Tech Briefing 2023

December 2023

Notes

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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Efforts toward Zero Defect Packaging

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Contents

- What is the Mid-Process Research Center?
- Highly-Reliable Processes
  (Maximized Process Performance)
- No Variation (Automated)
- Summary

DISCO

- Purpose of Establishment
- As the wafers on which circuits are built in the front-end process of semiconductor manufacturing have extremely high added-value, high yield is required in the processes that follow. Among these processes, in the grinding (wafer thinning) and dicing (wafer singulation through cutting) processes handled by DISCO, there is a risk that one processing failure may cause the entire wafer's quality to deteriorate. Therefore, caution and accuracy are required for operations such as processing and transfer in particular. In addition, if a large number of defects occur in the back-end process, most of the time, alternative wafers cannot immediately be supplied from the front-end process. As a result, this may have a significant impact on the entire supply chain and become a large issue in the lean manufacturing of the automotive industry. Recognizing these issues, DISCO has newly positioned these processes that are conventionally in the back-end process of semiconductor manufacturing as part of the "mid-process" and has been proceeding with R&D in this area.
- DISCO has officially established the mid-process research center as a site to conduct R&D for the mid-process and perform demonstrations for customers. This center has permanent installations of the wafer transfer system RoofWay as well as the cluster system MUSUBI, and research is underway to reduce the equipment operator's responsibilities and improve semiconductor wafer processing and transfer quality through automation of the production system.
- As semiconductor use in automotive applications is increasing, stricter quality management is being required for semiconductors as well, as they are responsible for the user's life. Therefore, through this center, DISCO will aim at realizing a production system that eliminates operator intervention as much as possible in order to reduce quality variation that arises from human involvement.

Concept

Automotive Devices
Demand for stricter quality management

Zero Defects
No variation in quality

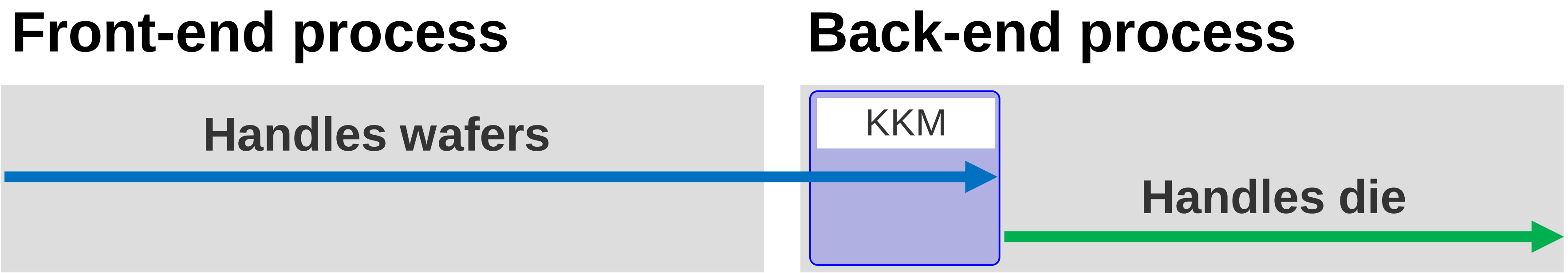
In order to realize this, we need

Maximized process performance **+** **Automation**

Both are required!

What is “Mid-Process”?

KKM is situated within the back-end process but transfers wafers rather than die



Processing failure causes entire wafer quality to deteriorate.

- **Caution and accuracy are required for operations such as processing and transfer in particular.**

Grinding and dicing, conventionally included in the back-end process, are positioned as part of the “mid-process.”

