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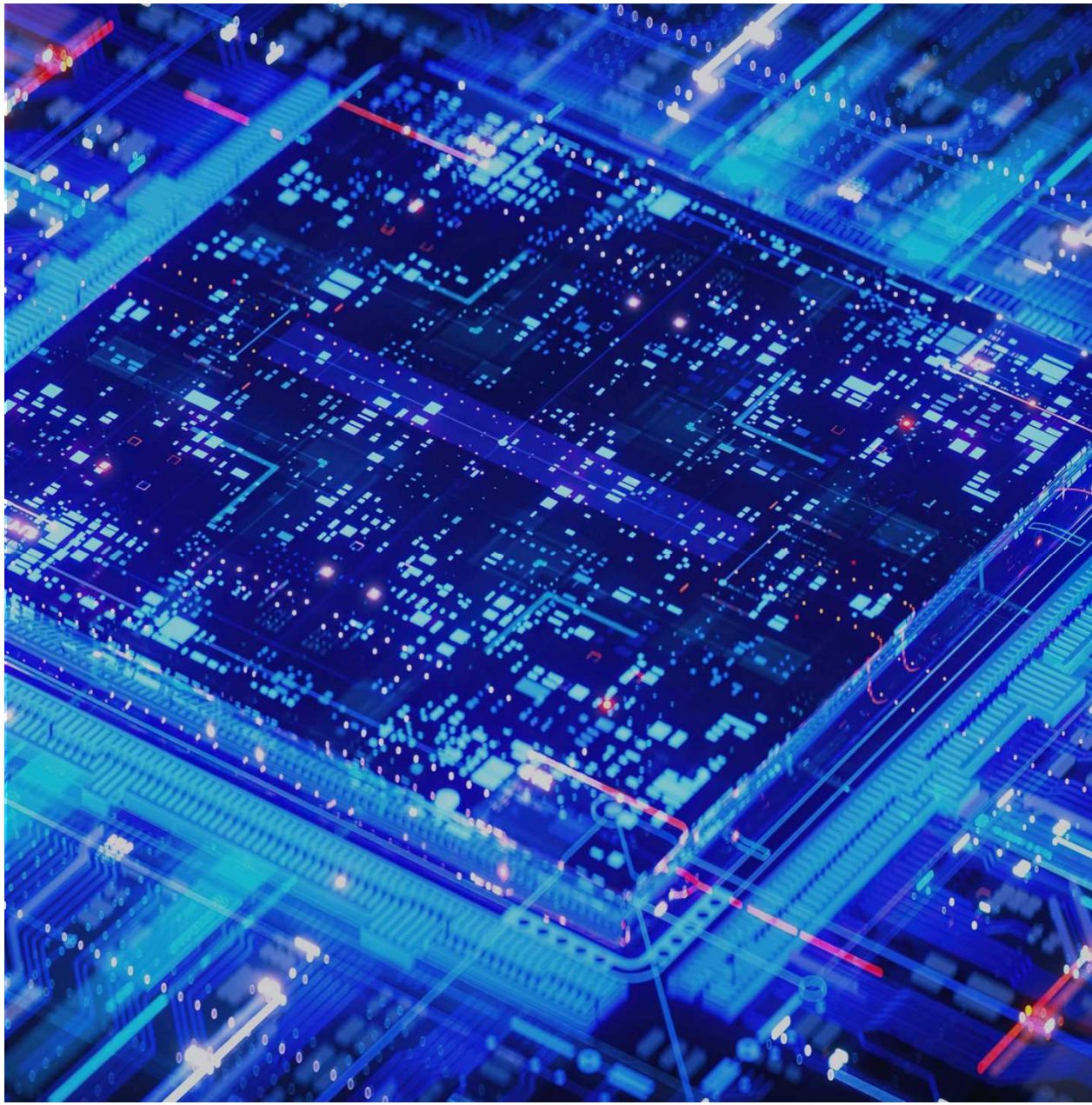
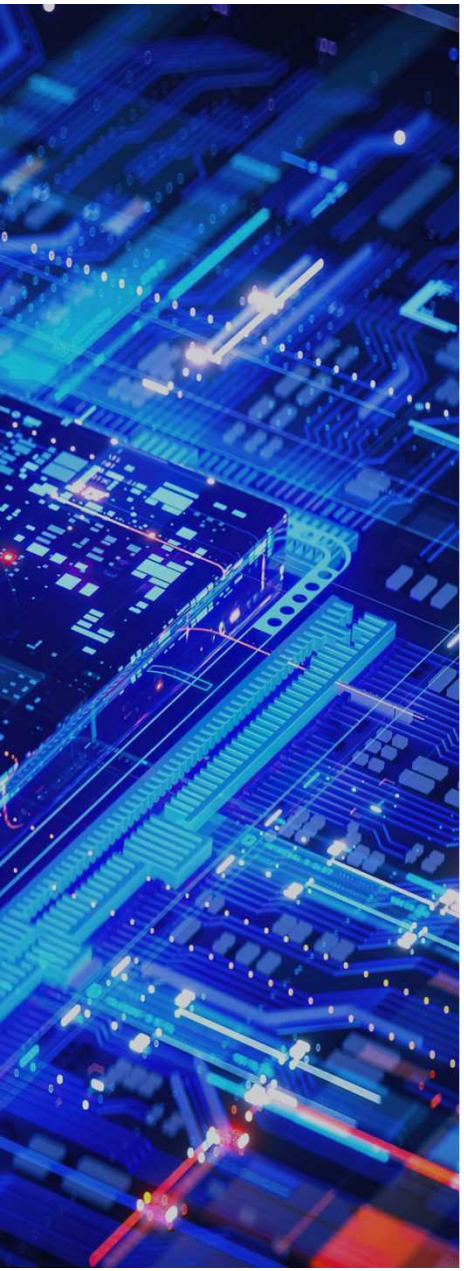
ULVAC, Inc.

IR Seminar 2023

Dec.11, 2023

Please note that the IR seminar materials and explanations have not been prepared for technical purposes, and some parts have been simplified to facilitate investors' understanding.





<Today's Agenda>

I. Double-Sided Evaporation Roll-to-Roll Equipment for EV Batteries Market Trends and Business Development ▶P.6

Yoshiki Iso, General Manager, FPD Division

Joined ULVAC in 2002, worked as an engineer of evaporation and sputtering deposition in FPD Division , and worked in PM and planning department from 2012, General Manager of FPD Division from 2023.

Yoshiaki Yamamoto, Senior Manager, R2R Group, FPD Division

Joined ULVAC in 2006; after working as an engineer of laser, CVD, and sputtering in FPD Division, engaged in the development of sputtering and evaporation equipment as the head of development department of FPD division from 2021, the head of R2R Group in the FPD division from 2023.

Masaki Takei, Senior Manager, Applied Vacuum Technology Research Dept. Institute of Advanced Technology

Joined ULVAC in 2005, engaged in research and development of sputtering processes and materials at the Advanced Technology Research Institute until 2015,engaged in the development of vacuum technology for batteries from 2016, Senior manager of Institute of Advanced Technology from 2022.

II. Market Trend of Next Generation Power Devices and Our Approach ▶P.25

Harunori Iwai, General Manager, Advanced Electronics Equipment Division

Joined ULVAC in 2000. After working mainly as a sputter engineer in Advanced Electronics Equipment Division, transferred to China in 2020, General Manager of Advanced Electronics Equipment Division from 2022.

Semiconductor and Electronics, Battery markets to grow in the Mid- to Long-Term

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- " Smart Society, Digitalization, Metaverse" x "AI" x “Green Energy"
  Semiconductors and Electronics, Batteries: "Technological Innovation" x “Investment in Production Increasement"
- Establishment of Regional Supply Chain (Government Support)

Green Energy
Increased Energy Efficiency and Storage Efficiency

- **Power Devices**
- **Batteries**
- **Various Electronics Devices**

Building regional supply chain Attracting Factories with Government Support

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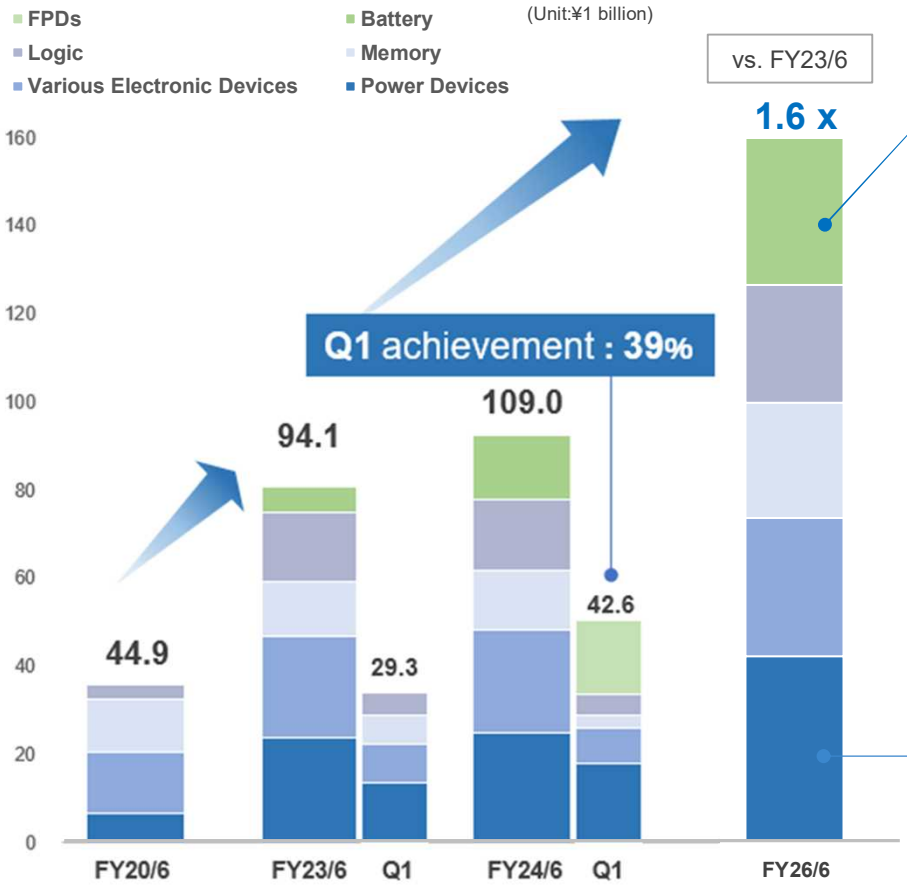
Growth Drivers (Power, Various Electronics Devices, Semiconductors and Batteries)

Order Forecast of Growth Drivers



Battery
4.7 x

- Full-scale investment in mass production of double-sided evaporation Roll-to-Roll equipment for smaller, higher-capacity and safer EVs batteries has started, driving the future growth

Power Devices
1.5 x

- Continuous growth due to increased demand for green energy and EVs, and investment in SiC, wafer size upgrade

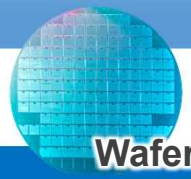
Solving Social Issues

Smart and Digital Society Realization

Green Energy Conversion Low Power Consumption

Memory | Logic IC | Sensor・Electronic Devices | Power Device | Battery

Miniaturization/ High performance/ Low power consumption


Wafer


Glass


Plastic

Vacuum Thin Film Processing Technology

Sputtering | Vacuum Evaporation | CVD | Etching/ Ashing | Ion Implanter

Components | Materials | Customer Support

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Double-Sided Evaporation Roll-to-Roll Equipment for EV Batteries Market Trends and Business Development

Yoshiki Iso General Manager, FPD Division

Yoshiaki Yamamoto Senior Manager, R2R Group, FPD Division

Masaki Takei Senior Manager, Applied Vacuum Technology Research Dept.
Institute of Advanced Technology

Leading the World
In Vacuum Technology

Summary

Today, we will report on the market trend of double-sided evaporation films and manufacturing equipment for EV batteries, as well as on the business development of R2R evaporation equipment for EV batteries

- **Why is Evaporation Film Technology necessary?**

  With the rapid expansion of EVs and EV batteries, double-sided evaporation film is contributing to the solution of the technological issues of battery safety improvement, downsizing and weight reduction, cost reduction, and environmental load reduction.

  - The replacement of the current collector (one of the battery components) from conventional metal foil to double-sided evaporation film is in full swing.
  - Potential for further demand growth in anticipation of all-solid-state batteries

- **What are the future business plans?**

  We have completed the development of AL double-sided evaporation equipment for Cathode Current Collectors and entered the commercialization phase:
  Starting with the double-sided evaporation film for the Cathode side, we will expand the evaporation technology to other battery layers.

  - Replacement of the Anode current collector from conventional Cu foil to Cu double-sided evaporation film.
  - Replacement of the Anode from the conventional environmentally hazardous coating film to a metallic lithium evaporation film.

