Tech Briefing 2025

December 2025

Disclaimer:

Statements in this presentation with respect to DISCO's current plans, forecasts, strategies, and other statements that are not historical facts are forward-looking statements about DISCO’s future performance. These statements are based on management’s assumptions and beliefs in light of information currently available. Therefore undue reliance should not be placed on these statements. DISCO cautions that a number of important factors could cause actual results to differ materially from those discussed in the forward-looking statements. Such factors include, but are not limited to, economic trends worldwide and domestically within Japan, drastic fluctuations in exchange rates, war/terrorism, disaster, and/or spread of infectious disease.

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We cannot answer questions regarding specific customers.

Please note that we cannot answer questions that may lead to the prediction of a specific customer’s manufacturing process, production capacity, inquiry and investment trends, confidential production information, etc.

Each semiconductor manufacturer may have different technologies and manufacturing processes, which constitute confidential production information of each company.
In principle, we do not provide answers regarding specific customers’ orders, equipment specifications, throughput, etc.

The Basics of Kezuru and Migaku

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Contents

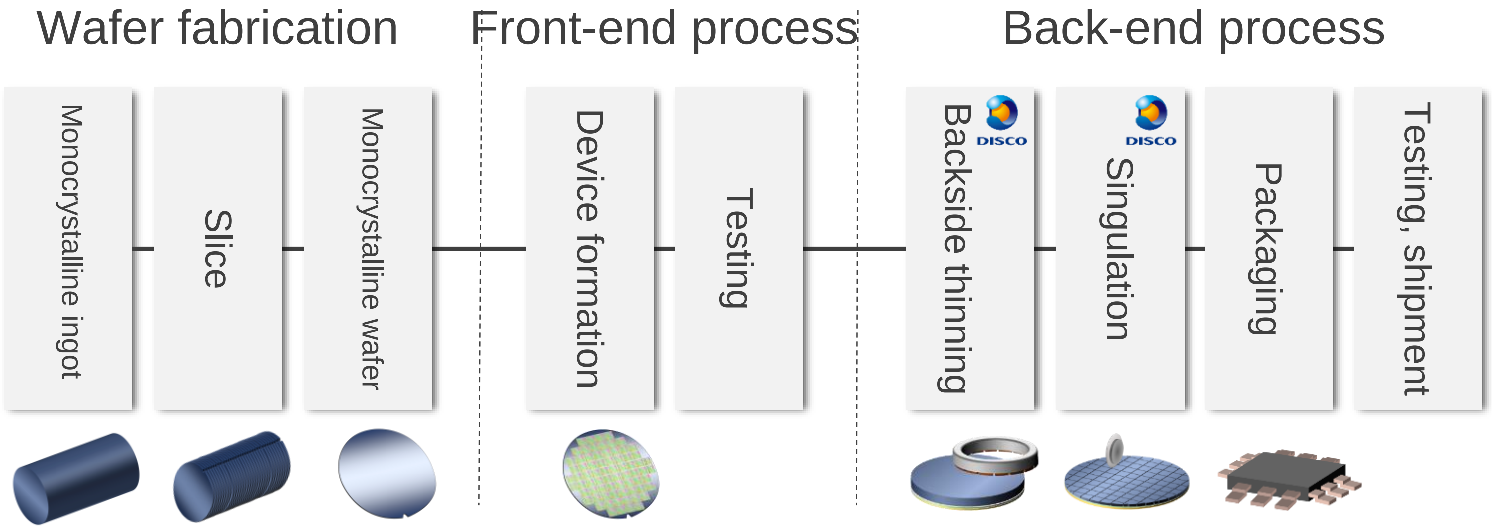
Grinding in the Semiconductor Process

- Conventional semiconductor manufacturing process
  - Wafer fabrication: Create an Si wafer (1)
  - Front-end process: Form transistors on the front side of the Si wafer
  - Back-end process: Thin the Si wafer (grinding), singulate, then packaging

(2) (3)

Grinding makes an appearance in a maximum of 3 areas

The higher the value of the product, the more frequently the grinding process is used, and the more important it becomes



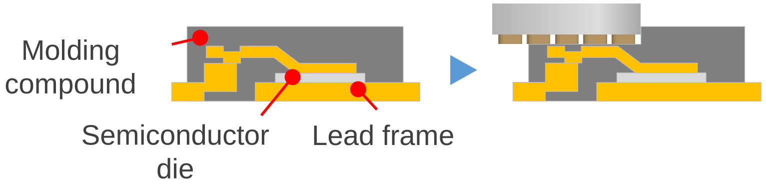
Examples of Applications

Flat surface grinding during wafer fabrication

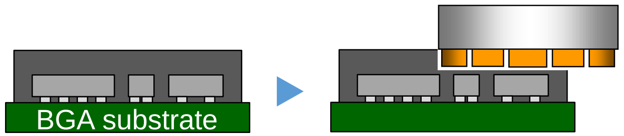
Thinning of device wafers (BG)

Semiconductor package grinding

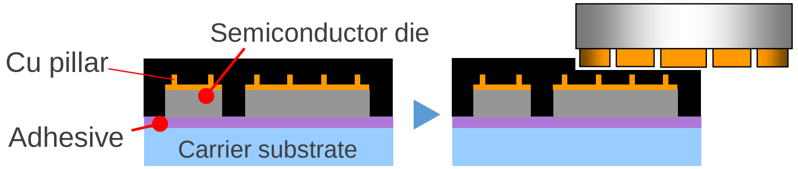
E.g. 1)



E.g. 2)



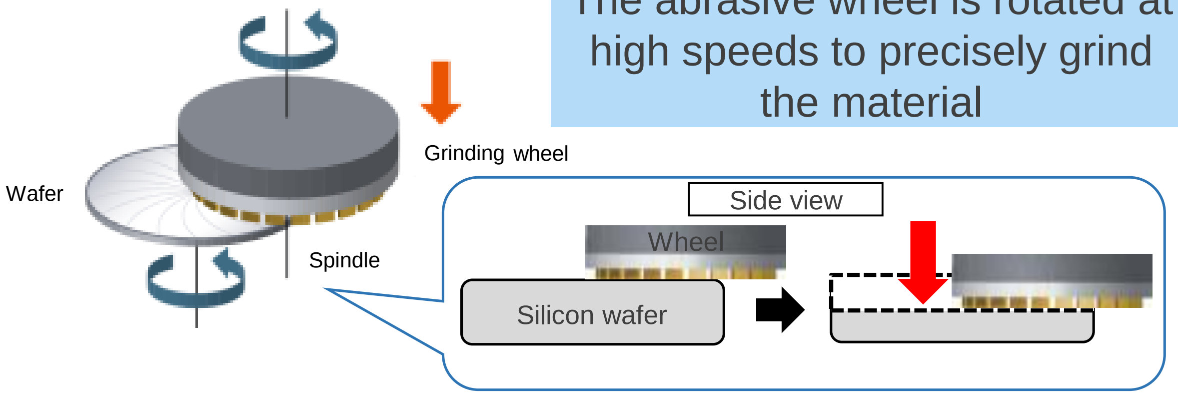
E.g. 3)



Kezuru and Migaku

Kezuru (grinding): volume removal

The abrasive wheel is rotated at high speeds to precisely grind the material

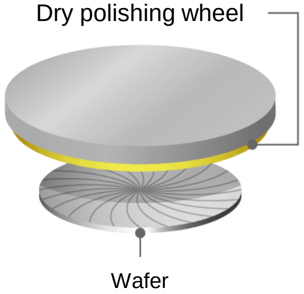


Becomes thinner after being ground by the wheel

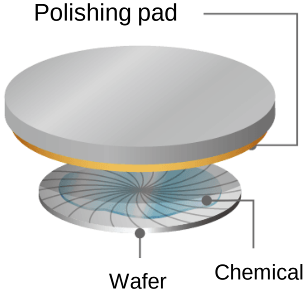
Migaku (polishing): improving the surface condition after grinding (surface roughness, grinding damage, etc.)

If the surface after grinding is adequate, polishing may not be needed

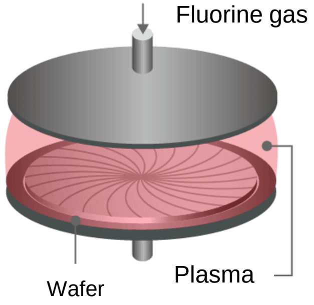
Dry Polishing



Wet Polishing (CMP)

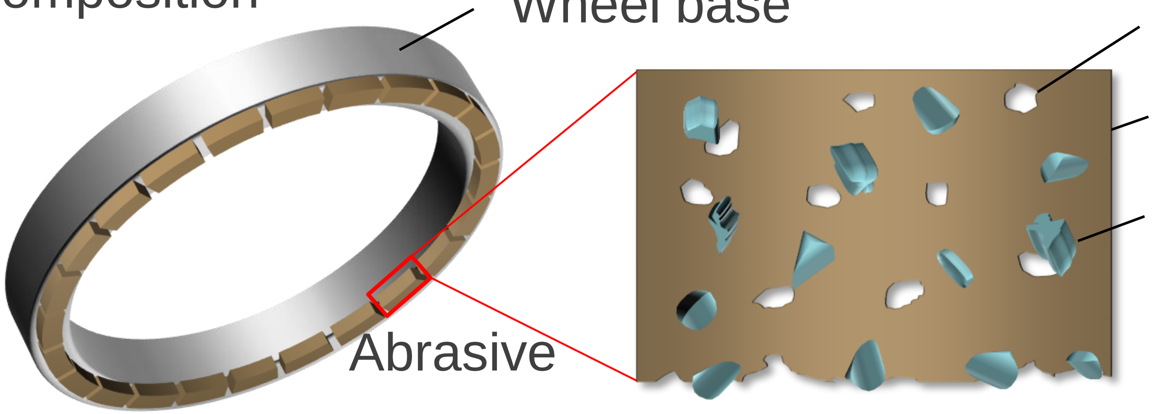


Dry Etching



The optimal polishing method is selected based on the required cleanliness and die strength