Efforts toward Complete Automation of Clean Room Production

DISCO

Quality-related demands for cutting-edge automotive logic ICs

Zero Defects

Minimization of defect occurrence and outflow risk

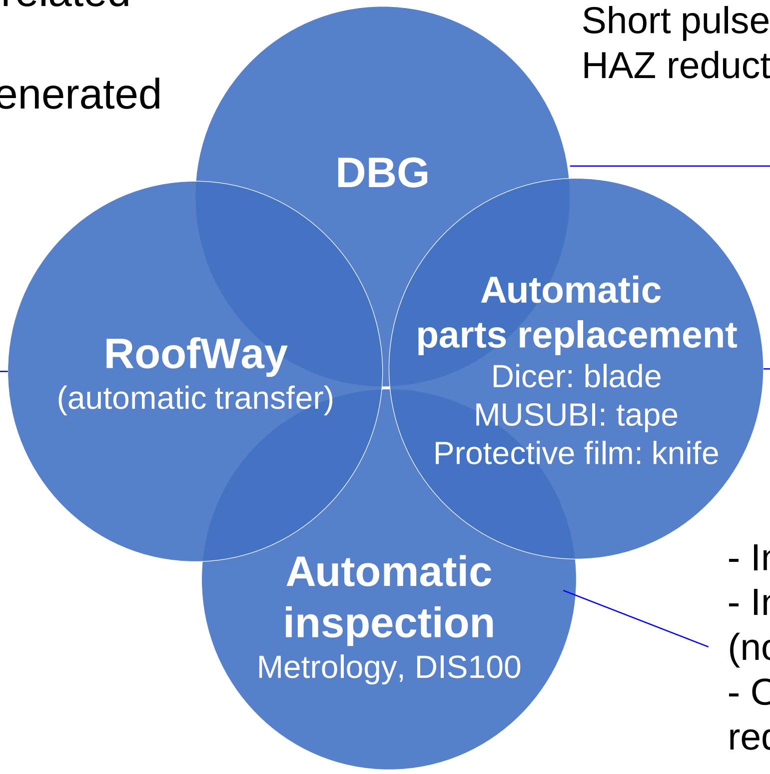
Maximization of process performance and quality stability

Automation of production

Four elements of CR production automation

Reduction of
- Operator-related variation
- Human-generated particles

Edge trimming:
Triangular die flying prevention, backside scratch reduction
Short pulse laser:
HAZ reduction, front-side chipping reduction