EV shift accelerates worldwide

- Prohibit the sales of new internal combustion engine vehicles (gasoline/diesel), including hybrids, by 2030

- Prohibit the sales of new gasoline-powered vehicles by 2035 (excluding hybrid vehicles)

✓ Countries declared carbon neutrality targets
✓ Big automobile manufacturing countries declared "Out of the gasoline car".
✓ 2030-2035 onward: Trend to prohibit Gasoline-powered vehicles

- Zero-emission vehicles to account for 50% of new car sales by 2030
- California prohibits sales of new gasoline-powered vehicles by 2035

- Prohibit the sales of new gasoline-powered vehicles in 2035 (excluding hybrid cars)

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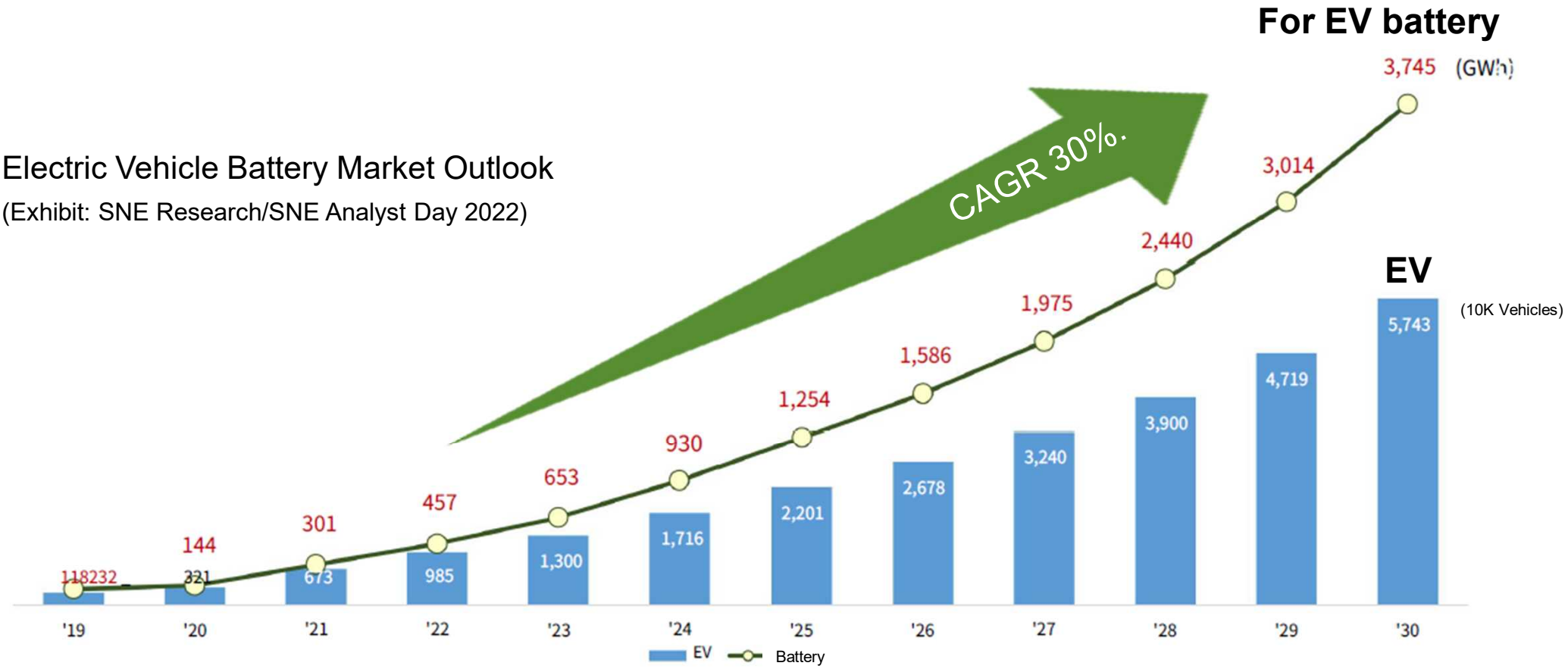
EV and Battery Market

EV market will grow at an average of **25%** per year from 2022 to 2030

EV Battery sales are expected to increase **8** times by **2030** compared **to 2022** （CAGR 30%）

Electric Vehicle Battery Market Outlook

(Exhibit: SNE Research/SNE Analyst Day 2022)



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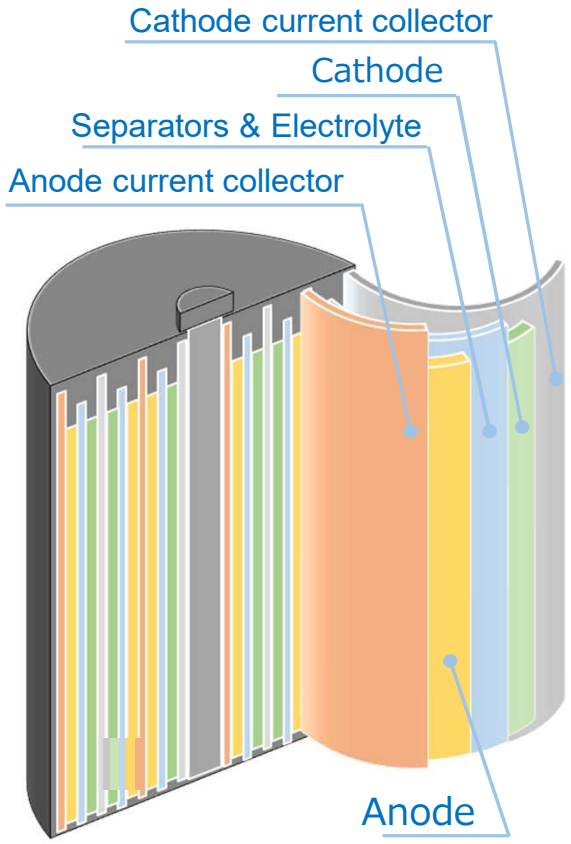
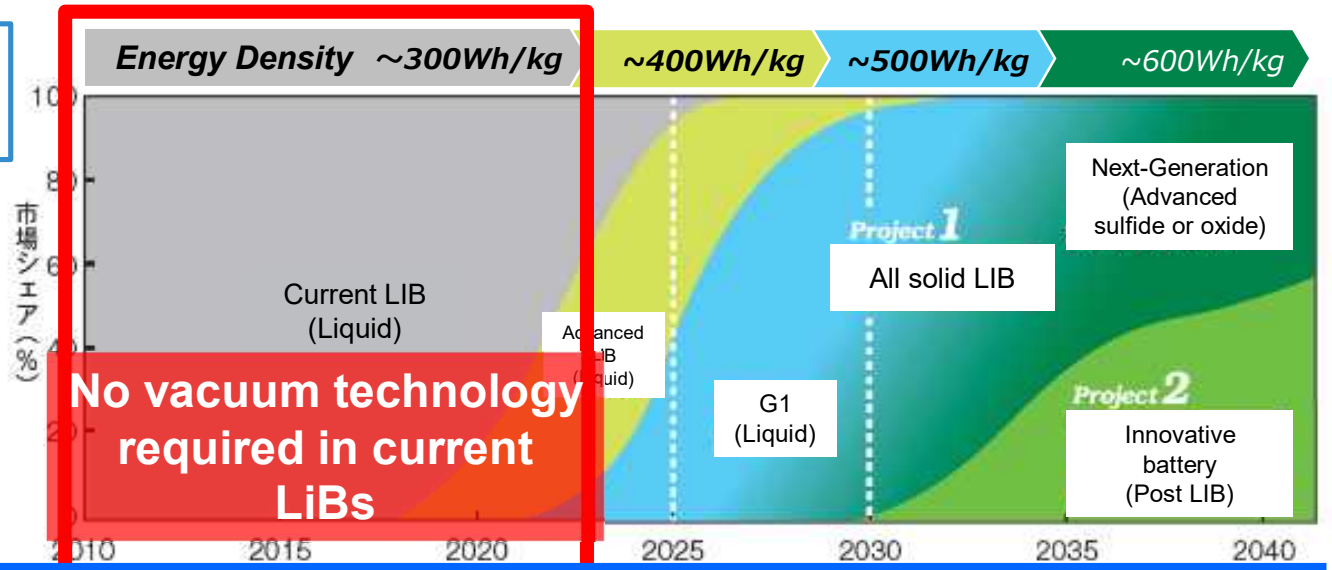
Trends in Battery (LiB) Technology and Vacuum Technology Adoption for Next Generation EVs

Various components are becoming more energy efficient and less in thickness to realize higher performance of EVs batteries





Cathode Current Collector	Al foil	12μm	6μm	4μm
Cathode	LFP・NCM	High Ni compound		Sulfur / Air
Separators	PP	PP+Ceramic coating		All solids
Electrolyte	liquid system	Polymer-based	(Sulfide)	(Acid)
Anode	Graphite	Graphite＋Silicon		Lithium metal
Anode current collector	Cu foil 10μmfoil	8μm	6μm	4μm

Vacuum technology required in next-generation LiBs

Ref.) Focus NEDO 2018 No.69, p.9
NEDO Rechargeable Battery Technology Development Roadmap 2013,p.10

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Next-generation EV Battery (LiB) Technology Challenges

Challenge 1: **Safety Improvement**

Suppression of thermal runaway by short-circuit phenomenon inside the battery

Challenge 2: **Reduction of size and weight**

Extended driving range and expectations for aviation applications such as Drones,EVTOLs

Challenge 3: **Reduction of material costs**

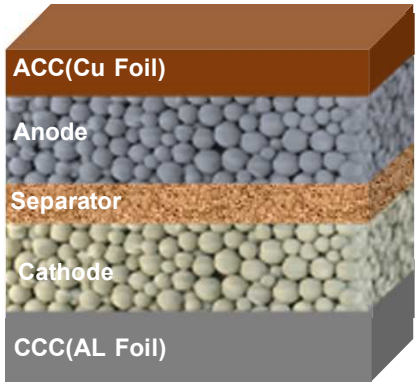
Battery costs account for approximately 40% of vehicle costs

Challenge 4: **Reduction of GHG**

Greenhouse Gases reduction in Battery Manufacturing
Green Tech in Battery Manufacturing

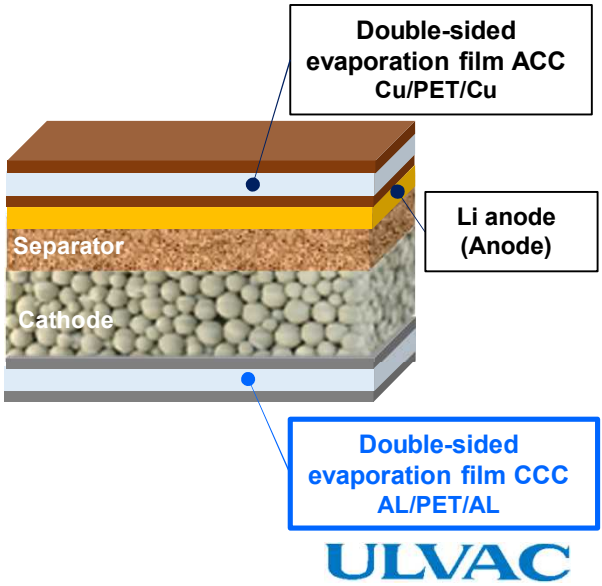
Full-scale adoption of double-sided evaporation films for battery components such as **Cathode Current Collectors (CCC)** as a solution to the four technical challenges

Liquid LiB Basic Structure



CCC : Cathode Current Collector
ACC : Anode Current Collector

Battery Structure ULVAC aims for



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ULVAC's Battery Strategy

- **R2R equipment for manufacturing double-sided evaporation-type Cathode Current Collector (CCC), based on film capacitor technology, is now in the commercialization stage.**
- **Aiming to achieve medium-term growth by expanding into double-sided evaporation film type for Anode Current Collectors (ACC).**
- **Also applying vacuum technology to the anode, aiming for long-term growth by establishing Li metal anode manufacturing technology.**

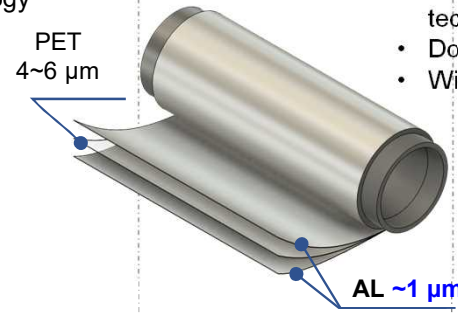
FY2020 | FY2021 | FY2022 | FY2023 | FY2024 | FY2025

Film Capacitor

- Ultra-thin film transport technology
- AL high speed deposition technology

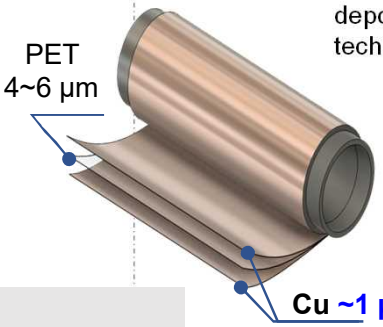
Double-sided evaporation film for Cathode current collector (CCC)

- AL thick film deposition technology
- Double-sided deposition
- Wide film



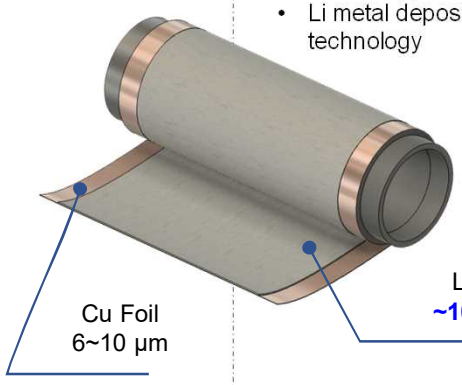
Double-sided evaporation film for Anode current collector (ACC)

- Cu thick film deposition technology



Anode

- Metal foil conveying technology
- Li metal deposition technology



Supply Chain of battery components such as CCC/ACC

ULVAC → production equipment → Materials Processing Manufacturer → Battery component → Battery Manufacturer → battery → EV Manufacturer

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Why Focus on Double-sided Evaporation Film CCC?