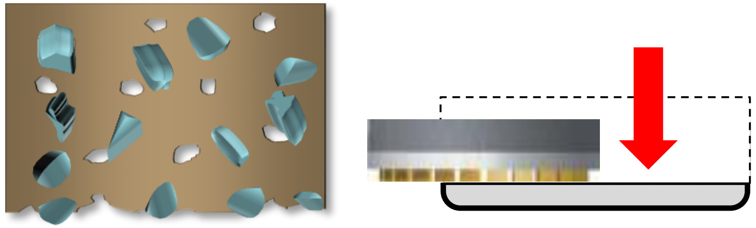
Wheel composition



Self-sharpening
As the abrasives get worn out, new abrasives from the inside of the segment are exposed, maintaining the processing performance and quality

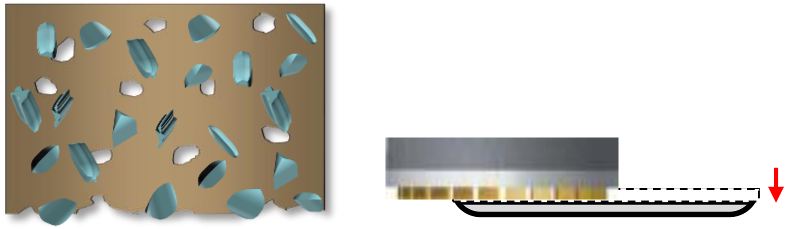
Rough grinding/fine grinding

Conventionally, two types of wheels are used to perform grinding in two steps, rough grinding and fine grinding



Abrasive diameter: large

Grinding power: high
Wear: small
Damage: large



Abrasive diameter: small

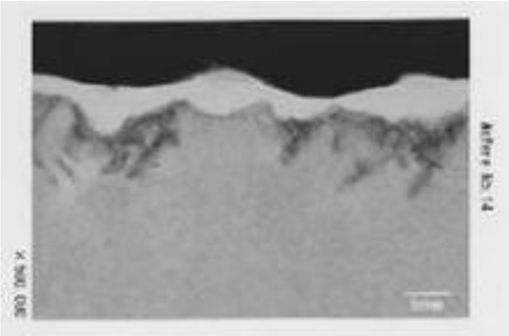
Grinding power: low
Wear: large
Damage: small

The number of grinding axes differs depending on the removal amount (1 to 4 axes)

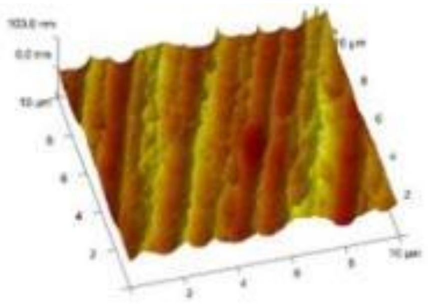
Migaku

- By performing polishing after grinding, the grinding damage is removed and the surface roughness is improved

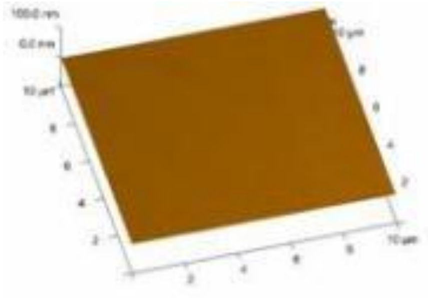
Damage from grinding



Roughness after grinding



Surface condition after polishing
(Dry Polishing)



- DISCO provides various polishing methods as well
  - DISCO’s original dry polishing method that has been widely adopted (DP)
  - Wet polishing for a high level of cleanliness (CMP)
  - Dry etching (plasma) for a higher die strength

Purpose of front-end CMP: planarization
-Planarization to increase the accuracy of lithography
-Planarization of each BEOL wiring layer
etc.
This is different from the purpose of the CMP process that is provided by DISCO

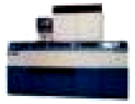
History of the Grinder

DISCO

Grinder

1980

DFG-83H/6
1980-1994
World's first creep-feed grinder
4-6 inches
3 spindles



DFG-82IF/8
1988-1995
DISCO's first in-feed grinder
4-8 inches
2 spindles

1990

DFG840/841
1994-2004
Small footprint, high throughput
4-8 inches
2 spindles, 2 chuck tables

DFG850/860
1998-2006
Turntable mechanism
4-8 / 8-12 inches
2 spindles, 3 chuck tables

DFG841HS/830
1994-2007
4-8 inches
2 spindles, 2 chuck tables

DFG870/871
1996-2005
Motor-driven fine adjustment
8-12 inches
1 spindle, 2 chuck tables

2000

DFG8540/8560
2000-
Stable thinning
4-8 / 8-12 inches
2 spindles, 3 chuck tables

DGP8760
2004-2011
Grinder/Polisher
8-12 inches
3 spindles, 4 chuck tables

DAG810
2002-
Manual grinder
4-8 inches
1 spindle, 1 chuck table

DGP8761
2008-
High throughput
8-12 inches
3 spindles, 4 chuck tables

DFP8140/8160
2001-
Dry Polisher
4-8 / 8-12 inches
1 spindle, 1 chuck table

DTG8440
2008-
TAIKO® process

DFG8360
2004-
8-12 inches
1 spindle, 2 chuck tables

1980s
Development of the first-generation grinders

1990s
Support for 300 mm

2000s
Development of Grinder/Polishers

2010s
Support for difficult-to-process materials, package substrates

2020s
High-precision grinders

Grinder

2010

DFG8830
2012-
Hard and brittle materials, high throughput
4-6 inches
4 spindles, 5 chuck tables

DAG8010
2016-
Large package substrate grinding
Max. 600 x 600 mm
2 spindles, 1 chuck table

DFG8640
2018-
High-precision grinding
8 inches
2 spindles, 3 chuck tables

DTG8460
2013-
TAIKO® process

DFP8141
2017-
CMP for difficult-to-process materials
4-8 inches
1 spindle, 2 chuck tables

DFG8340
2010-
High accuracy, small volume grinding
4-8 inches
1 spindle, 2 chuck tables

2020

MUSUBI
DM8762
2019-
High precision, high throughput
8-12 inches
3 spindles, 4 chuck tables

DFG8541
2022-
Reduces risk of breakage during thinning
4-8 inches
2 spindles, 3 chuck tables

DFG8011
2024-
Large package substrate grinding
Max. 700 x 700 mm
2 spindles, 2 chuck tables

DFG8561
2025-
Reduces risk of breakage during grinding
4-8 inches
2 spindles, 3 chuck tables

DAG811
2023-
Manual grinder
4-8 inches
1 spindle, 1 chuck table

DFG8020
2020-
Panel Level Packages
Max. 390×390 mm
2 spindles, 2 chuck tables

DFG8660
2023-
High-precision grinding
12 inches
2 spindles, 3 chuck tables

DFG8030
2020-
Strip grinding (thin, rectangular substrates)
2 spindles, 2 chuck tables

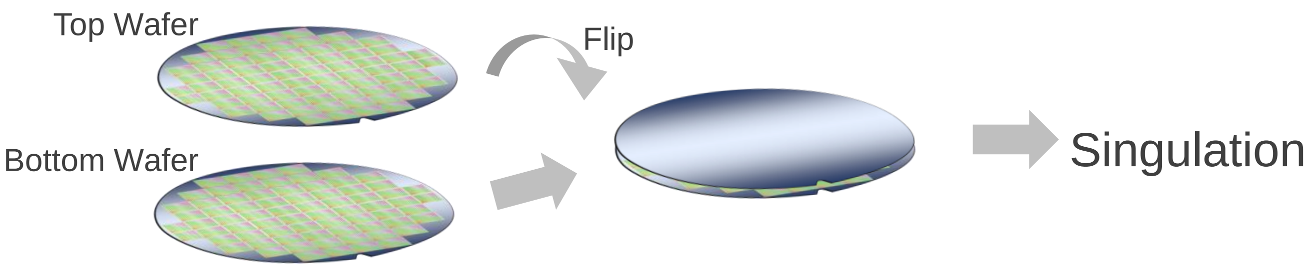
Equipment Lineup

DISCO

Workpiece size	DAG (Manual grinder)	DFG (Fully automatic grinder)			DGP (Grinder/Polisher)	DFP (Fully automatic polisher)
		1 Spindle	2 Spindles	4 Spindles	3 Spindles	1 Spindle
φ12 inches or larger			● **DFG8011** Max. 700 mm x 700 mm ● **DFG8020** Max. 390 mm x 390 mm			
φ12 inches	● **DAG810/811** φ300 mm support is a user-specified specification	● **DFG8360** 1 spindle, fully automatic	● **DFG8560** 2 spindles, fully automatic ● **DFG8561** Improved quality, usability ● **DFG8660** High-precision grinding		● **DGP8761** 2-spindle grinding + 1-spindle polishing ● **DMG8762** Successor equipment to DGP8761 Compatible with MUSUBI®	● **DFP8160** Dry Polishing
φ8 inches	● **DAG810** 1 spindle, manual ● **DAG811** Improved processing stability and operability	● **DFG8340** 1 spindle, fully automatic	● **DFG8540** 2 spindles, fully automatic ● **DFG8541** Improved quality and usability ● **DFG8640** High-precision grinding	● **DFG8830** φ8-inch support is a user-specified specification		● **DFP8140** Dry Polishing ● **DFP8141** Wet polishing (CMP)
φ6 inches				● **DFG8830** High productivity using 4 spindles		