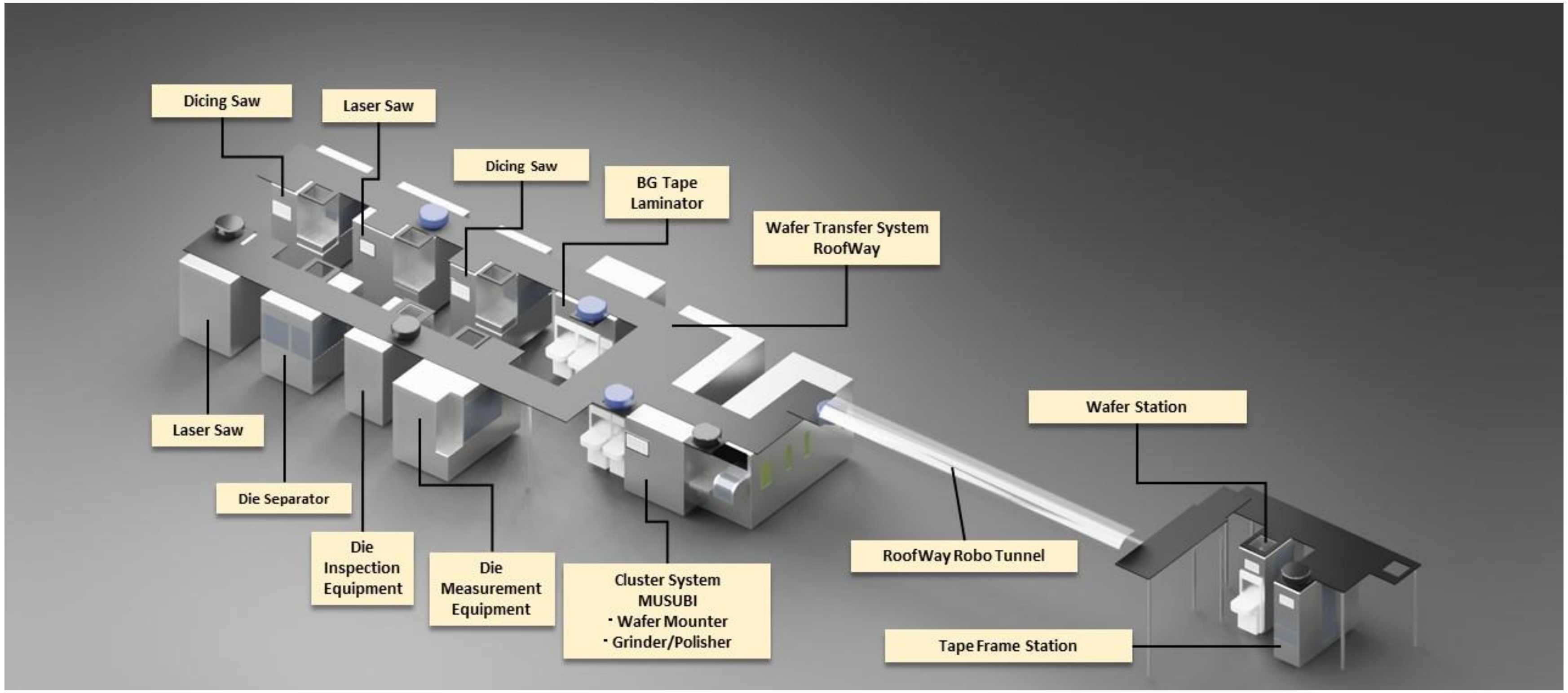


Operator-related variation reduction

- Inspection-less processing
- Inspection of all die (not only sampled die)
- Operator-related variation reduction

With utilization of these 4 elements, drastic reductions to and substitutions for routine operator work in clean rooms can be expected.

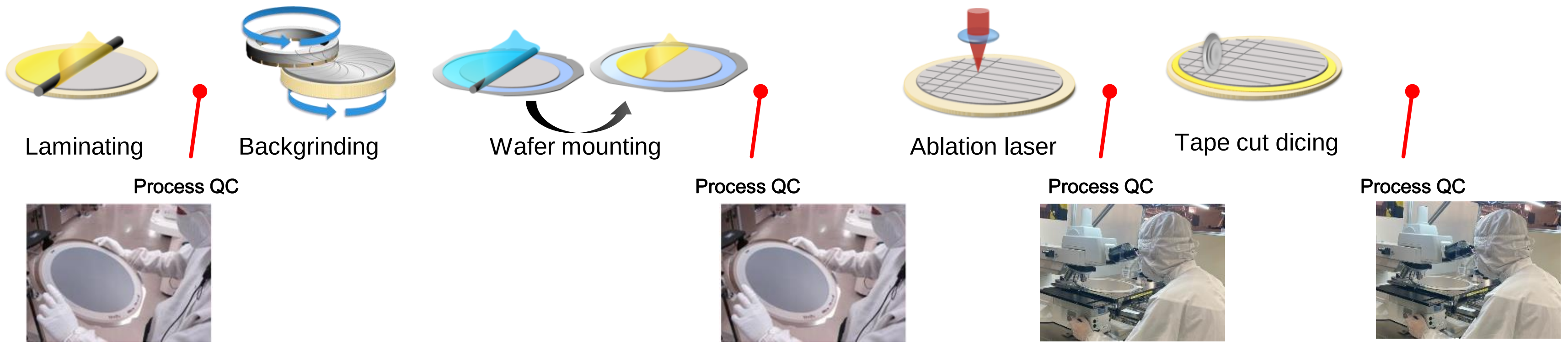
Wafer transfer system RoofWay and cluster system MUSUBI are permanently installed at this center.



In this line, a fully-automatic transfer robot connects a series of processes, such as wafer thinning, dicer/laser singulation, 6-side die inspection and data storage after processing, etc.

Production Process Example Comparison

Current Line: Logic Process

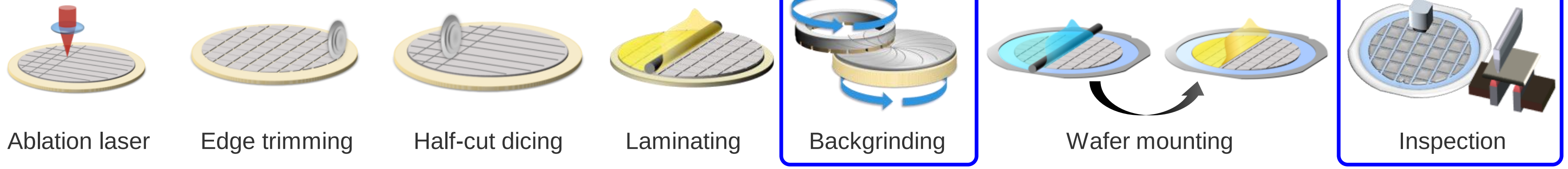


QC required

Limitations on reliability with operator-performed work

Mid-Process: Logic DBG Process (Labor-Saving Line)