Reason 1: **Safety Improvement**

Reason 2: **Reduction of size and weight**

Reason 3: **Reduction of material costs**

Reason 4: **Reduction of GHG**

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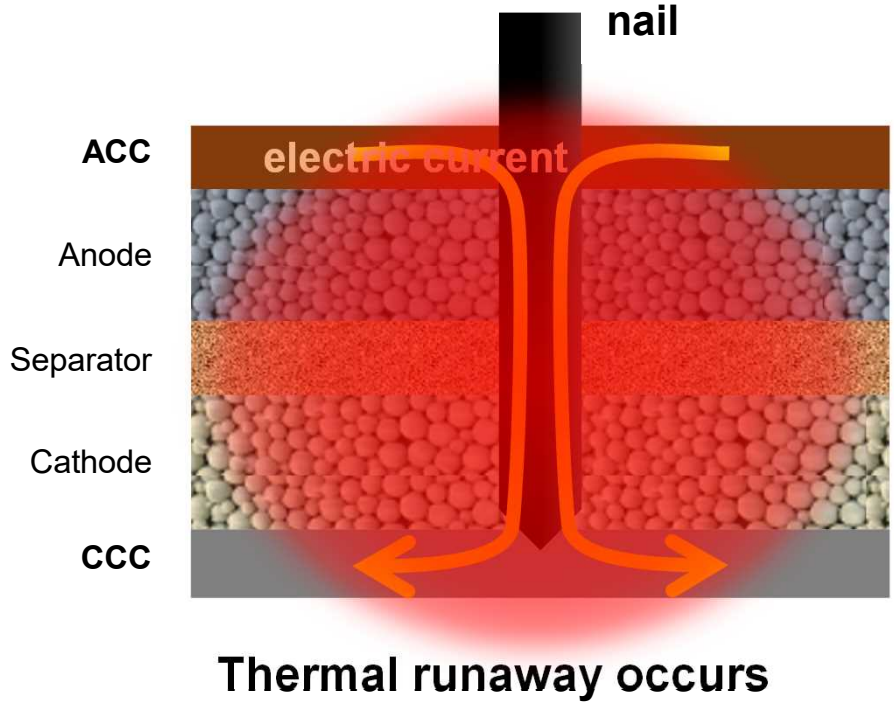
Why Focus on Double-sided Evaporation Film CCC?

Reason 1: Safety Improvement

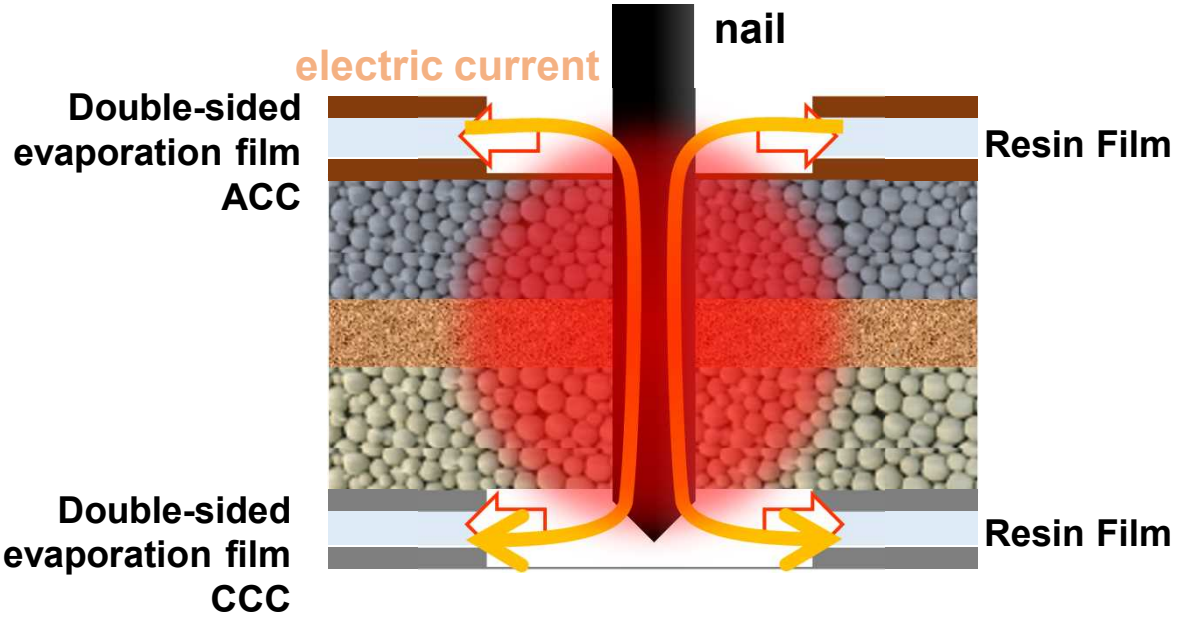
Short-circuits can be suppressed inside the battery

Metal foil current collector



Thermal runaway occurs

Double-sided evaporation film current collector



Resin film fuses to prevent combustion

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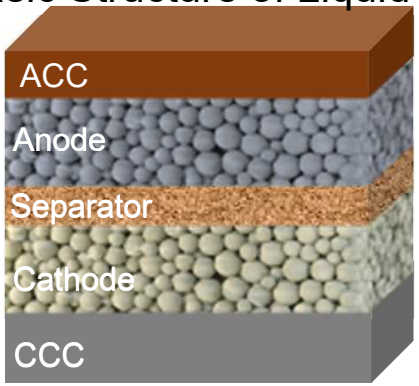
Why Focus on Double-sided Evaporation Film CCC?

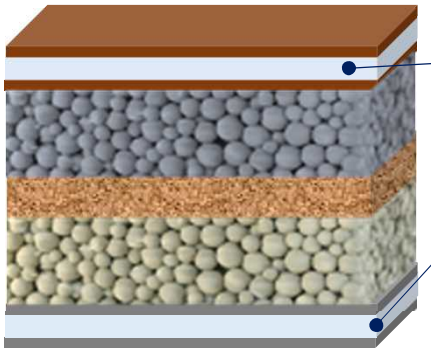
Reason 2: **Reduction of size and weight**

Replacing conventional copper and aluminum foil with double-sided evaporation film enables lighter weight and higher energy density

Basic Structure of Liquid LiB



Double-sided Evaporation Film



per MWh	unit	Liquid LiB Structure	**Double-sided Evaporation Film Adopted**	Difference
ACC Weight	kg	645	289	-55%
CCC Weight	kg	389	139	-64%
Other battery weight	kg	2,966	2,966	0%
Battery weight	kg	4,000	**3,394**	**-15%**
energy density	wh/kg	250	**294**	**18%**

(Source)Funder Securities Research Institute

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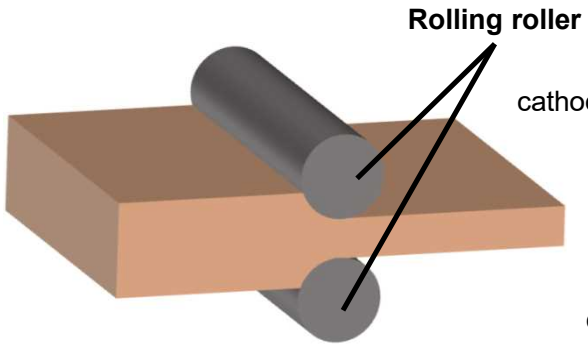
Why Focus on Double-sided Evaporation Film CCC?

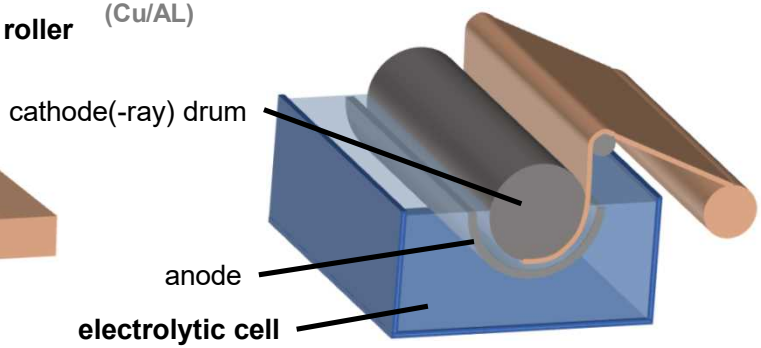
Reason 3: **Reduction of material costs**

Fewer manufacturing processes and wider widths compared to metal foil enable higher productivity and lower manufacturing costs

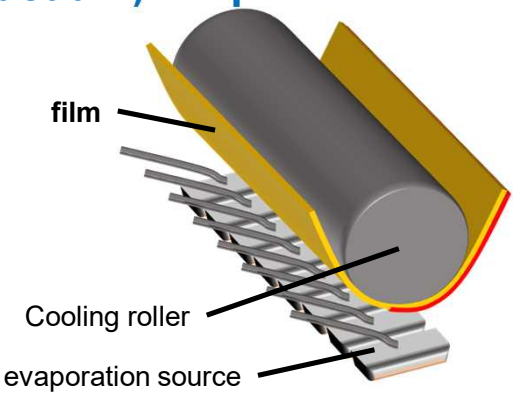
Rolled foil (AL)



Electrolytic foil
(Cu/AL)



(Vacuum) Evaporation foil



	Rolling Foil	Electrolytic Foil	Evaporation Foil
Manufacturing Process	rolling method	plating method	**Vacuum Evaporation**
Thickness Range	6μm to 100μm	4.5μm to 140μm	**50nm to 3μm**
Maximum Width	650mm	1380mm	**1650mm → Expandable**
Production Difficulty	Long production cycle Relatively complex process	Short production cycle Relatively simple process	**Vacuum equipment** **Adhesion to resin**

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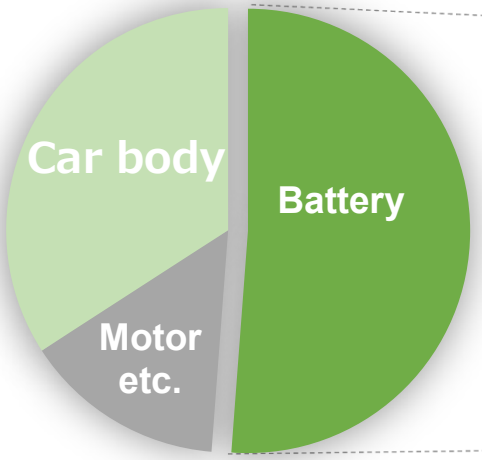
Why Focus on Double-sided Evaporation Film CCC?

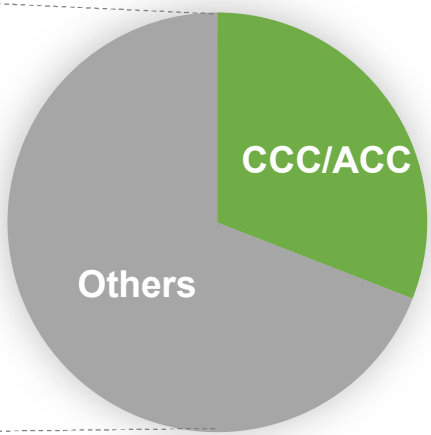
Reason 4: **Reduction of GHG**

Batteries account for more than half of CO2 emissions during EV manufacturing, and 1/3 of that is CCC/ACC

CO2 emissions during EV Manufacturing



CO2 emissions during manufacture of car batteries



CO2 emissions when manufacturing car batteries using double-sided evaporation film current collectors

20% Reduction

(Source: Based on IEA Global EV Outlook 2019)

Estimated by ULVAC

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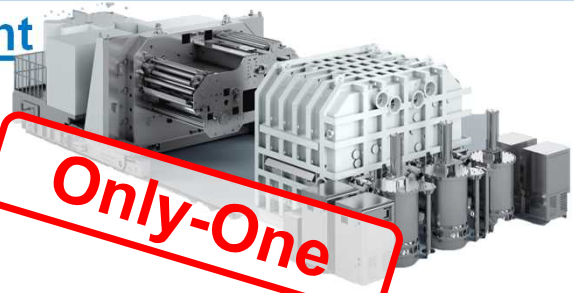
ULVAC's Differentiating Technology for the Double-sided Evaporation CCC Market

Double-sided evaporation film CCC manufacturing equipment

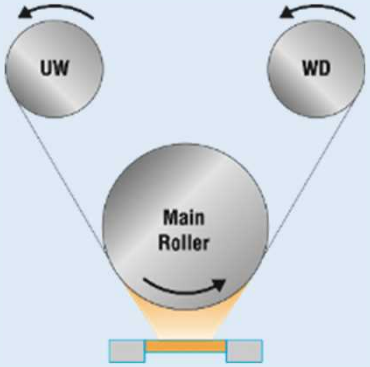


Only-One

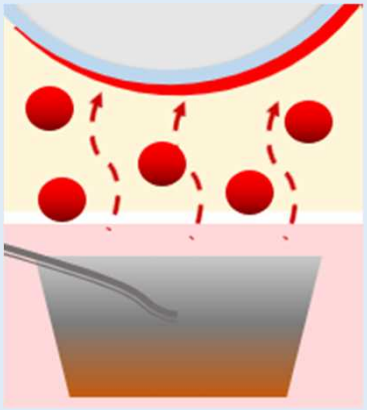
Film capacitor manufacturing equipment

No. 1

Single-sided Evaporation



Rapid Evaporation



7um-m/min.