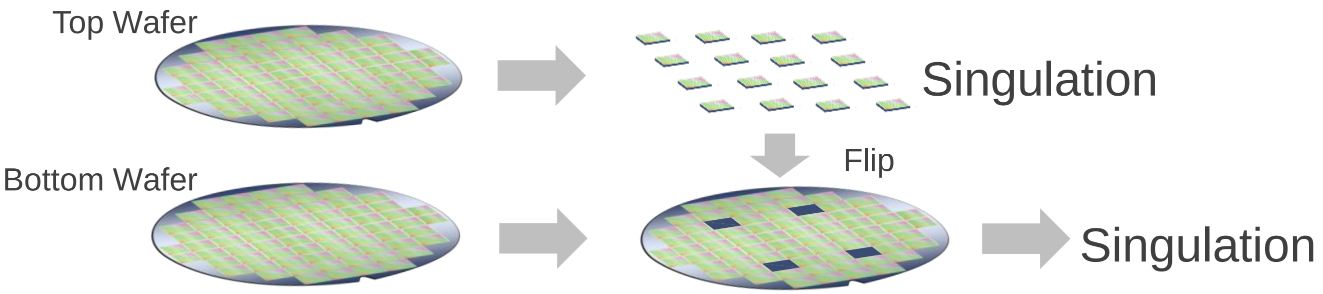
Spread of Hybrid Bonding

- Wafer to Wafer (W2W): Wafer-level direct bonding
  - Features: High productivity through lamination in one step
    Risk of lower yield (defective die also get bonded, and defects occur during wafer-level processing)



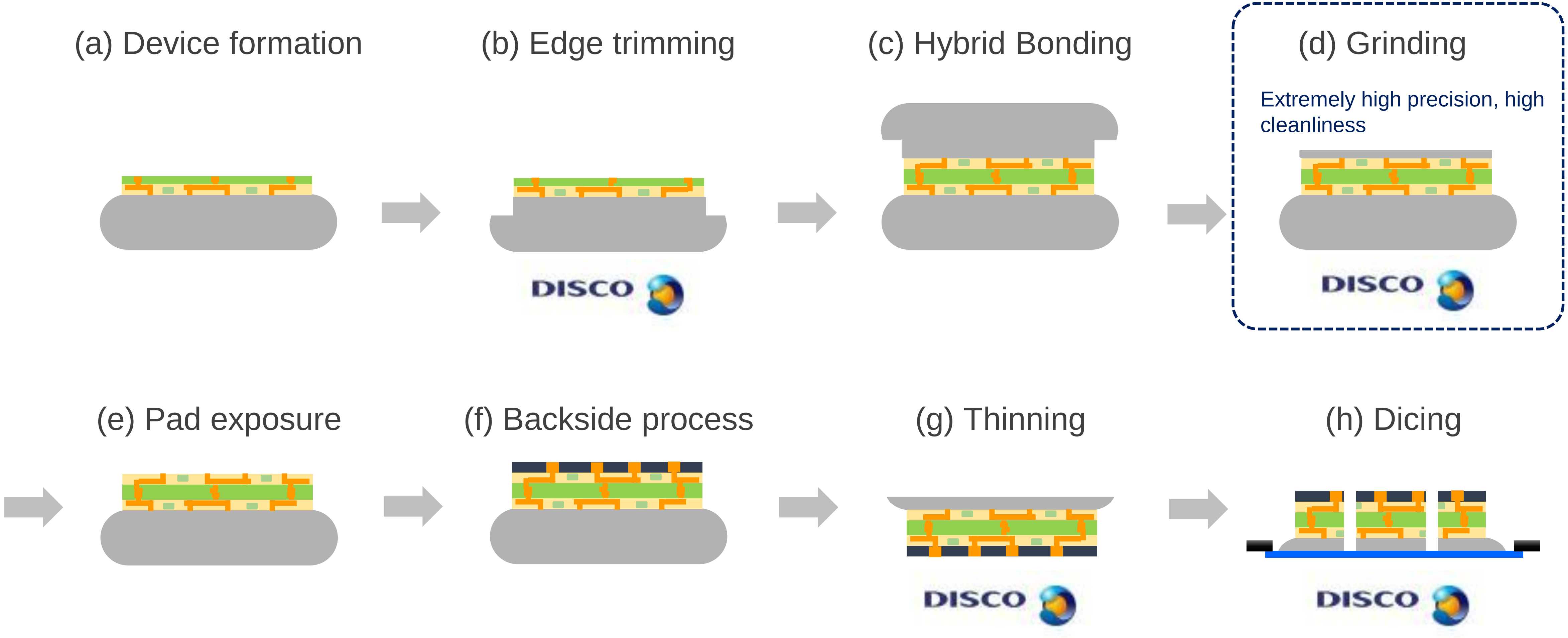
Examples of applications
including those under development
・Bonded memory
・BS-PDN

- Die to Wafer (D2W): After dicing, die are directly bonded to wafers
  - Features: Increased yield as only good quality die are bonded
    Decreased productivity as each die must be bonded individually