RoofWay



Automatic measurement: ground side

Automatic measurement: 6 sides of die

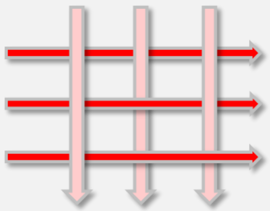
QC-less

Realization of a zero defect process

	Current line	Mid-process
Defect occurrence prevention	• Processing variation • Human error • Contamination, • foreign materials, corrosion	• DBG process • Short pulse laser • Automation
Defect outflow prevention	• Visual check • Sampling check	• Quality check for all lines, all wafers (front-side and backside) • Sidewall sampling check

Defect outflow prevention

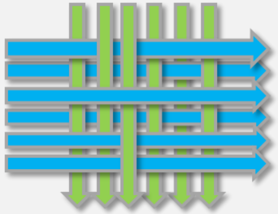
Defect occurrence prevention



Coarse quality filter

Defect outflow prevention

Defect occurrence prevention



Fine quality filter

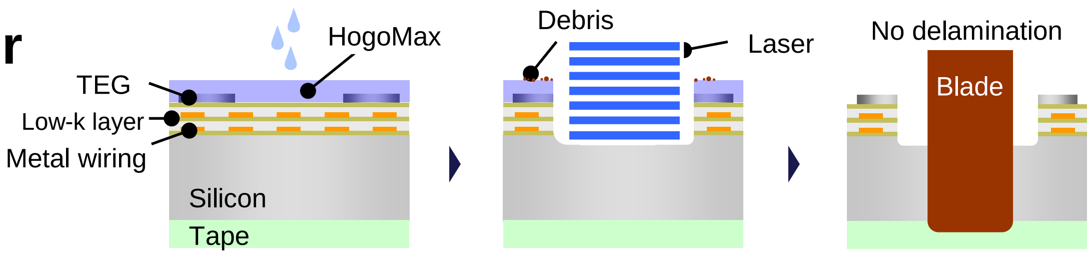
- **Laser grooving—produces minimal heat effects**
- **Edge trimming—eliminates defects caused by triangular die**
- **DBG process—produces less backside chipping**

Maximized process performance

Laser Grooving

- **Removes the front side (patterned side) using a laser**
  - **Generally, laser grooving is implemented to prevent interlayer dielectric film (low-k) delamination.**

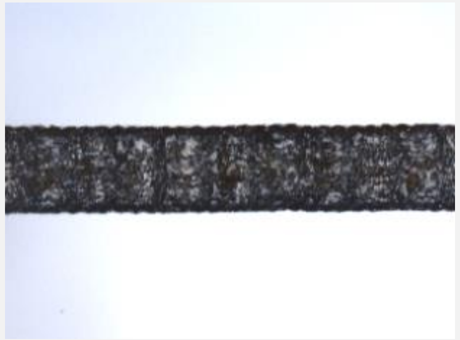
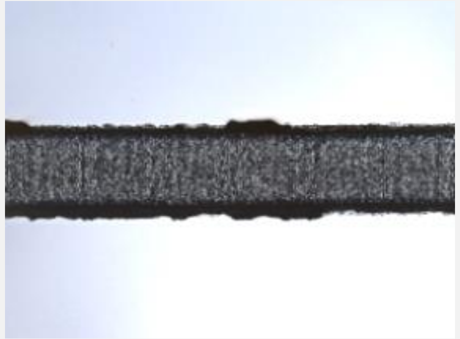
Realizes stable processing quality not dependent on surface condition