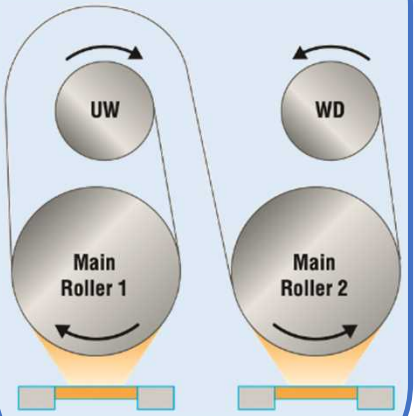
Sputtering: 0.6um-m/min

Thin Film

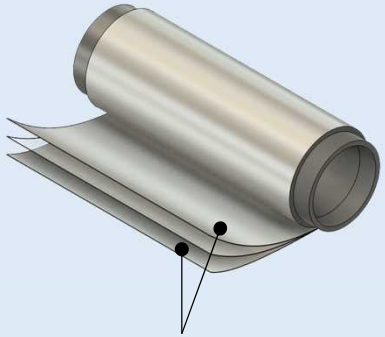
2um

Silicon wafer: 775um
Bag of potato chips: 60um

One time deposition on both sides



Thick Film Evaporation



AL ~1 μm

Semiconductor: 0.001um
Capacitor: 0.02um
TV:0.2um

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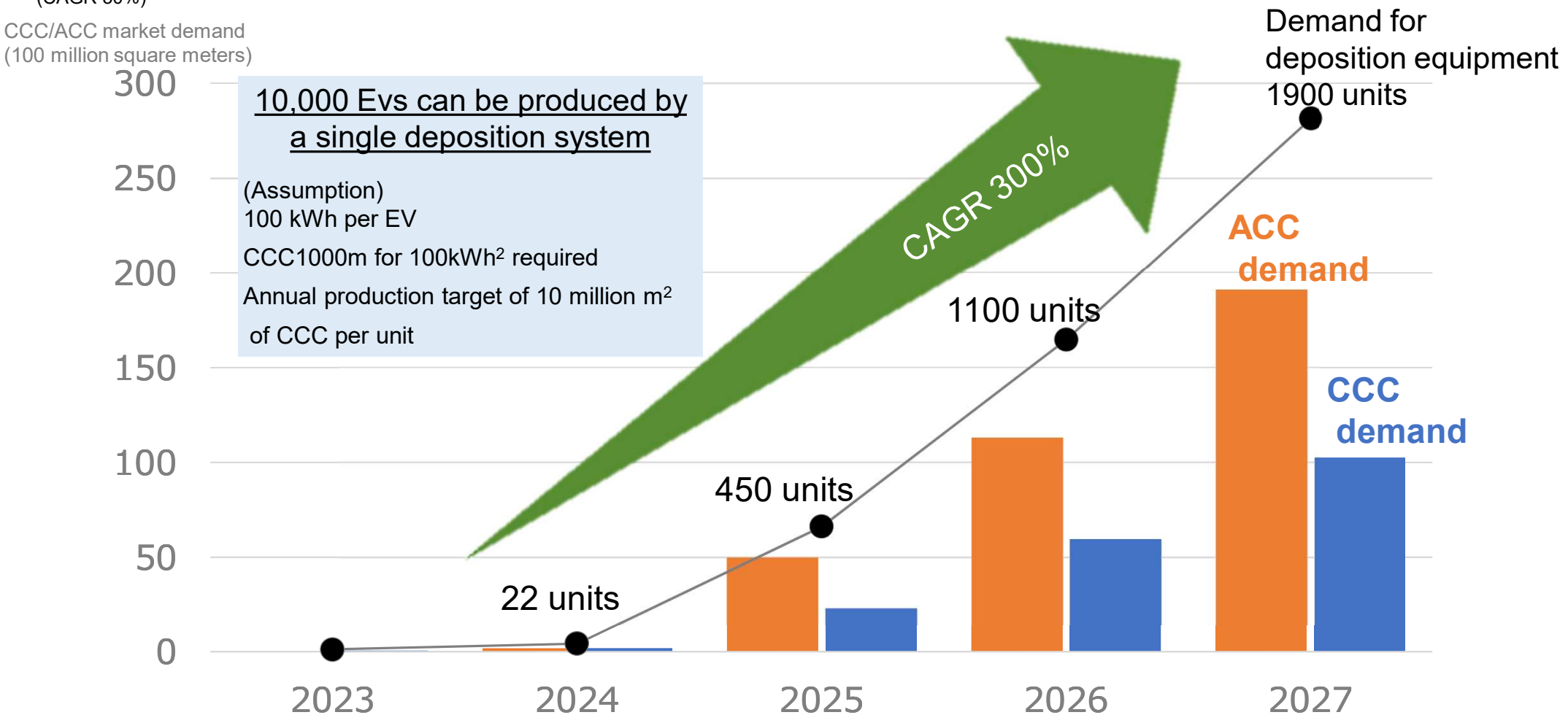
Market Scale of Double-Sided Evaporation Film CCC/ACC

CCC/ACC market and CCC/ACC deposition equipment market are expected to grow faster than the EV market growth rate (CAGR 30%)



Prepared by ULVAC based on data from the International Conference on Composite Collectors

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Why Focus on Double-sided Evaporation Film ACC?

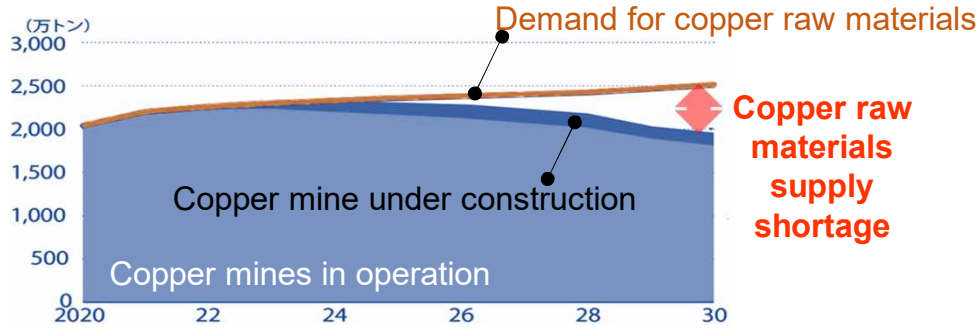
Reason 1: **Safety Improvement**

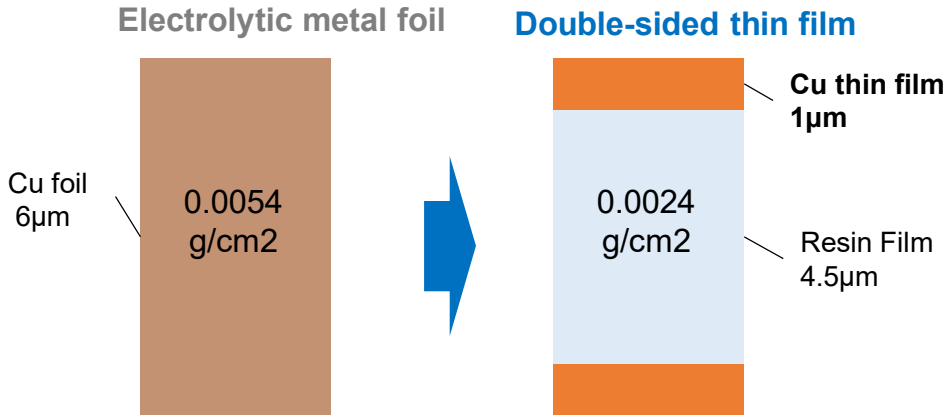
Reason 2: **Reduction of size and weight**

Reason 3: **Reduction of material costs**

Reason 4: **Reduction of GHG**

Reason 5: **Reduction of Cu raw materials**





Reducing copper usage by more than 50 %

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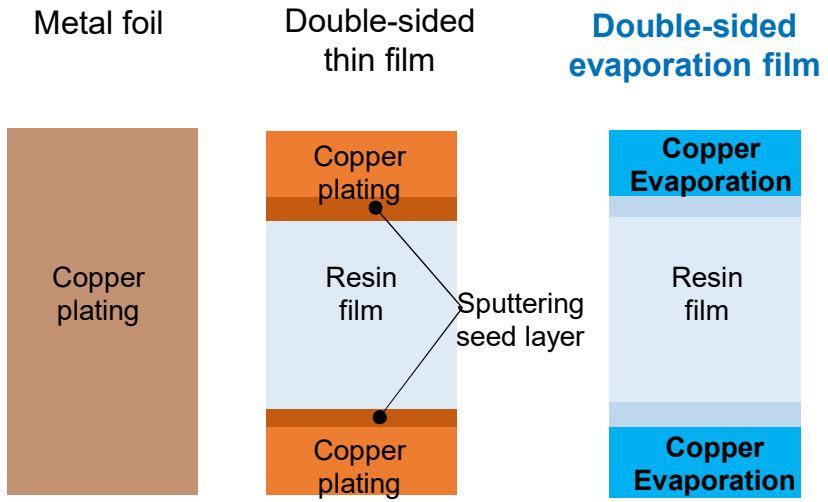
Status of Efforts for Double-sided Evaporation Film ACC



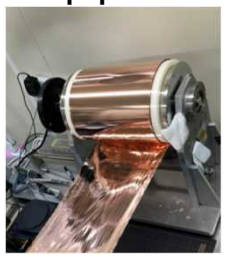
Copper thickness	**6μm**	**1+1 μm**
Dry production speed	**-**	**~15 m/min**
Plating production speed	**~X m/min**	**~5 m/min**
Manufacturing cost	**1**	**1.5**

1+1 μm
~20 m/min
-
0.6

Manufacturing costs are ULVAC estimates

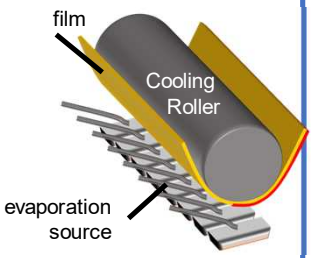
FY2023 → FY2024 → FY2025

Basic Evaluation for Small experimental equipment



Single Evaporation Source

Application Evaluation for mass production equipment



Multiple Evaporation Sources

Mass production equipment development

Mass-production equipment EWG-165 (Cu)

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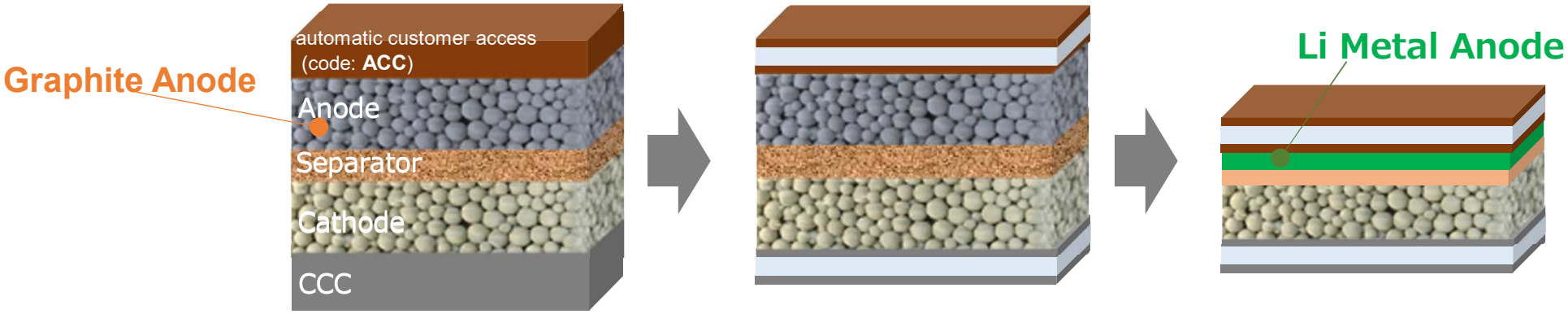
Why Focus on Lithium Metal Anode?

Further reduction of size and weight

Basic Structure of Liquid LiB **Double-sided Evaporation Film CCC/ACC**



per MWh	unit	Liquid LiB Structure	Adoption of Double-sided Evaporation Film	Li Anode
ACC Weight	kg	645	289	289
CCC Weight	kg	389	139	139
Anode weight	kg	1,200	1,200	**32**
Other battery weight	kg	1,766	1,766	1,766
Battery weight	kg	4,000	3,394	2,226
energy density	wh/kg	250	294	**450**

(Source: Compiled by ULVAC based on data from the Fangzheng Securities Research Institute)

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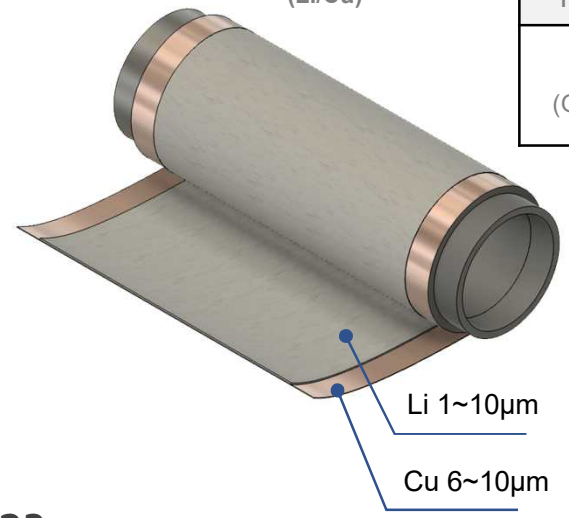
Lithium Metal Anode Production Technology Issues

Copper foil conveying technology in vacuum

The conventional R2R equipment is usually used to deposit on highly elastic resin film, while the anode of the battery requires the deposition on metal foil with low elasticity which wrinkles easily.

Lithium metal anode
(Li/Cu)

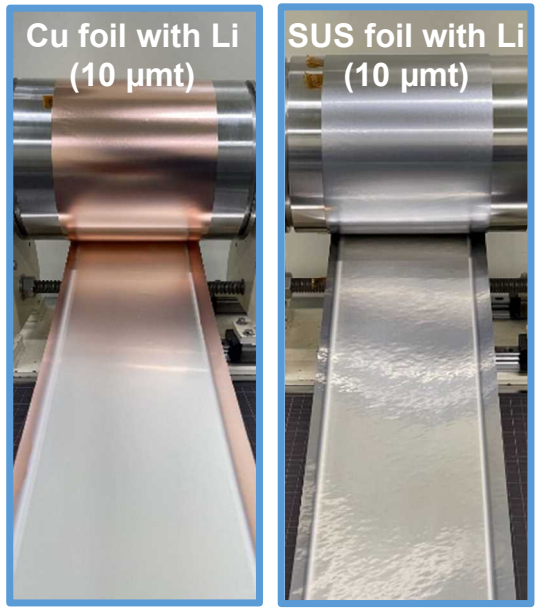


Physical Properties	**Copper Foil**	PET
elasticity (Growth rate)	**7%**	188%.

Evaporation of lithium on copper foil

Using the conventional conveying system optimized with PET etc.