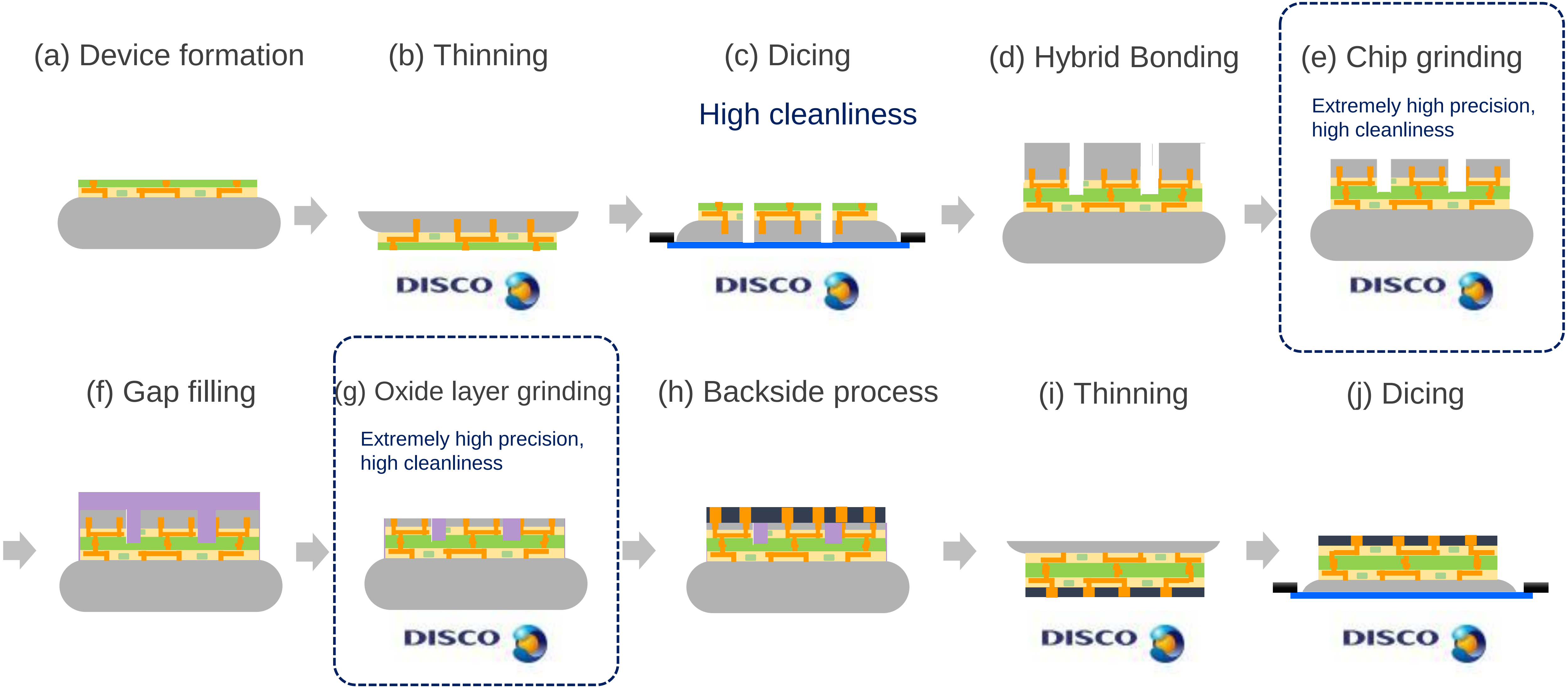


Examples of applications
including those under development
・Chiplet
・HBM

Example of W2W Process



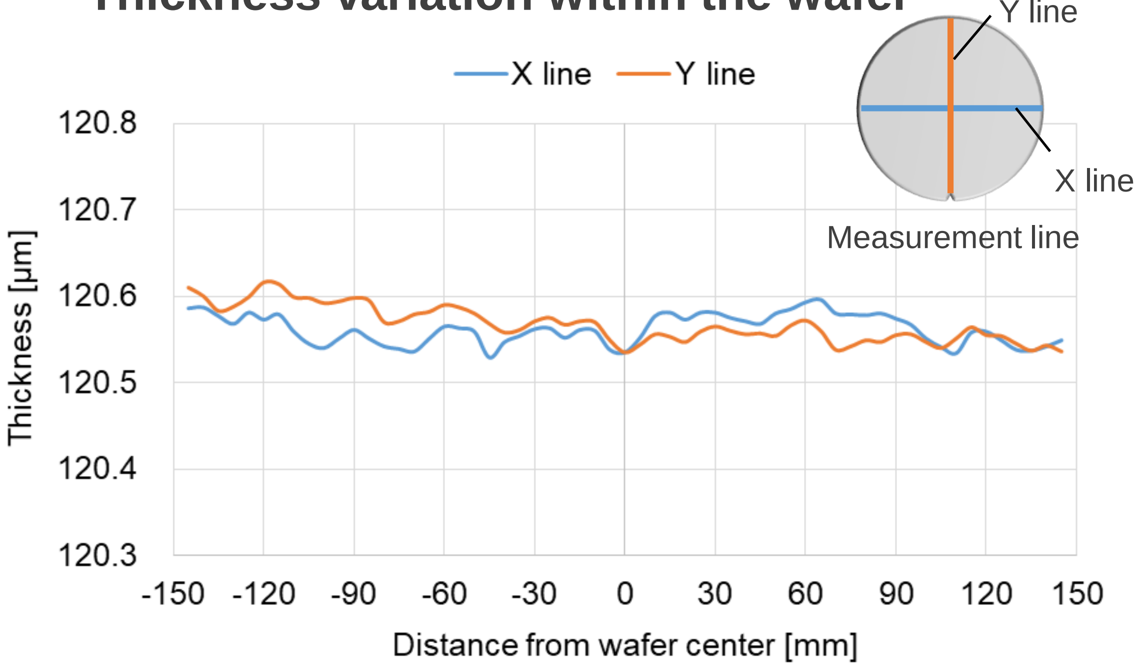
Example of D2W Process



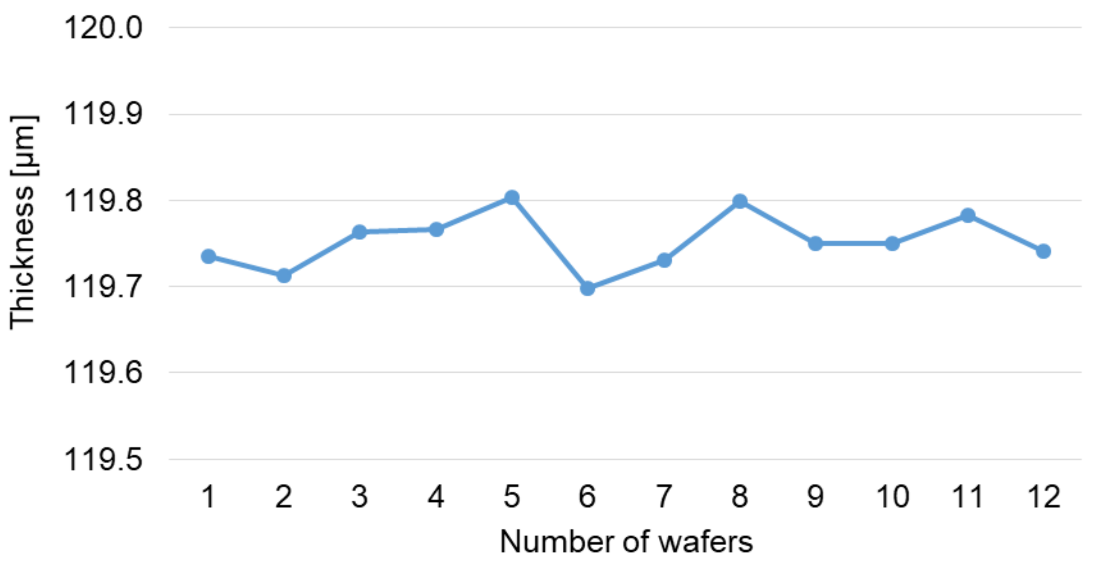
Grinding for Hybrid Bonding

- A grinder that can achieve extremely high-precision grinding and high cleanliness has been developed by DISCO
  - Optimized processing points, wafer shape correction function
  - Chemical cleaning within the grinder

Thickness variation within the wafer



Thickness variation between wafers



DISCO possesses the R&D ability to be able to quickly respond to changing market needs that accompany device evolution

*These are reference values using bare silicon wafers

Summary

- **Grinding is widely used in the semiconductor manufacturing process**
  - Wafer fabrication - Device wafer thinning - Package processing etc.
- **Involves two processes: grinding (Kezuru) and polishing (Migaku)**
  - Grinding: volume removal - Polishing: improving the surface condition after grinding
- **DISCO has prepared an equipment lineup that includes equipment with the specifications required for the needs of each market**
  - Markets: logic, memory, power devices, etc.
  - Grinders with 1 to 4 spindles
  - Polishing using processes such as Dry Polishing, wet polishing (CMP), and dry etching
- **DISCO responds quickly to new market needs as well**
  - Developed a high-precision, high-cleanliness grinder for hybrid bonding

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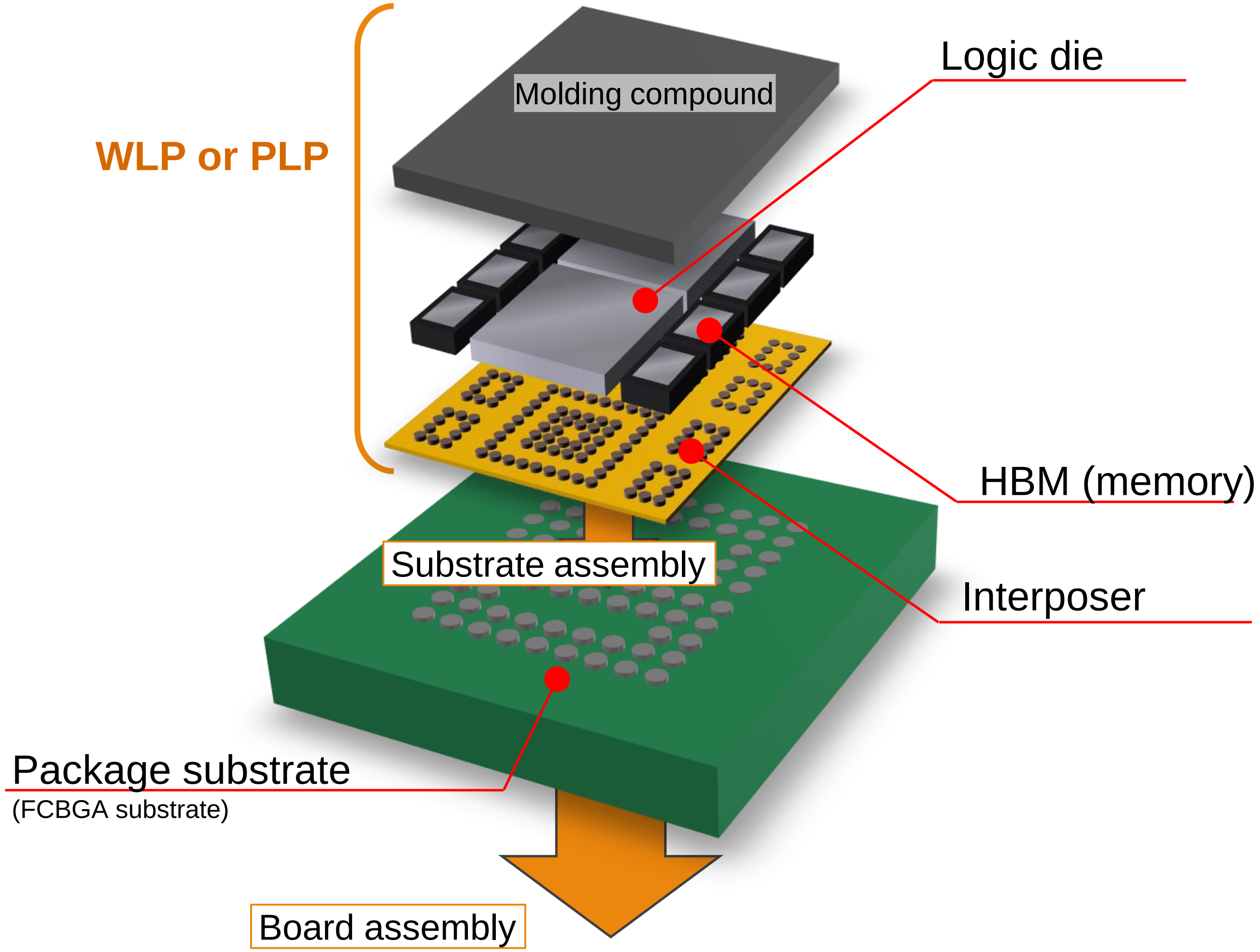
Advanced Packaging and KKM

Contents

- Understanding the basics of advanced packaging
- Semiconductor packages and KKM
  - FCBGA, FOWLP (revisiting the past)
  - 2.5D package (review)
  - RDL interposer
  - PLP
    - Challenges solved by PLP
    - PLP and KKM
    - Current situation of PLP
  - FCBGA substrate R&D trend

- Breaking down an AI semiconductor

Components other than logic and memory such as other die and passive components have been omitted for simplicity



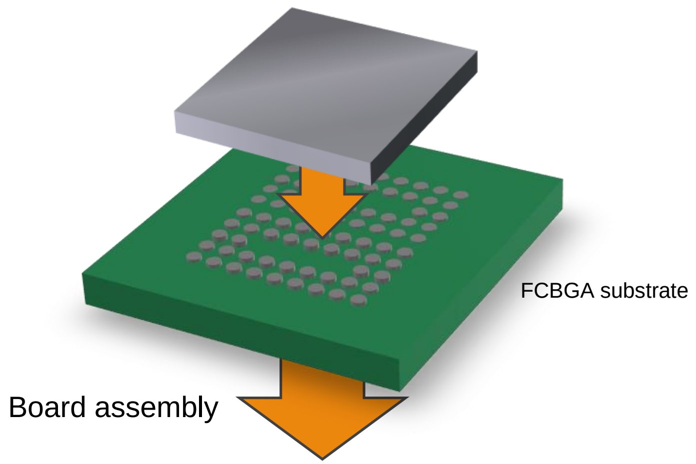
– Multiple logic and memory die are packaged
  ➡ Package becomes larger

  - To enable high-speed communication between the logic and memory, they are mounted via an interposer
    ➡ **Interposer becomes larger**

