Establish new highly efficient solvent extraction technologies by March 2026.
- Build and put into operation a large-scale recycling line in April 2027.

MITSUI KINZOKU

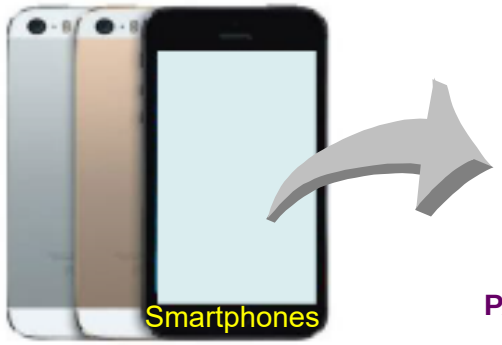
Appendix

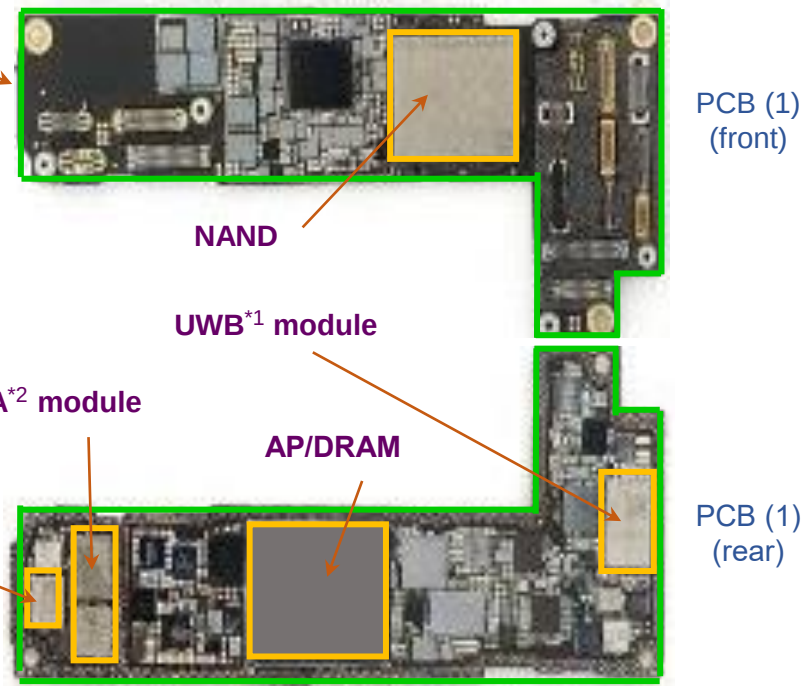
Appendix 1: Comparison of Subtractive Process/MSAP/SAP

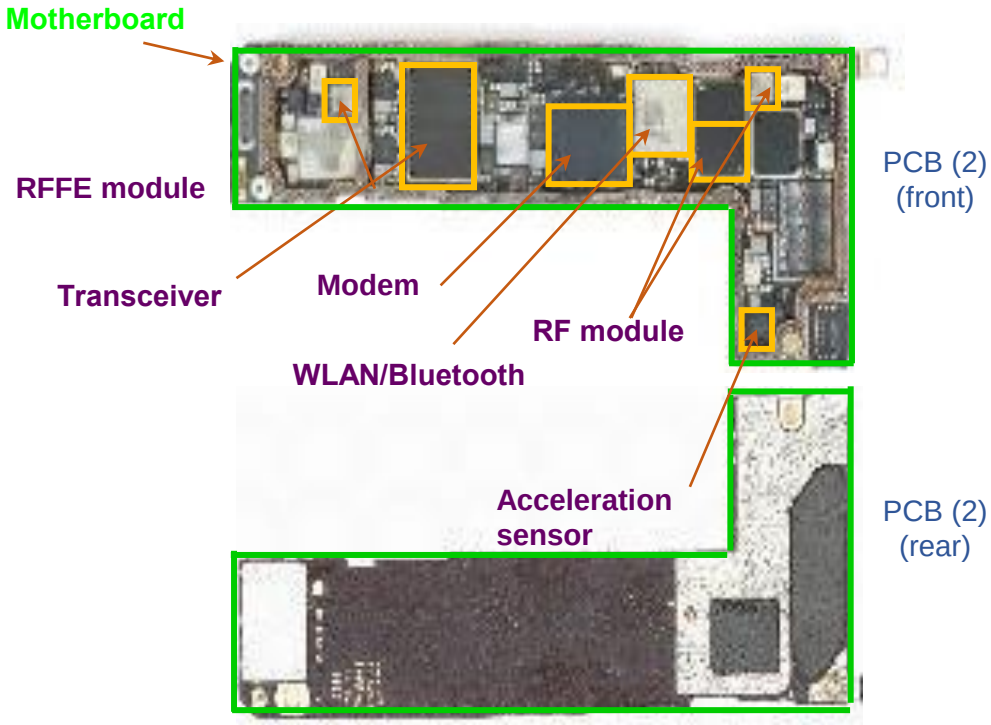
Process	Subtractive process	MSAP (Modified Semi-Additive Process)	SAP (Semi-Additive Process)
Laminate pressing			
Half etching		—	—
Laser perforation			 Including desmear removal
Electroless copper plating			
Patterning	Panel plating  Dry film exposure/ development  Hard etching  Dry film removal 	Dry film exposure/ development  Panel plating  Dry film removal  Seed layer thickness: 1.0 to 3.0 μm Flash etching 	Dry film exposure/ development  Pattern plating  Dry film removal  Seed layer thickness: 0.5 to 1.0 μm Flash etching 
Photo of circuit			