Technology realized for metal foil transportation



Basic verification on 150mm wide web small R&D equipment

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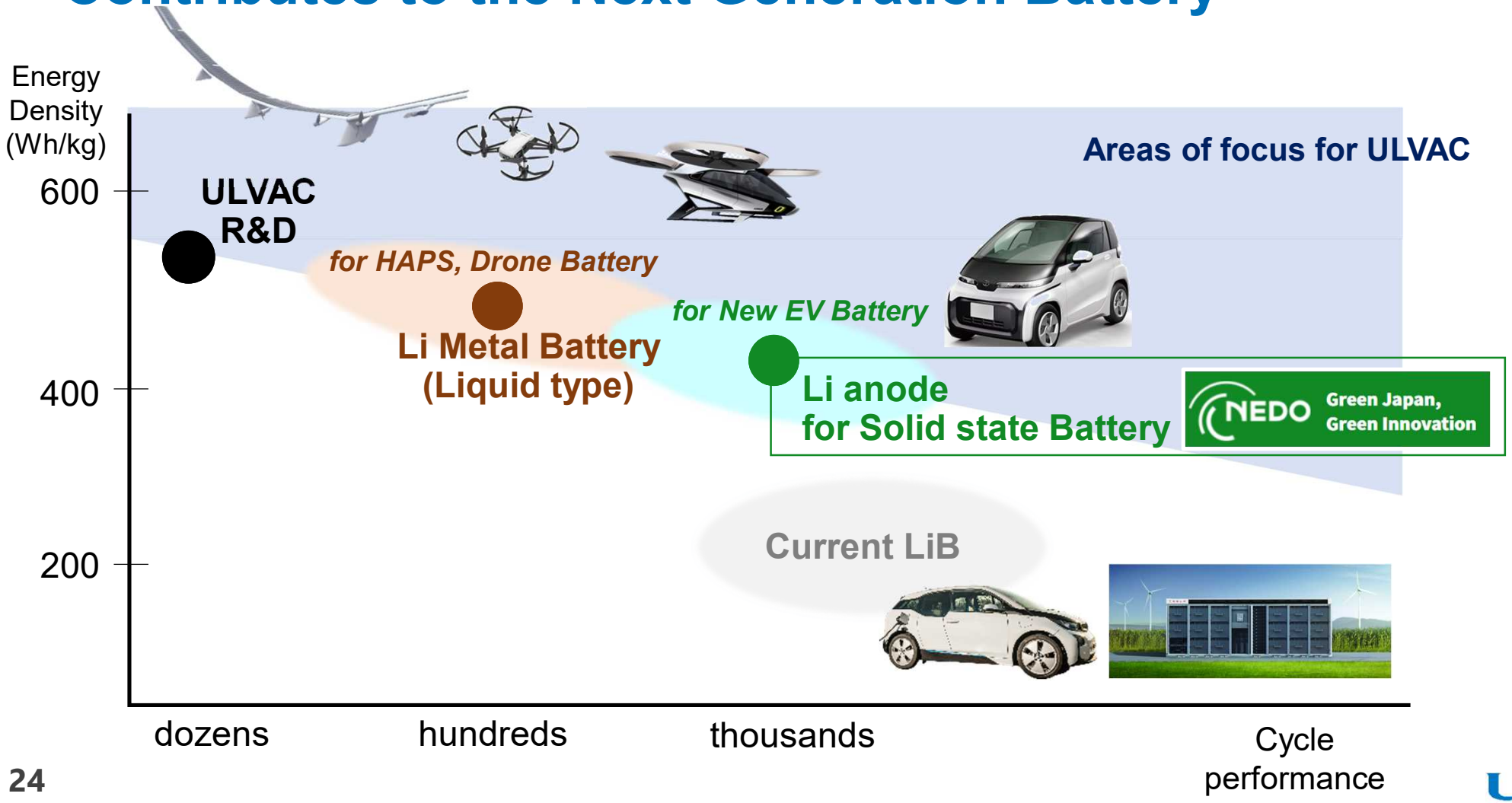
ULVAC's Roll-to Roll Evaporation Technology Contributes to the Next Generation Battery



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Market Trend of Next Generation Power Devices and Our Approach

Harunori Iwai
General Manager
Advanced Electronics Equipment Division

Leading the World
In Vacuum Technology

1. What is a power device?
2. Market size and trends of power devices
3. SiC power device manufacturing process
4. ULVAC's equipment lineup for SiC
5. Initiatives on GaN

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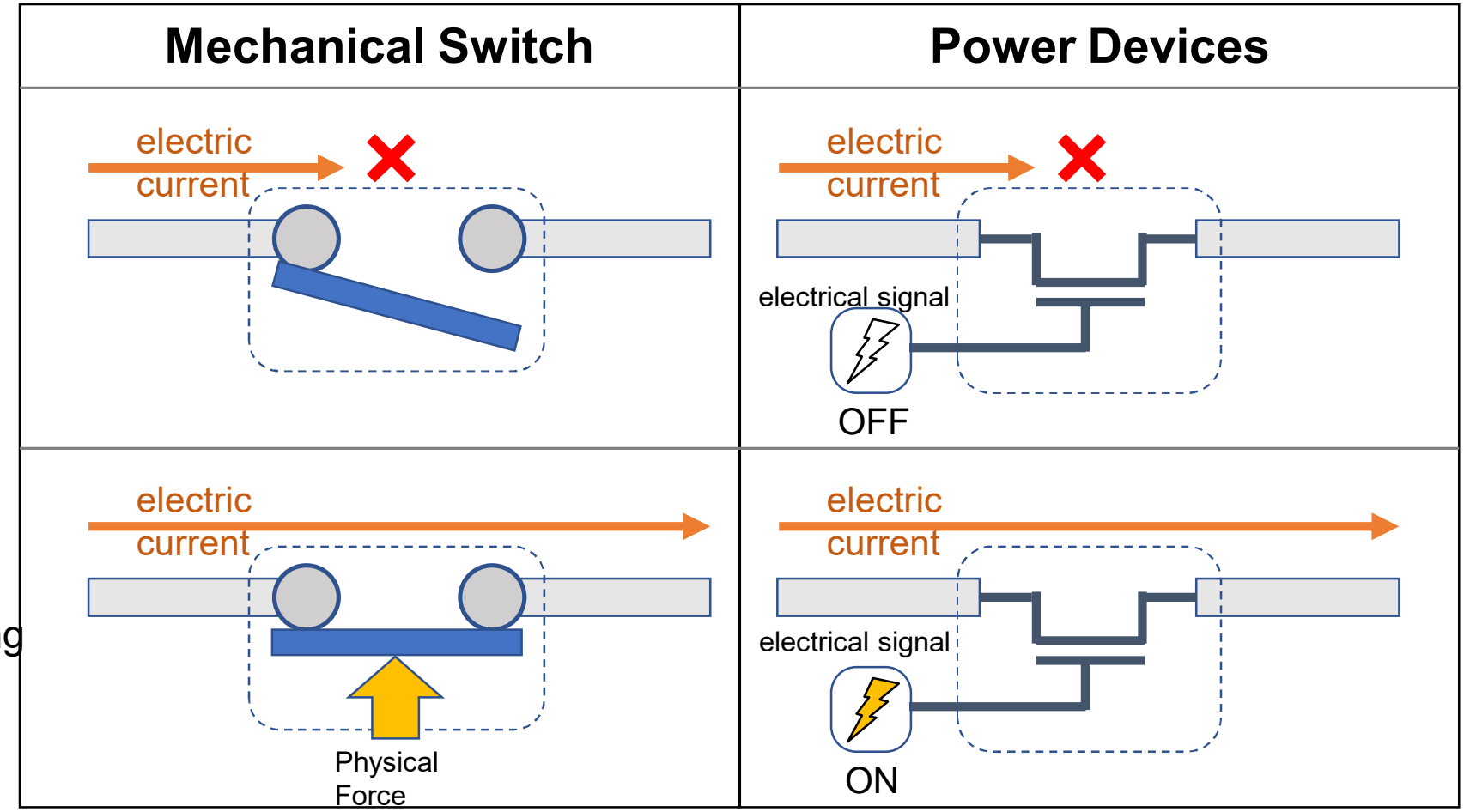
Power devices utilized in all fields



Compact, fast, long-life switches with no actuators

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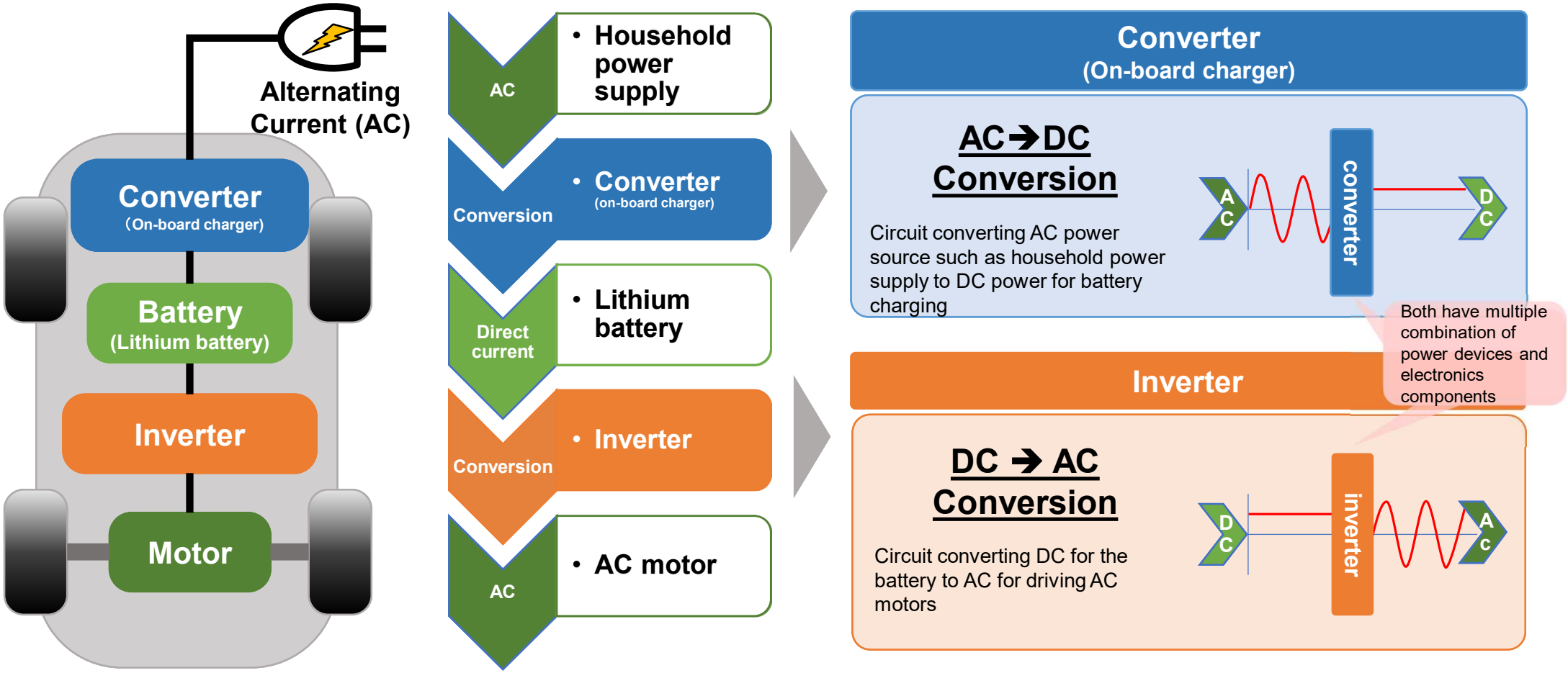
Role of power devices (e.g. EV)



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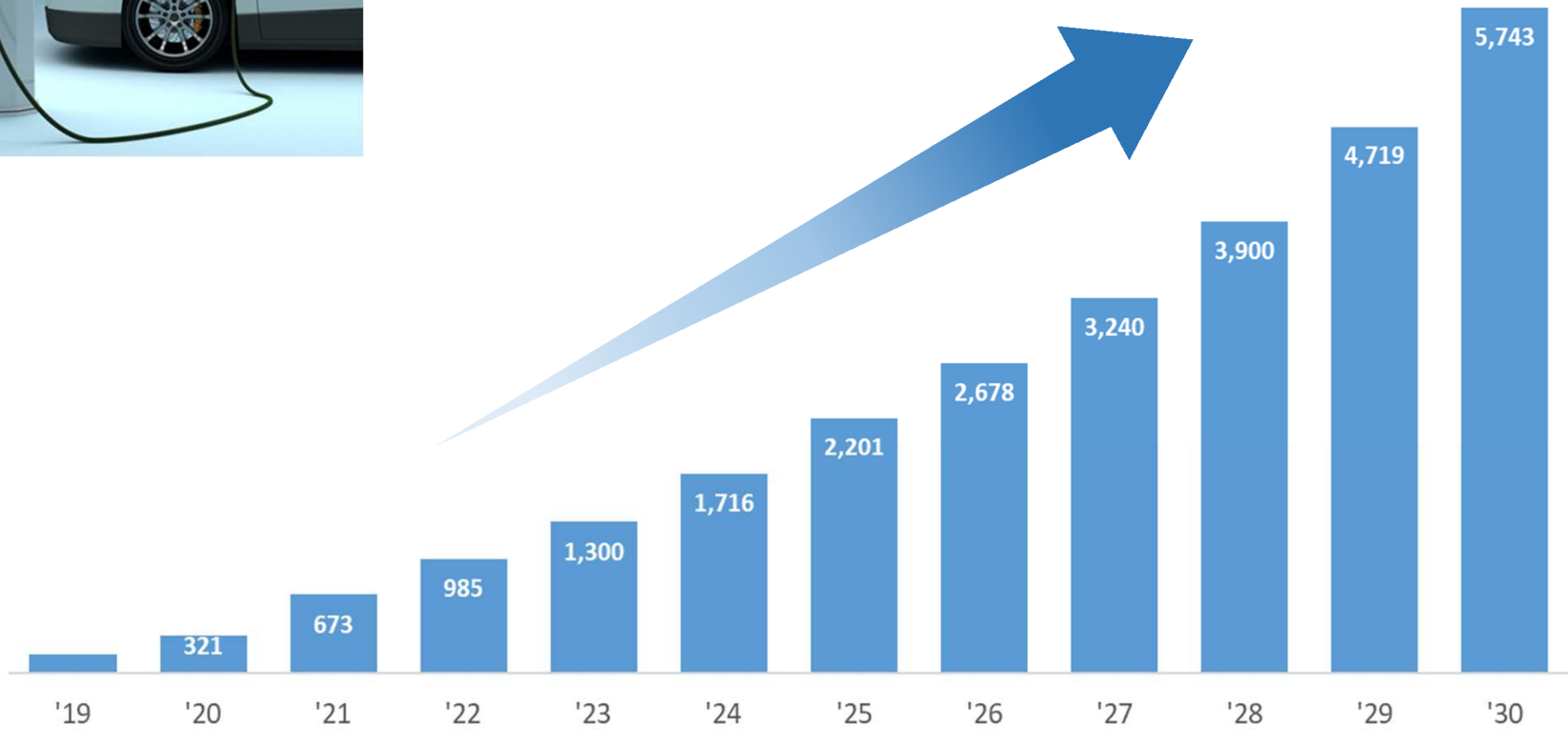
Demand for power devices also growing dramatically