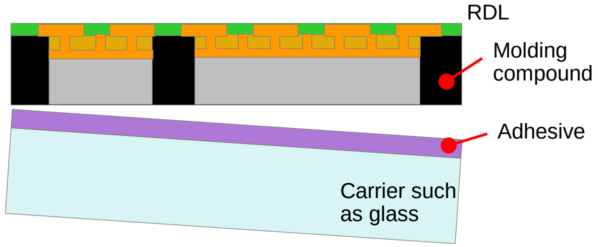
  - After molding multiple die on the interposer, it is assembled on a package substrate
    ➡ **Package substrate also becomes larger**

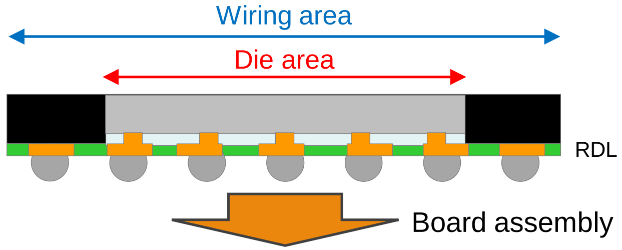
Semiconductor Packages and KKM

- **FCBGA (<u>F</u>lip <u>C</u>hip <u>B</u>all <u>G</u>rid <u>A</u>rray)**
  - Applications: all-purpose CPU, GPU
  - Si die that have been thinned and singulated are assembled on an FCBGA substrate
  - KKM opportunities
    - Si die: grinding → laser/blade dicing
    - FCBGA substrate: blade dicing



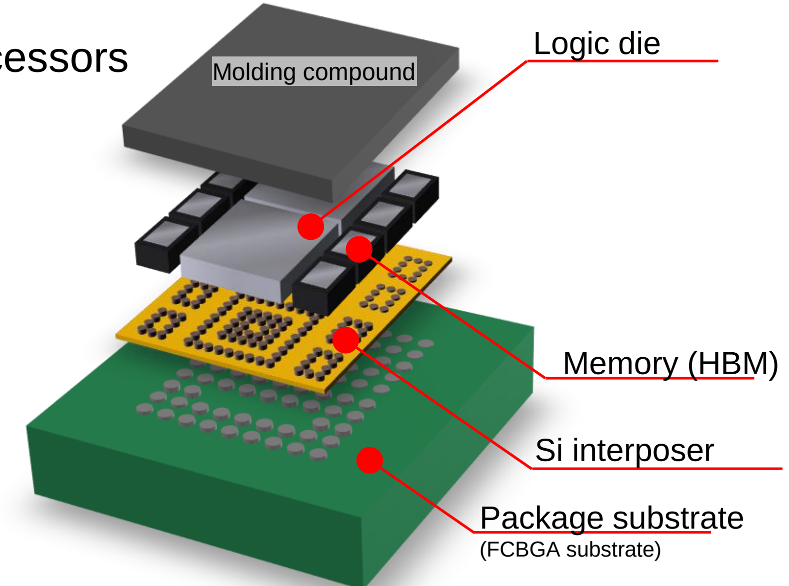
- **FOWLP (<u>F</u>an <u>O</u>ut <u>W</u>afer <u>L</u>evel <u>P</u>ackage)**
  - Applications: smartphone apps, PMICs for mobile devices, etc.
  - Si die that have been thinned and singulated are packaged using the Fan Out process
    - Re-wired on the carrier
    - **After molding, the Si die are exposed using grinding**
    - The package is singulated after RDL formation, carrier separation, and ball attachment
      - Composition without an FCBGA substrate
  - KKM opportunities
    - Si die: grinding → laser/blade dicing
    - Package: **mold grinding** → … → blade dicing

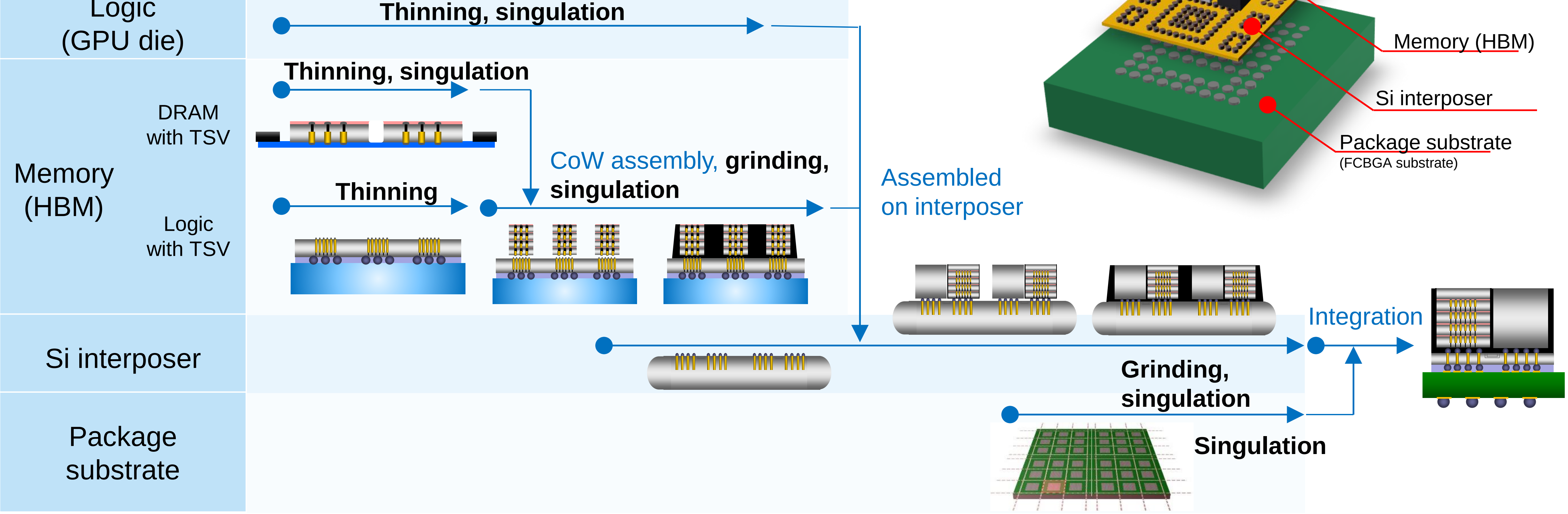




Semiconductor Packages and KKM

- **2.5D package**
  - Applications: AI accelerators, HPC (High-Performance Computing) processors
  - Multiple die are assembled on a φ300 mm Si interposer
  - Multiple KKM opportunities





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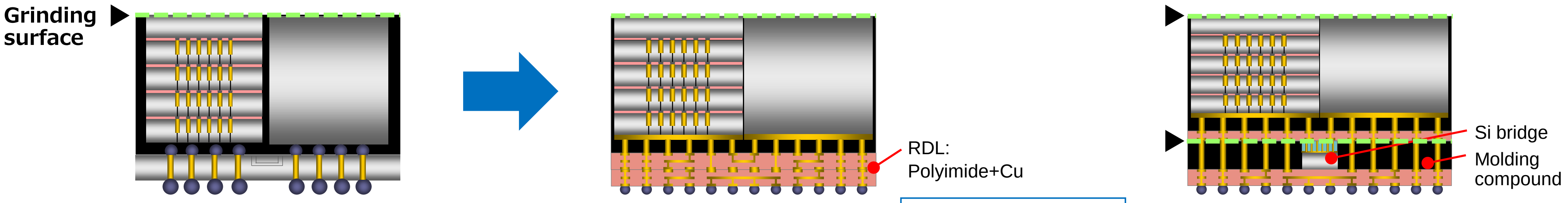
- **RDL interposer (Re-Distribution Layer)**
  - Changing the interposer material from Si to resin
    - Used in FOWLP technology
    - Reduces costs for the Si interposer wafers and the process
    - Improved electrical properties (depends on how freely material properties and wiring design can be selected)



Si interposer | RDL interposer | RDL interposer+**Si bridge**

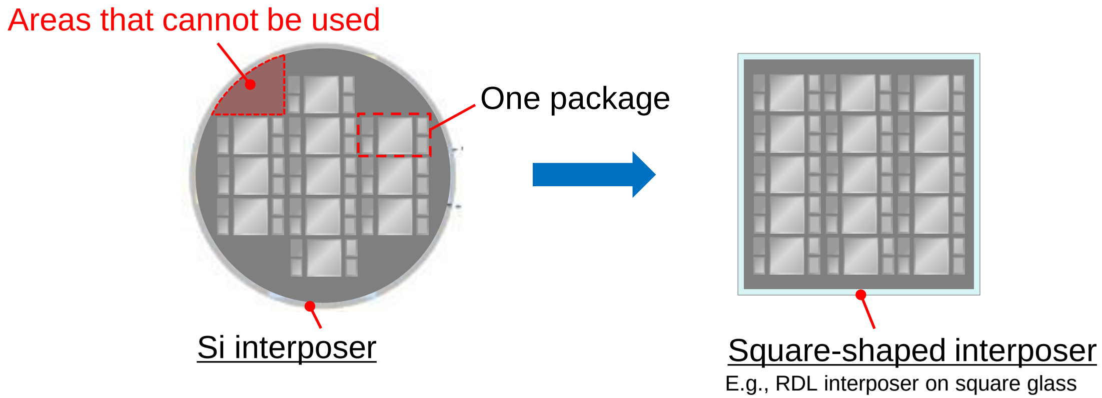
Formed on the carrier (such as glass)

Only the fine interconnects between the logic and memory are supplemented locally with a small Si die

  - KKM opportunities

Interposer \ KKM process	Si thinning	Si singulation	Mold grinding	Singulation
Si	✓		✓	✓
RDL			✓	✓
RDL+Si bridge	✓	✓	✓✓	✓