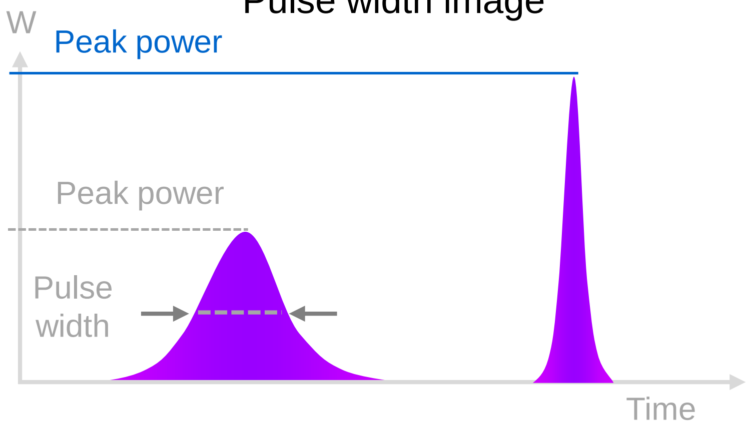
Protective film coating → **Laser grooving** → **Blade dicing**

- **Reduces heat damage with ultrashort pulse laser**
  - **Surface condition after laser grooving affects blade dicing**

Application example: Si laser grooving

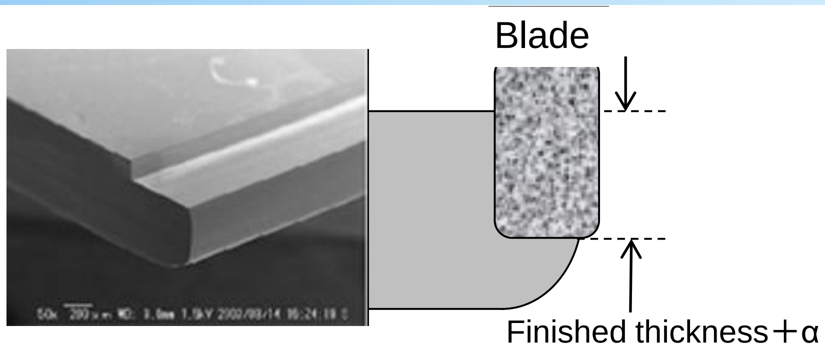
	Conventional laser	Short pulse laser
Front side		

Pulse width image

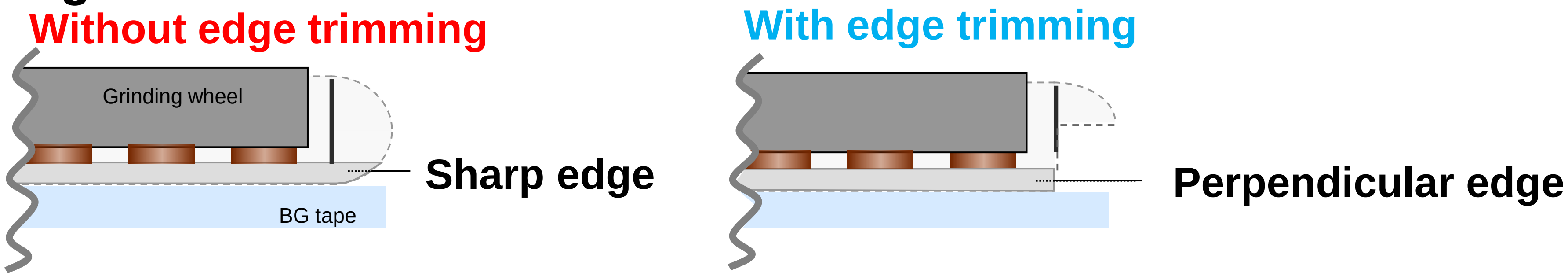


Edge Trimming

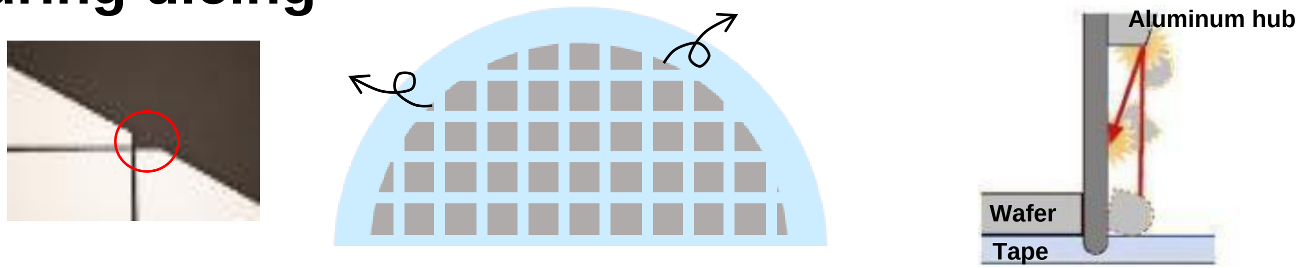
- **Trims the wafer edge using a dicing blade before backgrinding**