(Source: SNE Research/SNE Analyst Day 2022)

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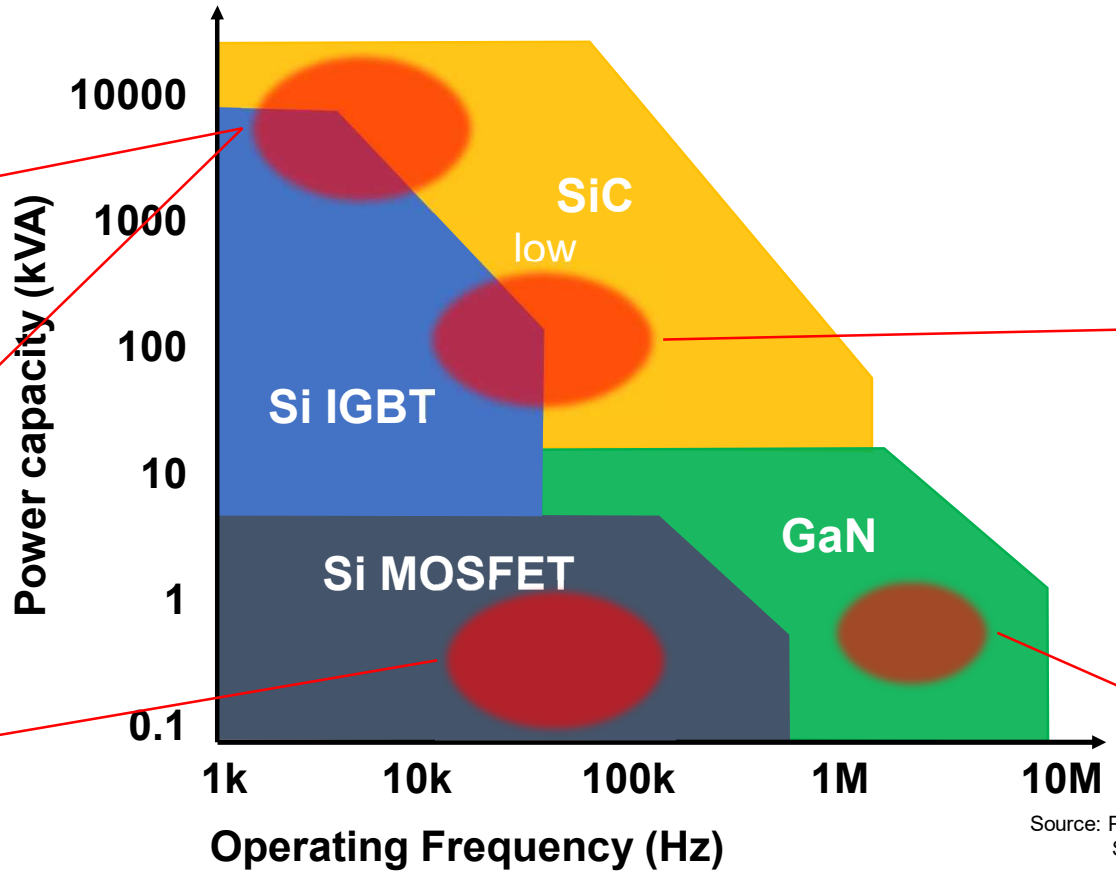
Evolving power devices



Source: Prepared by ULVAC based on "NEDO Technology Strategy Research Center Report Vol.103

	Si	SiC	GaN
Advantage	Low cost	Low power loss, compact size	High-frequency operation, compact size
Disadvantage	Upper limits on power and operating frequency	Expensive	Expensive, low current

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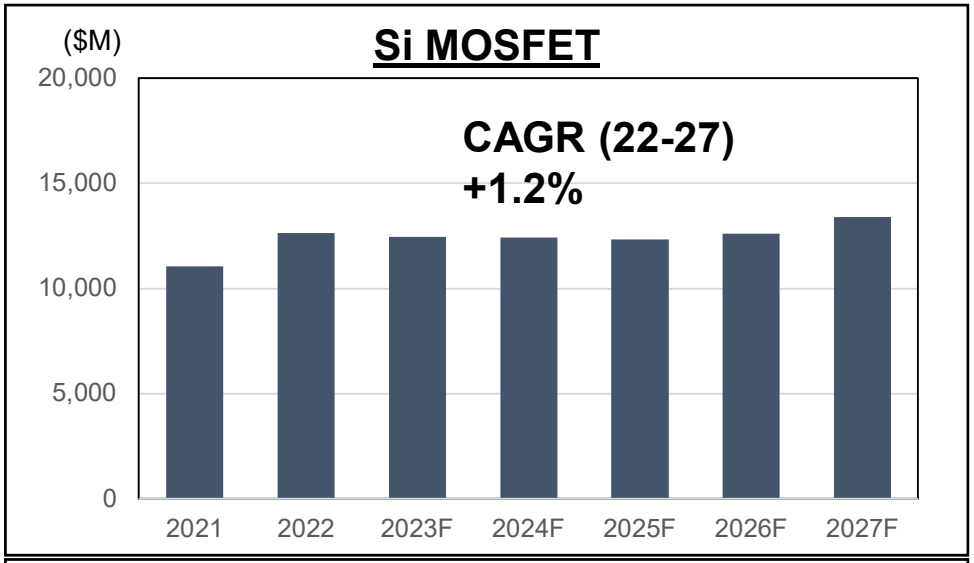
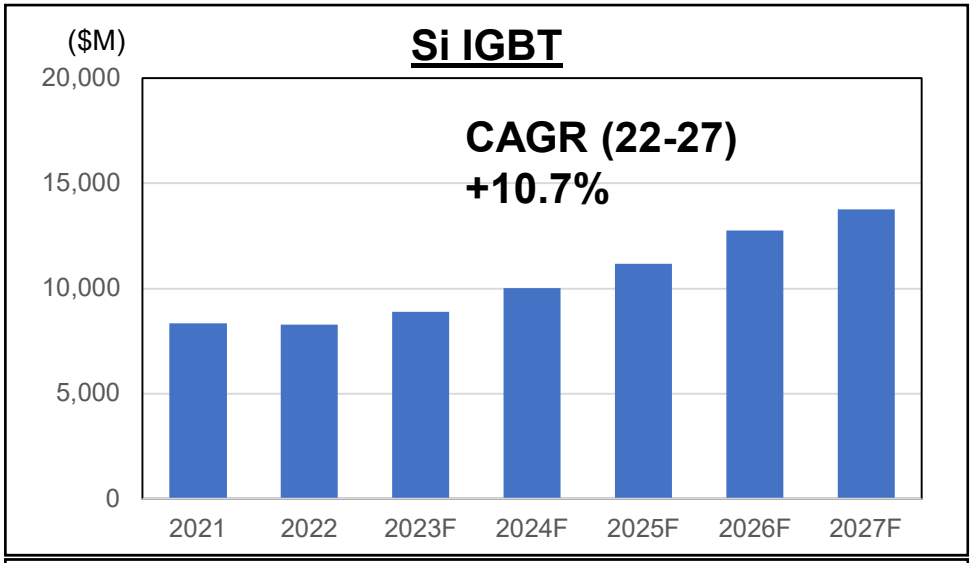
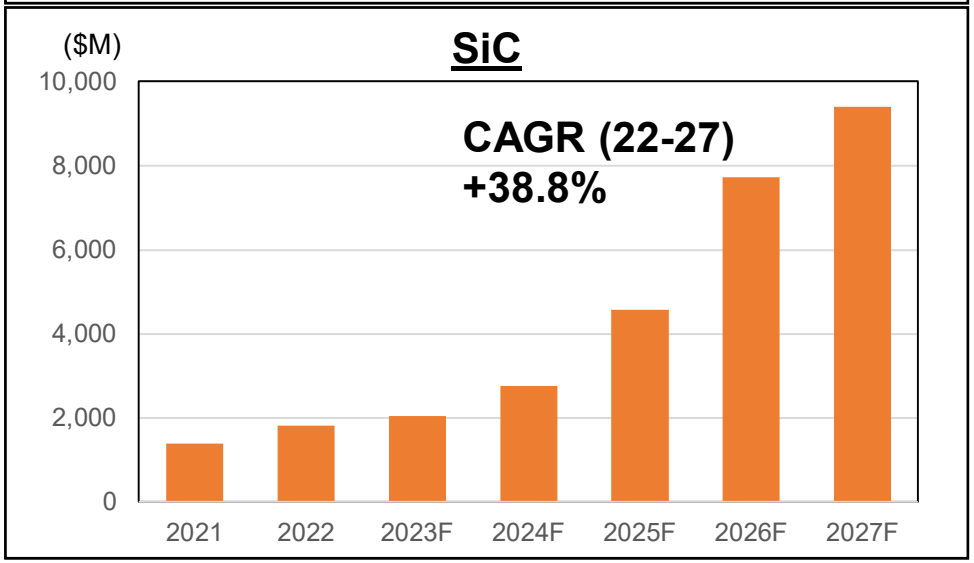
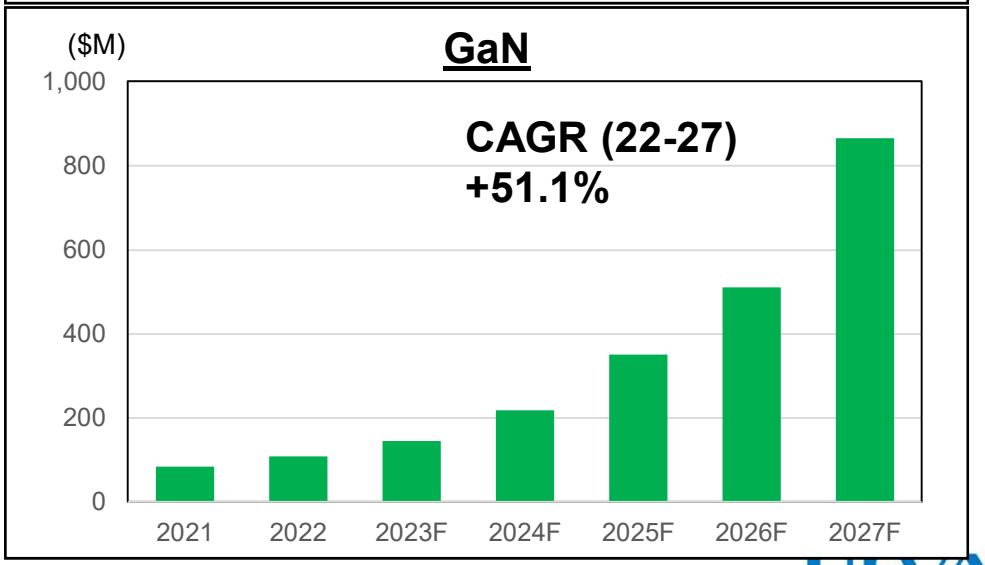
Growth of SiC and GaN markets





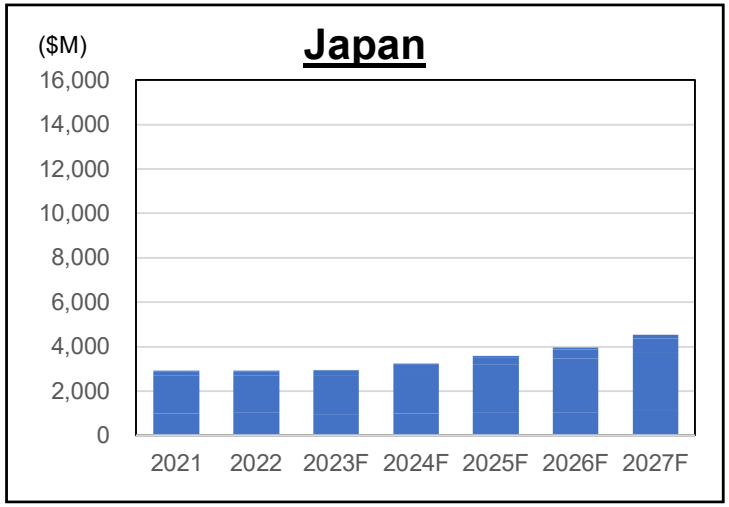


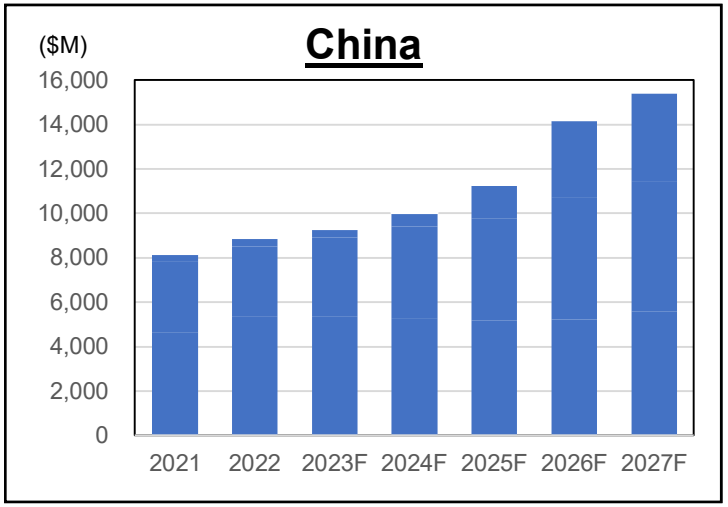


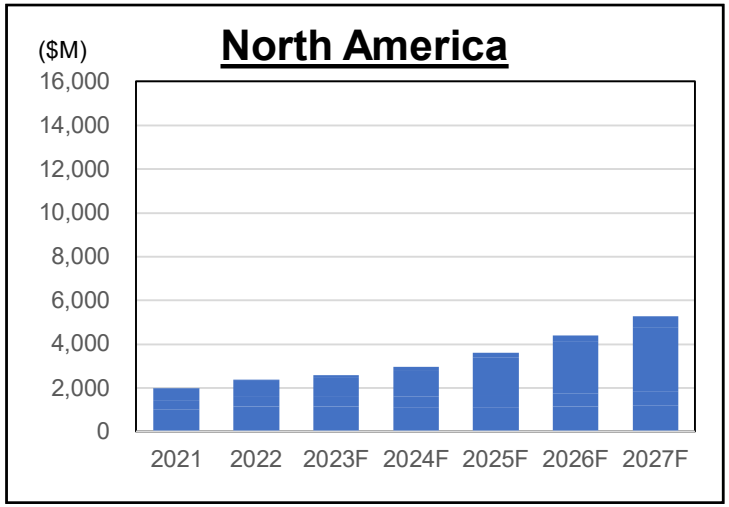
Source: Omdia, Consulting Project on Power Semiconductor, Aug. 2023