- **PLP (<u>P</u>anel <u>L</u>evel <u>P</u>ackage)**
  - Package assembled on a square-shaped substrate
    - 300 x 300 mm, 510 x 515 mm, 600 x 600 mm, etc.
    - **Improves the fabrication efficiency of 2.5D packages, which are becoming larger**



	□300 mm	510x515 mm, □600 mm
Dicer	 DFD6370	 DFD6310
Grinder	 DFG8020	 DFG8011

  - KKM for PLP
    - During the 2010s, a PLP-dedicated grinder was developed, and demo evaluations continue
    - Both dicers and grinders have been delivered to customers
    - During the 2020s, demo evaluations increased due to an increase in PLP process users

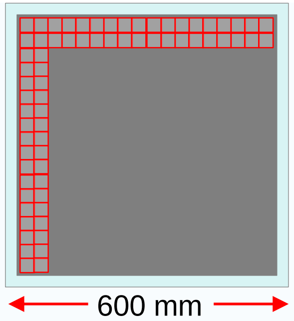
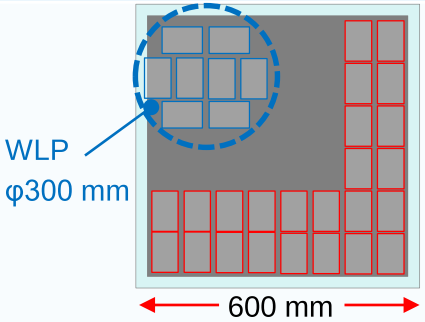
- Challenges of PLP
  - It is difficult to achieve the same process quality as WLP
    - Difference between round and square workpieces
    - Warpage

Need to develop new equipment and materials
→ Higher cost

- History of PLP
  - During the 2010s, FOWLP and 2.5D package first made an appearance
    - Most customers preferred WLP to PLP
      ➡ PLP supply chain remained immature
  - During the 2020s, 2.5D package using WLP reached its limits
    - Most customers started PLP development
      ➡ Full-scale start of establishing high quality for the PLP process

Recognized as having value exceeding simply the cost aspect for high value-added devices

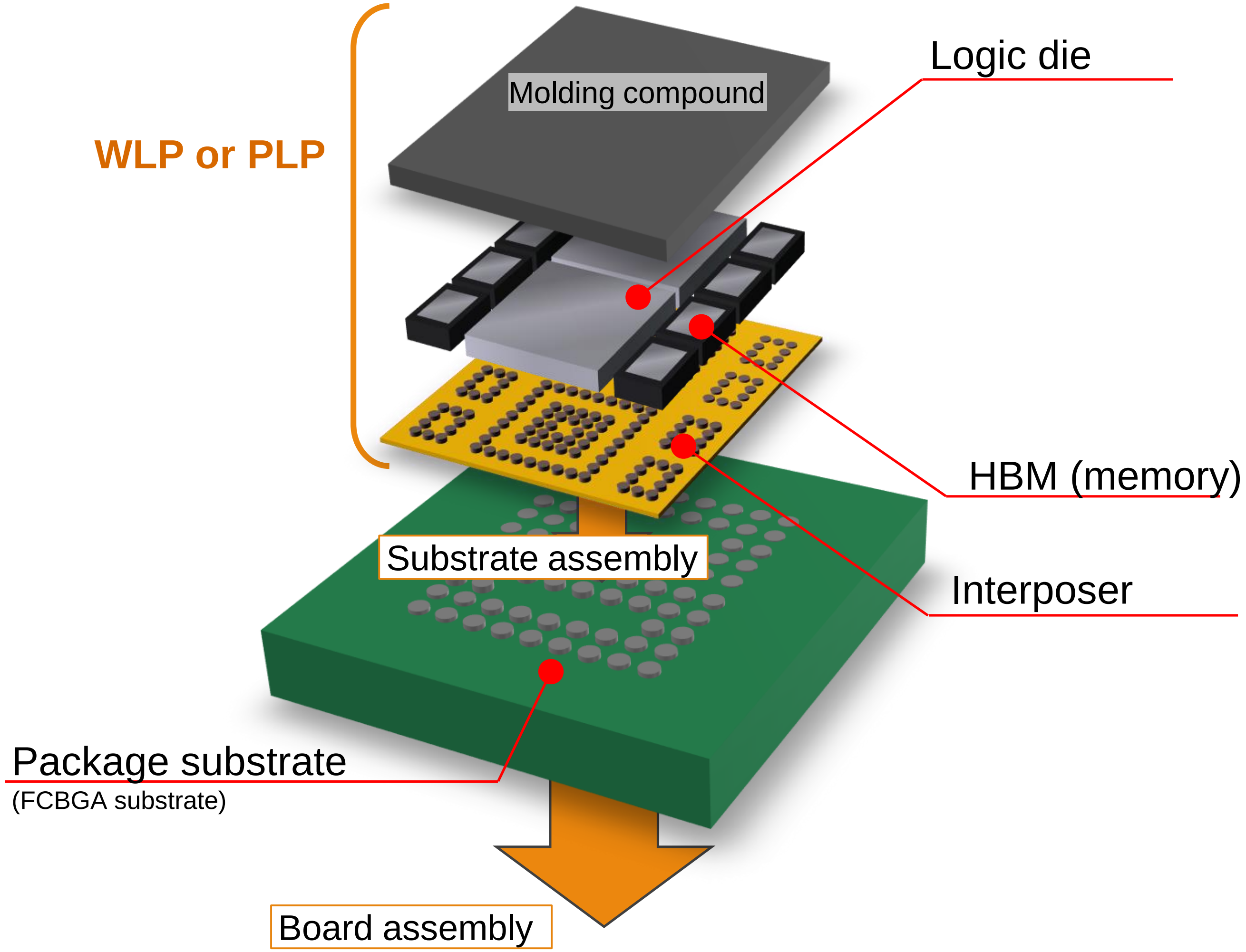
PLP trend comparison

	2010s	2020s
Concept	More die acquired per workpiece→Lower costs	
	High-volume production of small packages	Large interposer
Image		
Target products	Low end	High end
User	OSAT	IDM, foundry
Supply chain	Immature Market preferred WLP	Full-scale start

Semiconductor Packages and KKM

- Breaking down an AI semiconductor

Components other than logic and memory such as other die and passive components have been omitted for simplicity



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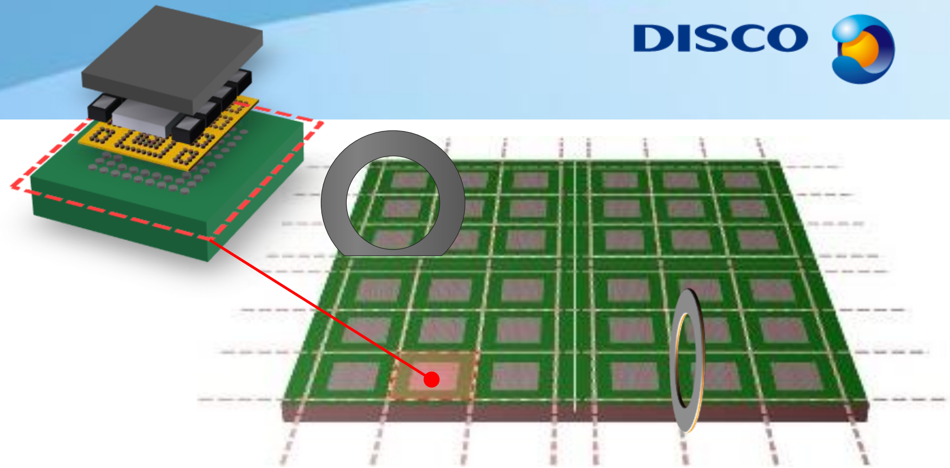
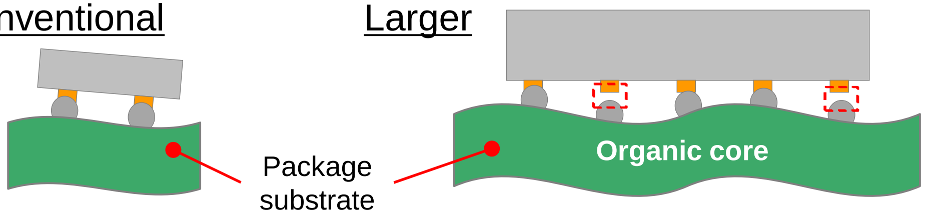


510 mm x 515 mm, etc.
Singulated using blade dicing

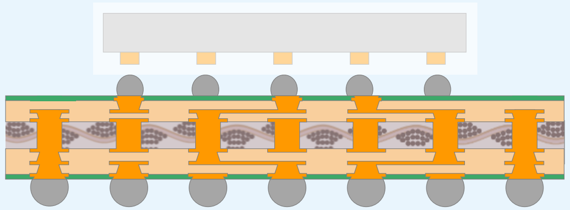
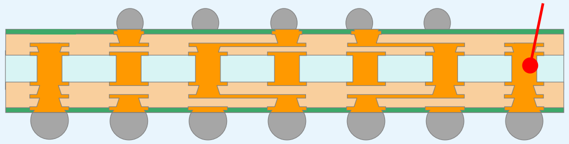
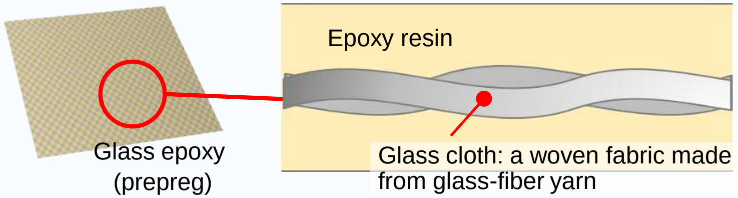
- FCBGA substrate R&D trend
  - Package substrates have also become larger to accommodate large 2.5D packages