- **Reduces sharp edges on wafer after thinning, preventing wafer breakage**

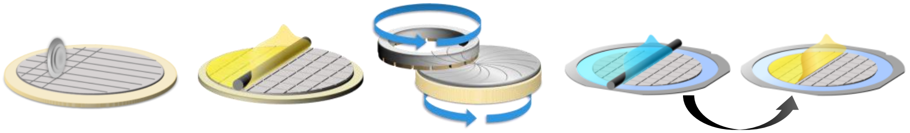


- **Reduces die damage and blade breakage due to triangular die flying during dicing**

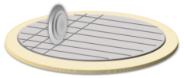


DBG Process

- **Thinning after wafer half cutting (grooving)**
- **Prevents defects due to triangular die flying**



Half-cut dicing

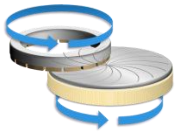


Does not cut into dicing tape

- **No blade damage**
- **Improved cutting speed**
- **No need to adjust cutting position (kerf check reduction)**

BG tape laminating

Backgrinding



Singulates into die during grinding

- **Good for backside chipping → die strength improvement**
- **Street reduction possible without step cut**

Wafer mounting

No Variation

- **What is “variation”?**
  - **“Variation” is a risk factor for human error-related defects.**
    - **Variation is difficult to eliminate even when countermeasures are taken, and the countermeasures themselves can become burdensome.**
    - **Other types of variation also exist, such as those related to parts and equipment.**

- **How can we achieve variation-less processes?**
  - **By reducing manned operation as much as possible through automation**
    - **Automation tools implemented at the Mid-Process Research Center**
      - **Remote-controlled operation, centralized data management (KKM-Link)**
      - **Automated transfer between equipment (RoofWay)**
      - **Automated tool replacement (blades)**
      - **Automated inspection (Metrology, DIS100)**
    - **Indirect benefits**
      - **Particle reduction**

RoofWay
Kiru·Kezuru·Migaku Technologies

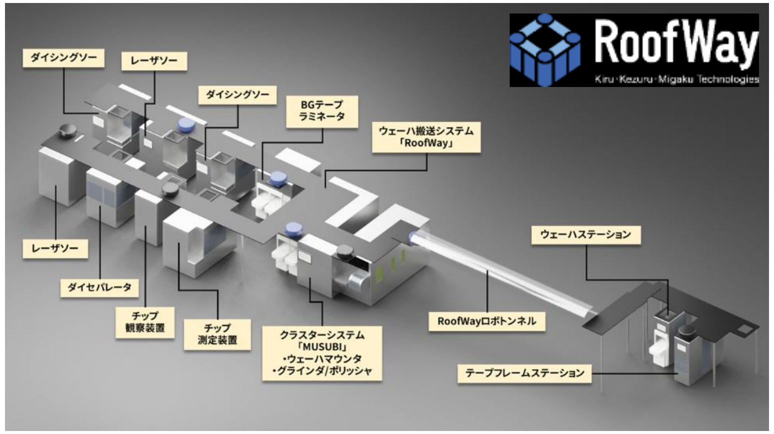
- **However, highly-reliable processes with high processing performance are also necessary.**
  - **If operator intervention is required, the advantages of automation are reduced.**

Automation Tool: RoofWay

RoofWay
Kiru·Kezuru·Migaku Technologies

Shortest TAT possible

(minimal time in clean room)



Automation Tool: Auto Blade Changer (ABC)

- **Downtime reduction through full automation of blade replacement and precutting**

オペレーターが手動で交換する場合　Manual blade replacement by an operator

フルオート終了・アラーム発報ブレード交換待ち
Fully automatic operation finishes, alarm is issued, waits for blade replacement
▶ ワークとブレードを照合、登録
Operator compares the workpiece and blade, registers information
▶ ブレード取付
Operator mounts the blade
▶ ブレードの初期ドレス
Initial blade dressing
▶ デバイスデータ選択、加工指示
Device driver data selected, processing command given