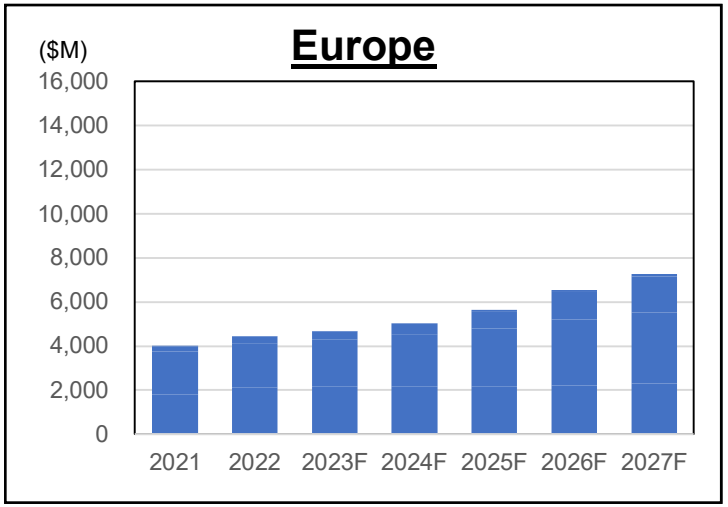
Results are not an endorsement of ULVAC. Any reliance on these results is at the third-party's own risk.

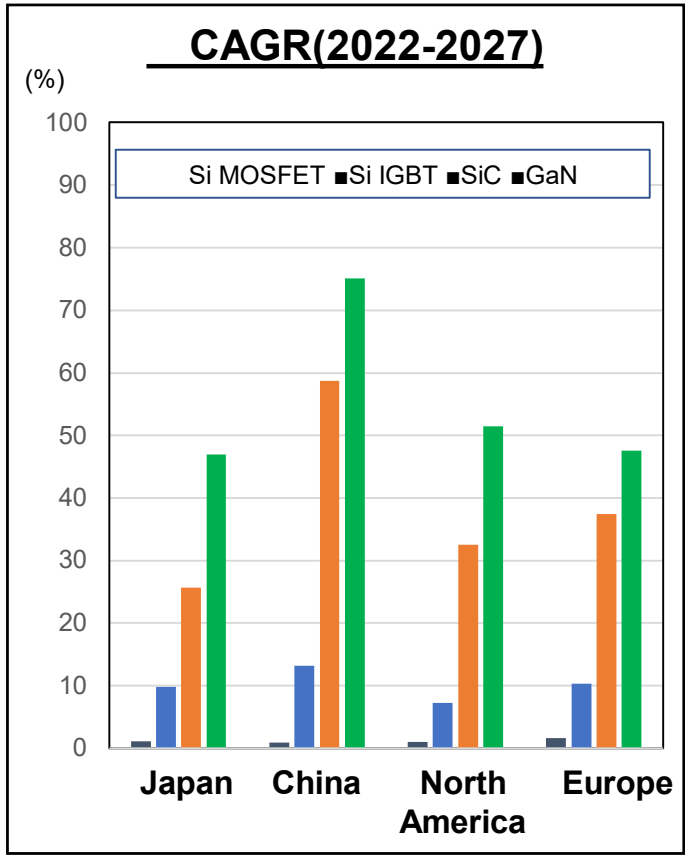
China's Power Device Market Growing with National Production Policy











Europe includes Middle East and Africa
Source: Omdia, Consulting Project on Power Semiconductor, Aug. 2023
Results are not an endorsement of ULVAC. Any reliance on these results is at the third-party's own risk.

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Increased substrate size and structural changes expand business opportunities

China

Substrate: 6-inch

Structure: Planar

*It is expected that 8-inch substrates with trench structure will be available in China in a few years.

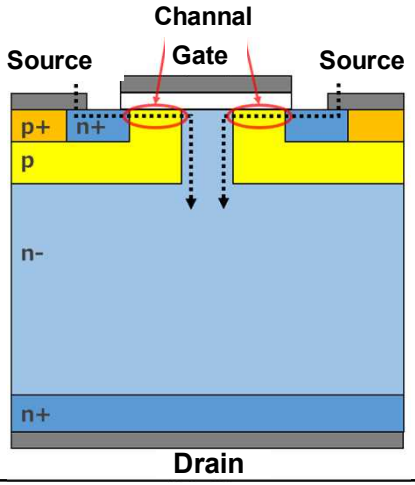
Japan

Shift in

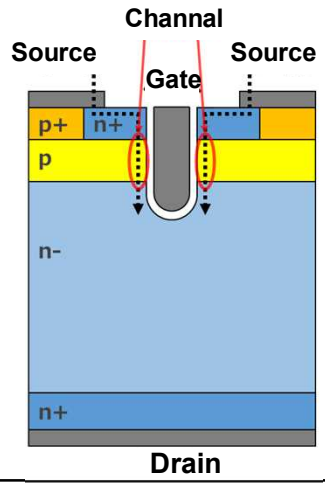
Substrate: 6-inch → 8-inch

Structure: Planar → Trench

Substrate warpage: 6 inches, approx. 200um
8 inches, 300-500um approx.



Planer	Structure	Trench
Simple process	**Advantage**	Low channel resistance (50%↘) Miniaturization is possible (20%↘)
High channel resistance Limits to miniaturization	**Disadvantage**	Complicated process



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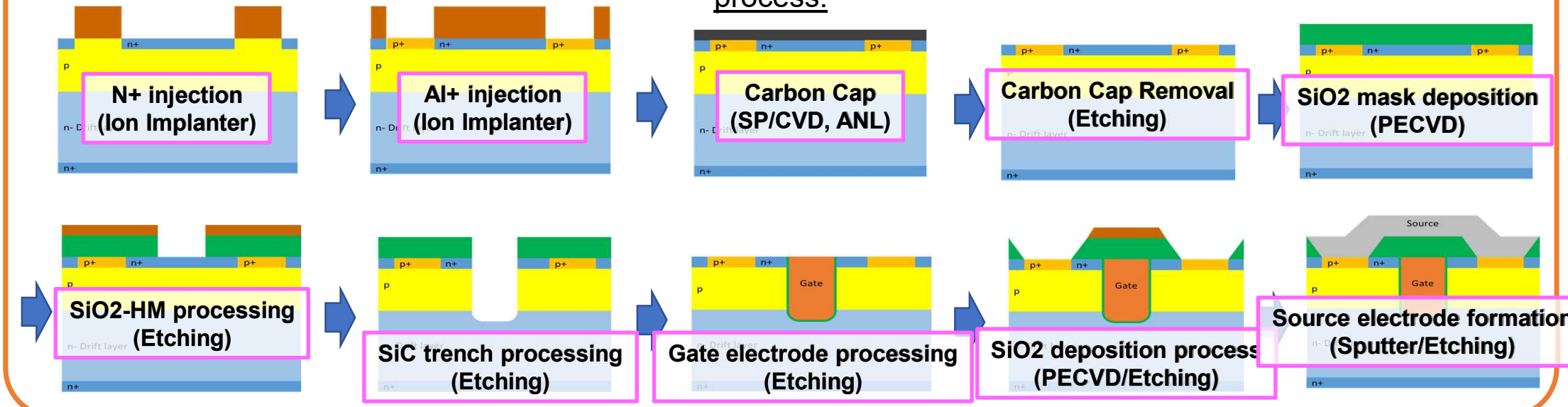
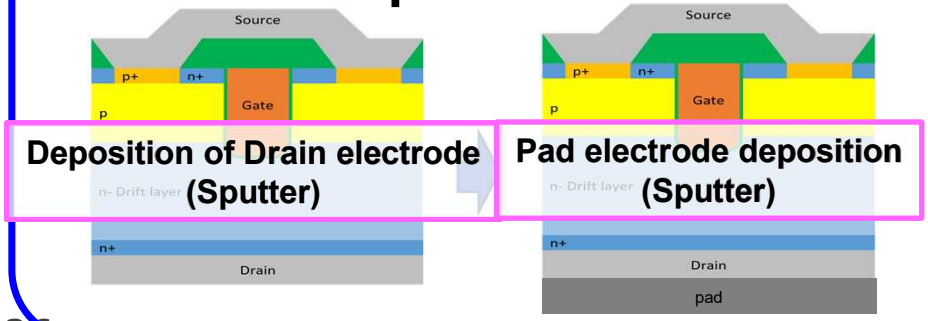
Equipment lineup for each process of SiC power devices

＜Surface process＞

*Equipment available from ULVAC is shown in () in each process.



＜Backside process＞



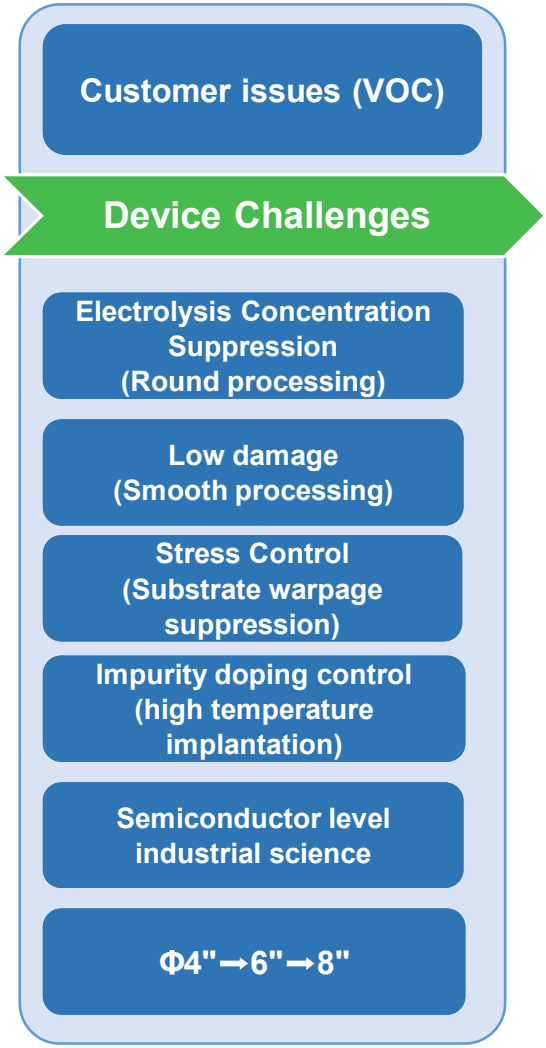
Equipment lineup of competitors

	ULVAC	A	B	C
Ion Implanter	○	○	○	—
Sputtering	○	—	○	—
Etching	○	—	—	○
PECVD	○	—	○	—

Source: Prepared by ULVAC from publicly available information

ULVAC's Vacuum Technology to Solve SiC Power Device Issues

		Si	SiC	issue
1)	Ion Implanter Number of times processed in one process	One time	**Plural times**	• Throughput
2)	Ion Implanter Processing temperature	Normal	**Low/High temperature**	• Ion Implanter Concentration Control • Throughput
3)	Warp of substrate	Small (none)	**Large**	• Substrate warpage suppression • Warped substrate transport
4)	Substrate Price	Low	**High**	Transport reliability
5)	Response to trench structure	Utilizing accomplishment in Si semiconductors	**New development necessary**	Process geometry control



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SiC power devices and ULVAC's contributions

Final product	Existing challenges of the system constraints	Key technologies to solve challenges	Customer issues (VOC)	Technology and products adapted to ULVAC
System	System task	Key technology	Device Challenges	Applicable Technologies and Products
Electric Vehicles	Downsizing	Device Design (Trench structure)	Electrolysis Concentration Suppression (Round processing)	 Ion Implanter
Charging station	High power	Low defect SiC substrate	low damage (Smooth processing)	 Sputtering equipment
solar battery converter	Low loss	Substrate less in thickness	Stress Control (Substrate warpage suppression)	
Railroad vehicles	High temperature operation	High reliability	Impurity doping control (high temperature implantation)	 Etching equipment
	Mass use Low cost	Aperture enlargement	Semiconductor level industrial science	
		Mass production (high throughput)	Φ4"→6"→8"	

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Strengths of Ion Implanter

IH Series

- Dual-stage design enables instantaneous switching between high and low temperatures realizing high productivity.
- A single unit covers multiple processes from high energy to low energy range
- Supporting 6 to 8-inch SiC transportation (warped/thin substrates)
- Equipment height fitting in a normal clean room