Conventional — Larger

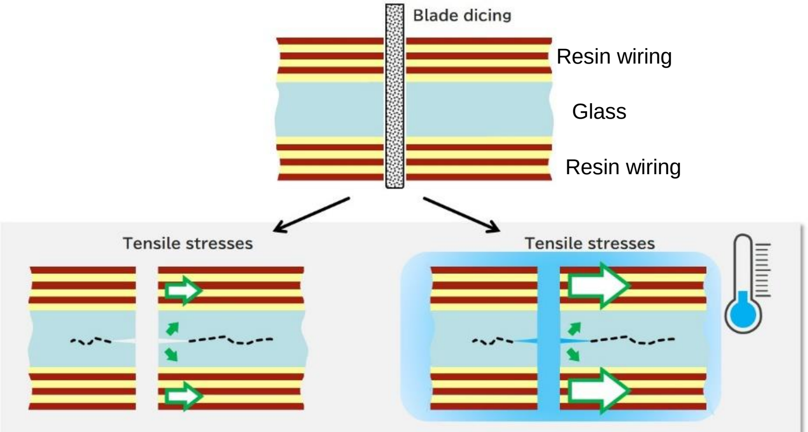


Challenges

- ✓ Thickness variation → Bonding defects
- ✓ Thermal expansion mismatch → Reduced reliability

	Organic core	Glass core
Image		
Core material		 One sheet of glass
Challenges	Dimensional accuracy Mismatched thermal expansion coefficient with Si	Processing performance (TGV processing, **singulation**) → Via breakage → **Resin-induced glass breakage**

Resin-induced glass breakage



Resin-induced glass breakage (SeWaRe)

Time elapsed at room temp.

Increase in stress due to change in environment temperature

New process under development

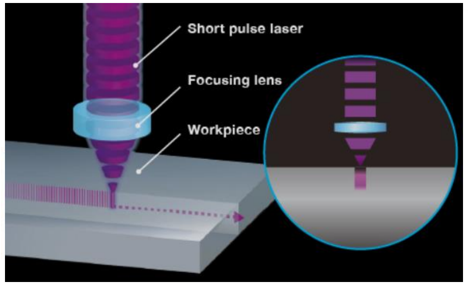
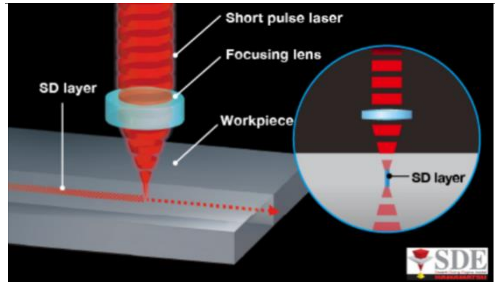
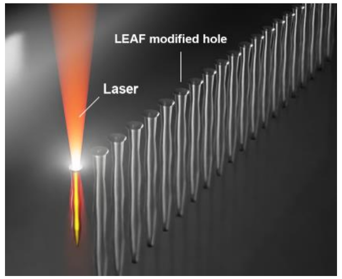
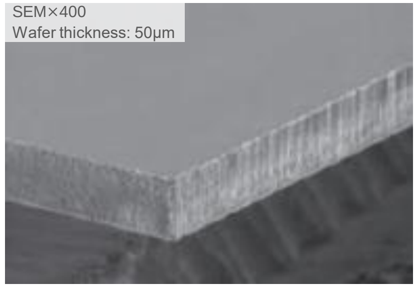
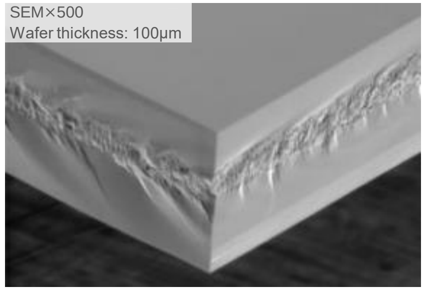
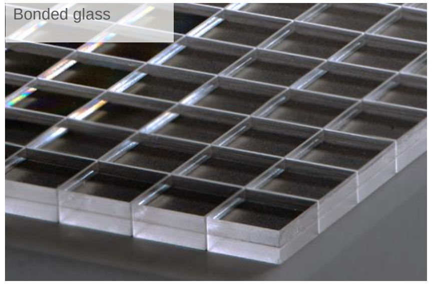
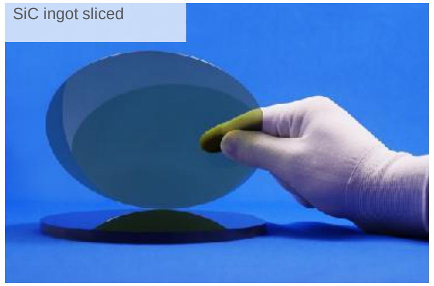
R&D improvements are being made for both glass core and organic core substrates

Influence of Pulse Width During Laser Processing

Contents

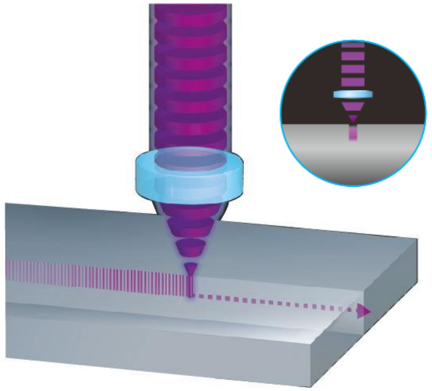
- Laser processing methods provided by DISCO
- Ablation processing
- Basic parameters of a laser head
- Comparison of the influence of pulse width
- DISCO’s laser development

Laser Processing Methods Provided by DISCO

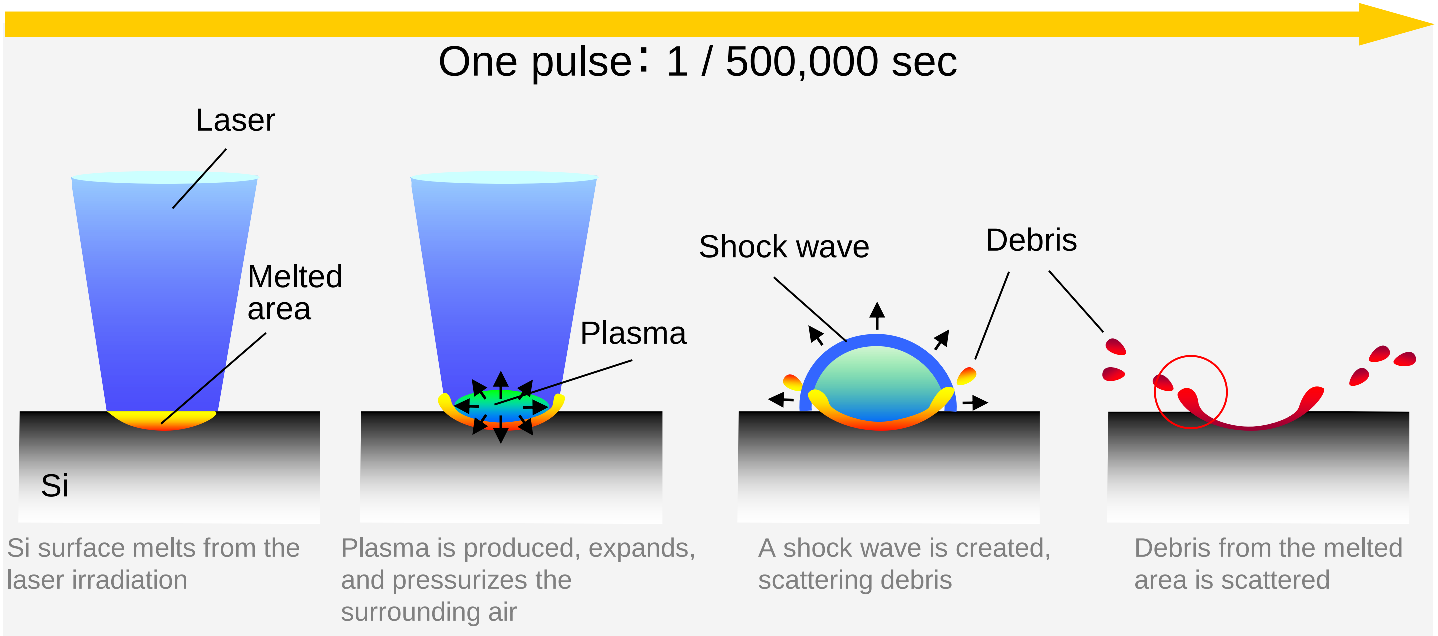
	Ablation	Stealth Dicing	LEAF	KABRA
Illustration				KABRA Kiru·Kezuru·Migaku Technologies
Processing mechanism	A processing method that locally focuses laser energy to sublimate and evaporate the solid	A method where a modified layer is formed by focusing a laser inside the workpiece, after which die are separated using external force	A separation method that applies the ablation technology	A method where a KABRA layer is formed inside an ingot and used as a starting point to split and create wafers
Sidewall				
Features	・Non-contact processing, mechanical load is low ・Can process hard materials that are difficult to process using blade dicing	・Less processing particles as it is an internal process ・Dry processing without the use of water is possible	Possible to process thick wafers with a narrow kerf and high aspect ratio	Simultaneously achieves high-speed ingot slicing and an increased number of wafers per ingot

Principle of Ablation Processing

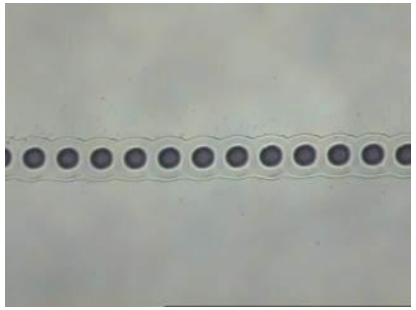
- A method where the workpiece surface is irradiated with a laser, vaporizing the material
- A laser with a high absorption for the specific material is required