Appendix 2: Major Applications of MicroThin™ (HDI/PKG-MT) (Smartphones)

Applications of HDI-MT: Components shown in green
Applications of PKG-MT: Components shown in purple



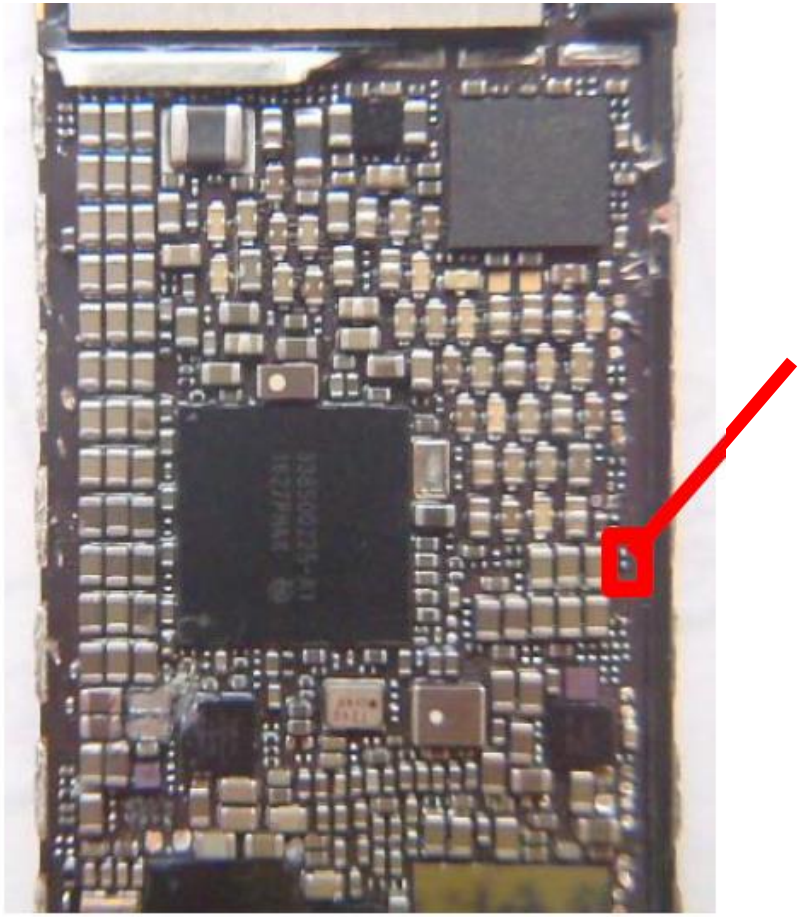




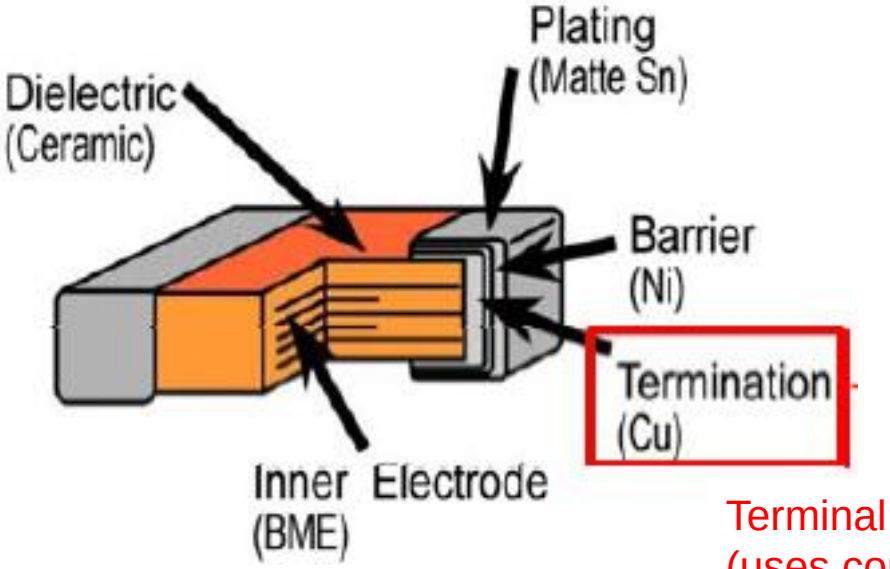
MT is expected to be used more widely with the increasing need for micro wiring, following the popularization of 5G smartphones and with increases in the number of modules mounted on motherboards.

*1: Ultrawideband radio communication
*2: Power amplifier
*3: Substrate mounted with an IC chip and SAW filter/capacitor/resistance/coil, etc.

Appendix 3: Use of Copper Powder in MLCCs



Smartphone PCB



Terminal electrode
(uses copper powder)