High productivity due to high/low temperature dual platen

other companies

Need to change the settings at changeover

⇒ Downtime occurs
Two units are needed to ensure production volume

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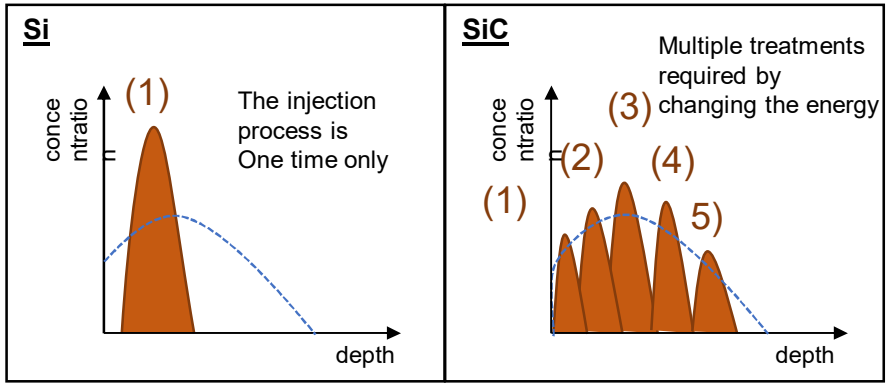
High temperature injection → **Low temperature injection**

Immediate response with recipes switching between high and low temperature

⇒ High productivity with a single unit

Correspond to Wide energy range for complex SiC processes



One unit covers multiple processes due to its ability to handle high to low energy = high productivity

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Strengths of Sputtering Equipment

uGmni-200S

SRH-420

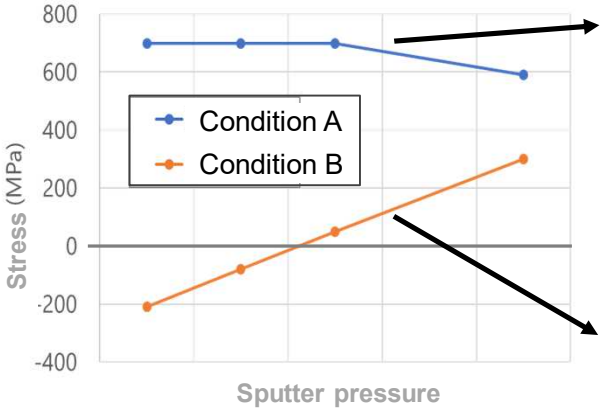
Transport reliability for warped substrates

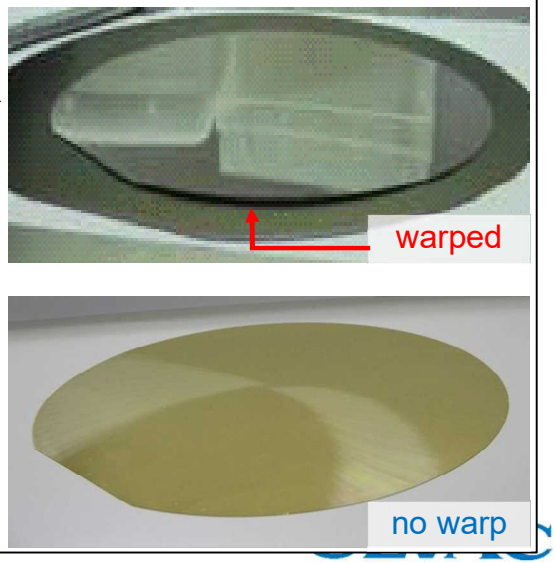
SiC	Si
Warp (~ several hundred um)	Almost flat

ULVAC's technology supports the transport of substrates with large warpage.

⇒**High transfer reliability for expensive SiC substrates**

Controlling board warpage through stress control





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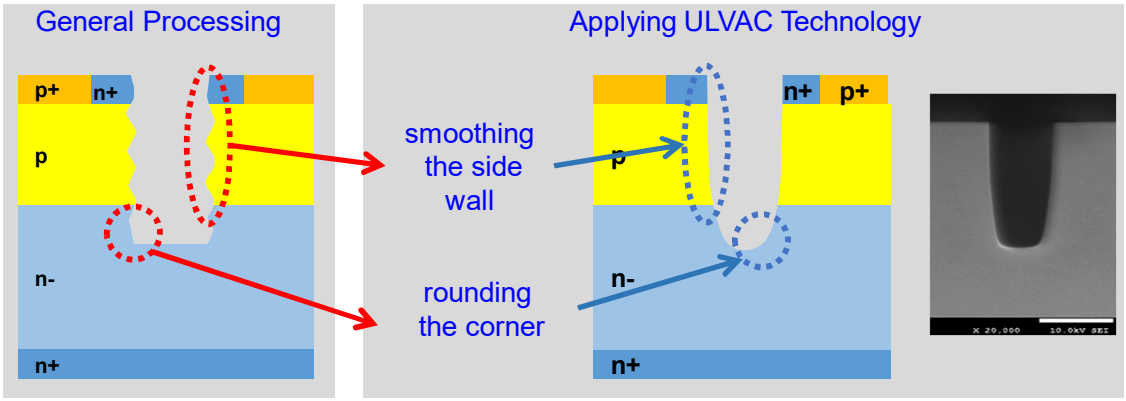
Strengths of Etching Equipment

uGmni-200E

- Improvement of device characteristics by processing geometry control
  (round shape, low damage, sidewall smoothing)
- Supports 6 to 8 inch SiC transport (warped/thin substrates)
- Control of in-plane distribution
- A common plasma source can be used for each process (materials).

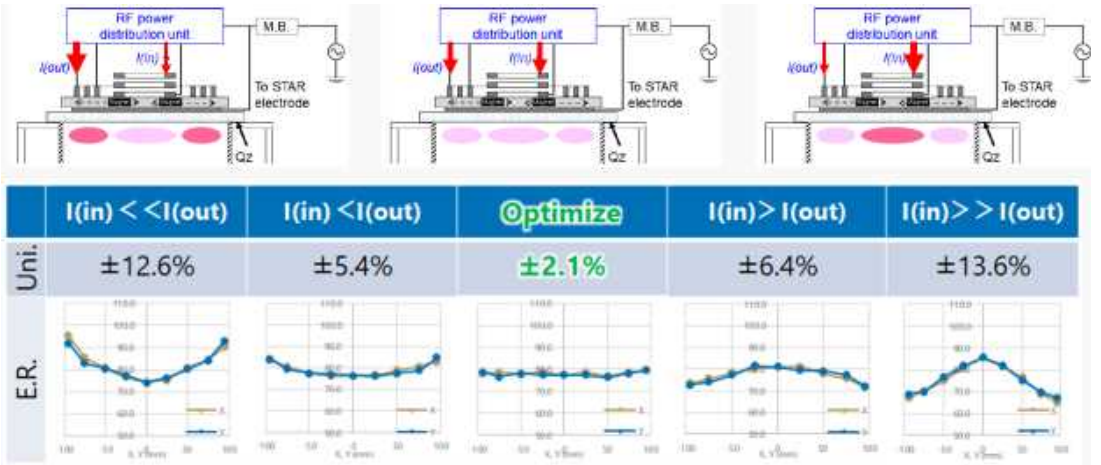
Device performance improvement by processing geometry control



Geometry controlled by ULVAC technology

⇒ **Improved device characteristics**

New Plasma Source: In-plane distribution control by ISM-duo



⇒ **Control of distribution profile to meet customer processes**

Mass Production Equipment Lineup for SiC Power Devices

Ion Implantation

- High/low temperature processes handled by a single unit.
- Wide energy range
- Supporting 8-inch substrates

Ion Plantation System
IH series

Sputtering

- Warped substrate transfer
- Stress control of thin film

Sputtering System
SRH-420
uGmni-200S

Dry Etching

- geometry Control
- Control of In-plane distribution
- Common plasma source

Dry Etching System
uGmni-200E

Evaporation

- Low cost
- Compact

Vacuum Evaporation System
ei-5

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Equipment Lineup for GaN Power Devices

Final product	Existing challenges of the system constraints	Key Technologies to Solve Challenges	Customer issues (VOC) (Equipment manufacturer support)	Technology and products adapted to ULVAC
System	System task	Key technology	Device Challenges	Applicable Technologies and Products
RF Communication	Downsizing	Device Structure	Low-damage processing	 Etching Equipment (uGmni-200E)
Power Device	High power	Low defect substrate	Ultra-thin film processing control (high selection vs. reproducibility)	 Sputtering equipment (SEGul)
LED/Laser	Low loss	Substrate less in thickness	Trench structure (rectangular, smooth)	 Ion Implanter (SOPHI-400)
	High frequency	High reliability	Impurity doping control	
	Mass use Low cost	Aperture enlargement	Same as semiconductor industrial science	
			Φ4"→6"→8"	

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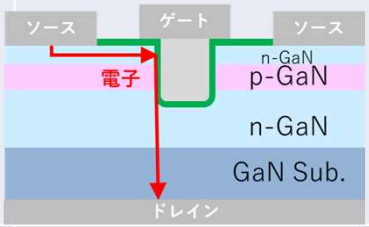
ULVAC's Strengths in Etching Equipment for GaN Power Devices

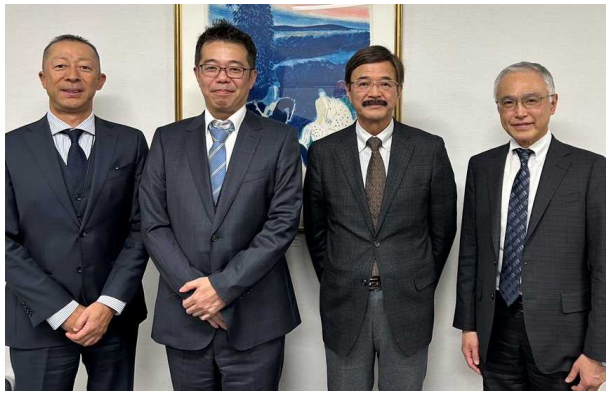
	Horizontal GaN	Vertical GaN
Situation: Equipment Device	Development Completed Mass-production in progress	Development completed Process adjustment in progress
Structure		
Direction of flowing electronics (current)	Horizontality	Vertical
Current output	Small	Large
Process difficulty	Medium	High
Cost (Substrate used)	Low to medium Si, SiC	High GaN

Development of Etching equipment for GaN -Collaboration with Nagoya University

Nagoya University founded in 1871

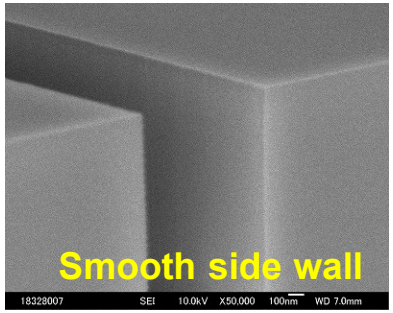
Conference presentation on "GaN Trench Formation

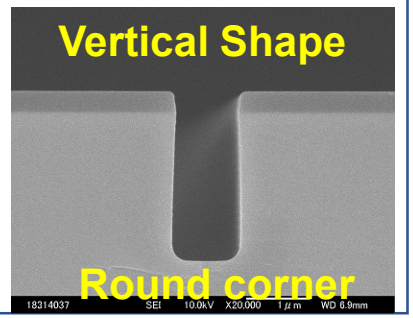
Shinji Yamada et al., Appl. Phys. Lett. 118, 102101 (2021);



2023.11.21 At ULVAC Symposium

From left: Mr. Kiyota, Mr. Iwai, Dr. Kaji of Nagoya University, Mr. Umeda





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			Φ4"→6"→8"	

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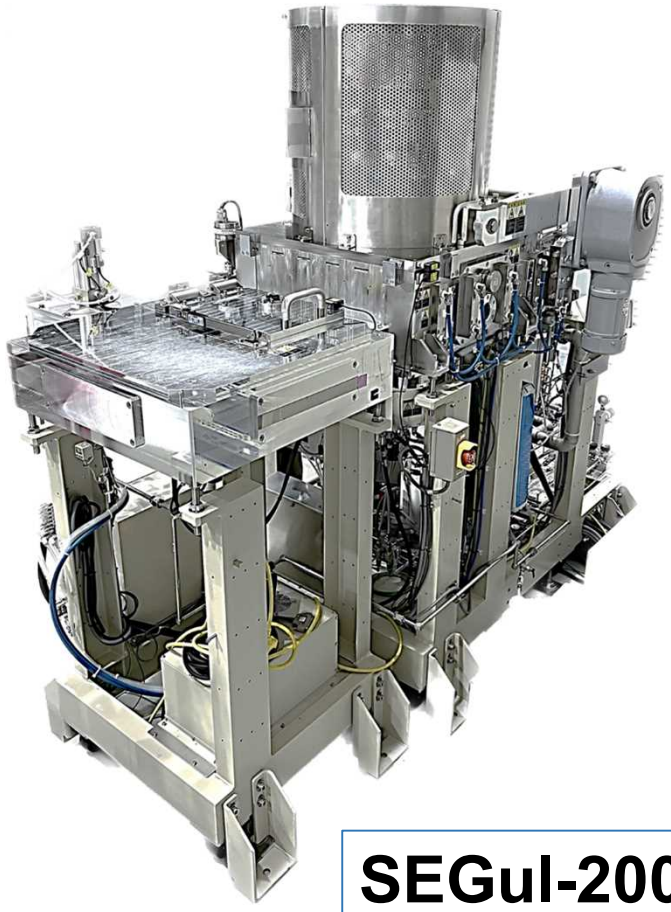
Strengths of Sputtering Equipment for GaN Power Devices

- ■Only Ga, N_2 , Ar and Si or Ge are used as deposition materials.
- ■Low temperature growth at <700°C
- ■High carrier density n-GaN [1.0E^{20} (/cm^3)]
- ■8-inch substrate in-plane uniformity [＜±10]

	MOCVD	GaN Sputtering
Deposition temperature	Over 1000°C	Less than 700°C
Detoxification facility Gas detoxification facilities, etc.	Necessary x	Unnecessary ○
Manufacturing cost	High ×	Low ○
Crystalline	Best ◎	Good ○
Carrier concentration	10^{19} (/cm)^3 ○	10^{20} (/cm^3) ◎



SEGul-200

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Vacuum technology

for manufacturing

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