Processing phenomenon image



Example: Si processing with non-overlapping pulses



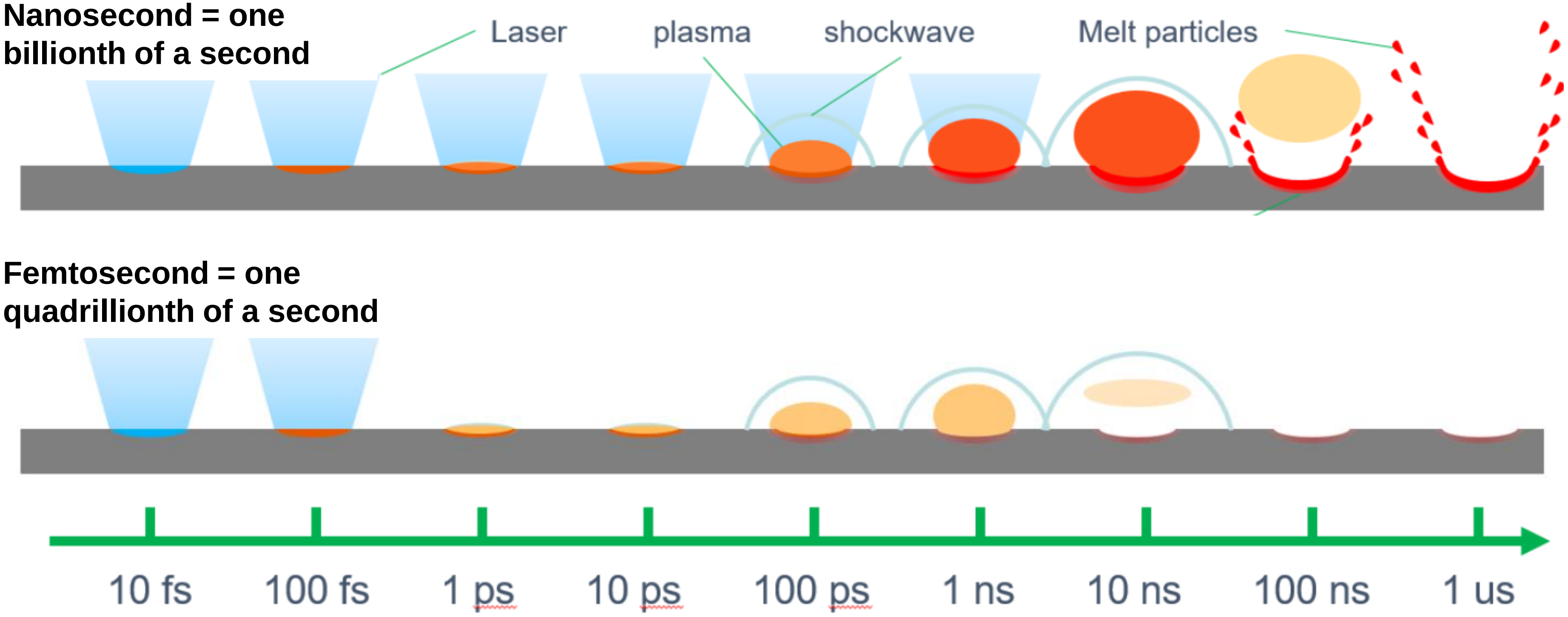
Energy is focused on the surface→Various materials can be processed

Basic Parameters of a Laser Head

- Main parameters
  - Wavelength / Pulse width / Average output / Repetition frequency / Stability etc.
- Influence of pulse width
  - Pulse width = irradiation time of one pulse

Nanosecond = one billionth of a second

Femtosecond = one quadrillionth of a second



Energy is continuously received while the material is in a heated state

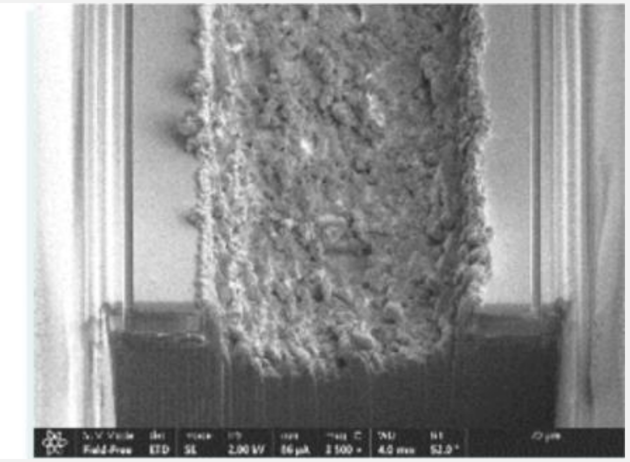
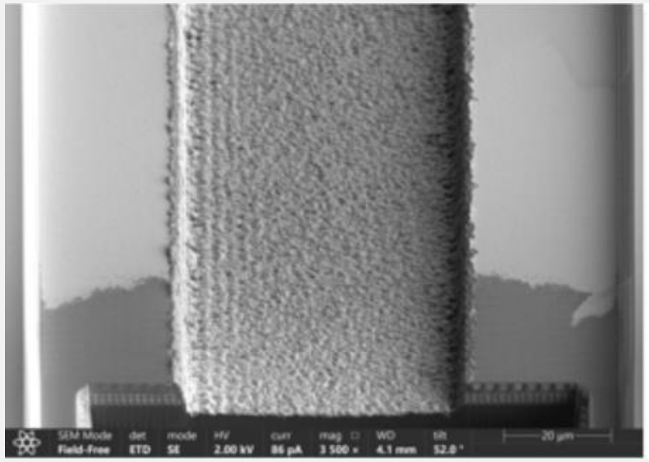
Advantage	Processing depth is deeper due to heat propagation
Disadvantage	Thermal damage

Material heats up after all irradiation is completed

Advantage	No thermal damage
Disadvantage	Localized heat propagation →Processing depth is shallow

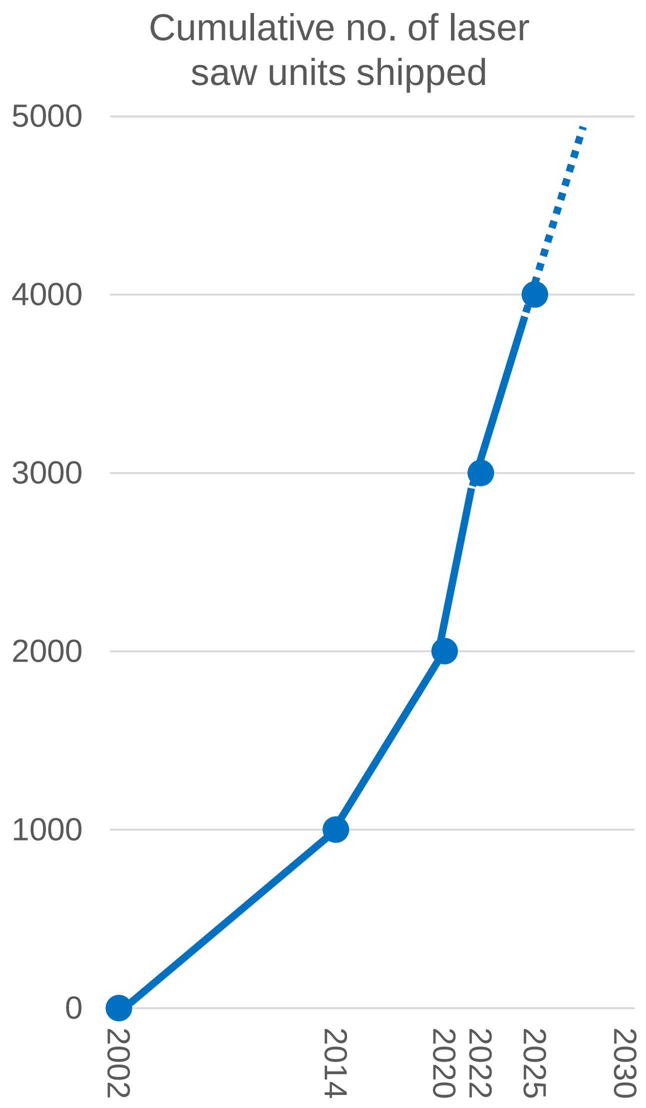
Comparison of the Influence of Pulse Width

- It is necessary to select the optimal laser head based on processing requirements

Pulse width	Nanosecond ⟷ Femtosecond	
Example of processing results		
Processing depth of one pulse	Deep	Shallow
Thermal damage	Large	Small
Laser head price	Reasonable	High
Laser head lifespan	Long	Short

DISCO’s Laser Development

- At DISCO, we conduct extensive validation of laser heads.
  Development of femtosecond lasers began around 2009, with a shipment track record of nearly 100 units.
- Depending on the required quality, nanosecond lasers may be sufficient in some cases, and laser heads are selected with mass-production capability in mind.
- Because femtosecond lasers concentrate energy within an ultrashort time, optical components are more susceptible to damage. Therefore, it is essential to establish an operation and maintenance framework to manage consumables, maintain beam quality, and ensure output stability.
- For singulation using lasers, the process is often combined with a blade dicer or SD, and a comprehensive understanding of the overall process is required.
- For “mass-production equipment,” in addition to the laser head, maintainability and a stable, long-term supply of products are important.
- Through co-development with a wide range of customers, we are advancing differentiation and patenting of our laser technologies.



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Notation
The yearly accounting period from April of the current year to March of the following year is denoted by FY (Fiscal Year), and quarterly accounting periods are denoted by 1Q (April – June), 2Q (July – September), 3Q (October – December), and 4Q (January – March). Depending on the monetary unit, figures lower than the minimum unit may be rounded up or down, as a result of which the total sum may not match.
Percentages are calculated based on the actual figures.

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