平均40分
Average 40 minutes
（ディスコ調べ /investigated by DISCO）

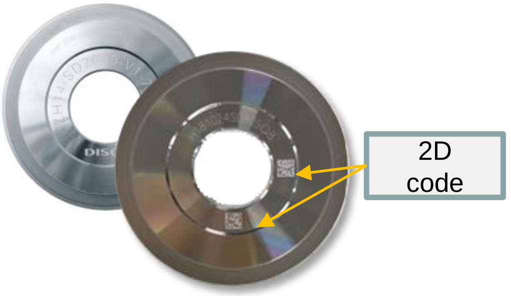
	Conventional method	ABC
Concept		

- 6 replacement blades stocked on each axis
- Scans 2D code on hub base to register blade information to equipment (patented)
    - Blade type
    - Actual kerf width (inspection data)
    - Actual blade exposure amount (inspection data)

– **Reduced operator-related blade replacement errors**
  - For example, incorrect blade type, blade tip breakage during mounting

– **Blade records management system**
  - To satisfy end-user quality assurance demands

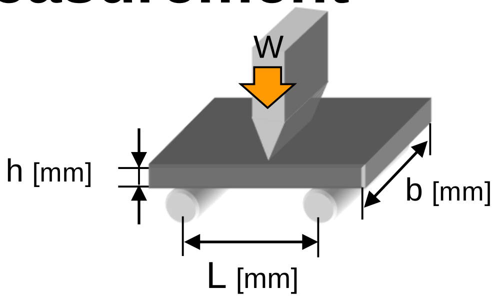
– **Reduced blade cost**
  - Maintains records for used blades so that blades can be used to end of life



Automation Tool: Metrology (DIS100)

- **Die measurement equipment that is fully automatic, from die picking to die strength measurement**

  – **Die strength measurement**
    - **3-point bending test**

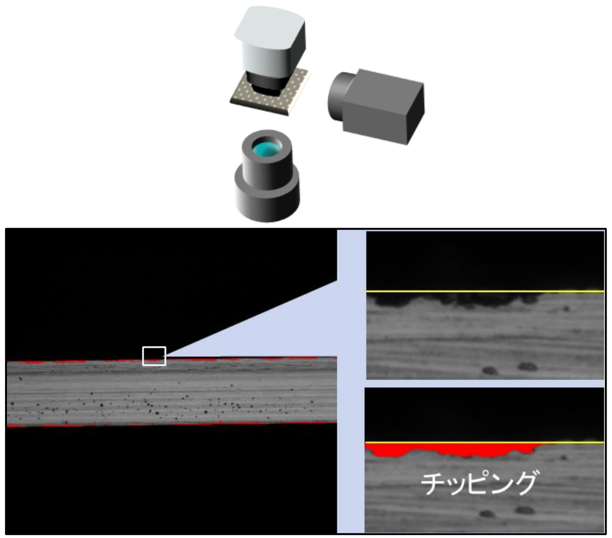


$$\delta = \frac{3LW \times 9.8}{2bh^2}$$

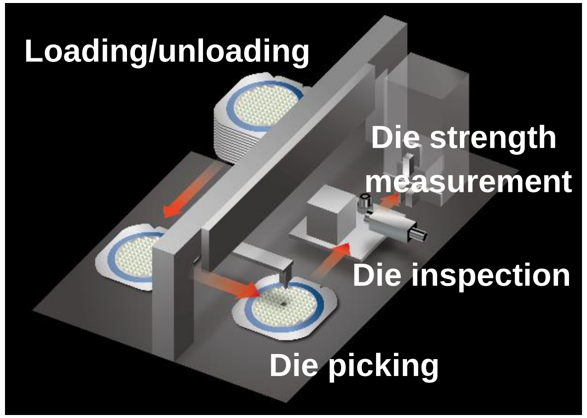
δ: Die strength [MPa]
W: Breaking load [kgf]

DIS100

  – **Supported inspection (options)**
    - **4-point bending, ball-point bending test**
    - **Die backside inspection: surface roughness measurement**
    - **Die sidewall inspection**
      – **1-point measurement: thickness measurement, chipping inspection**
      – **4-side measurement**



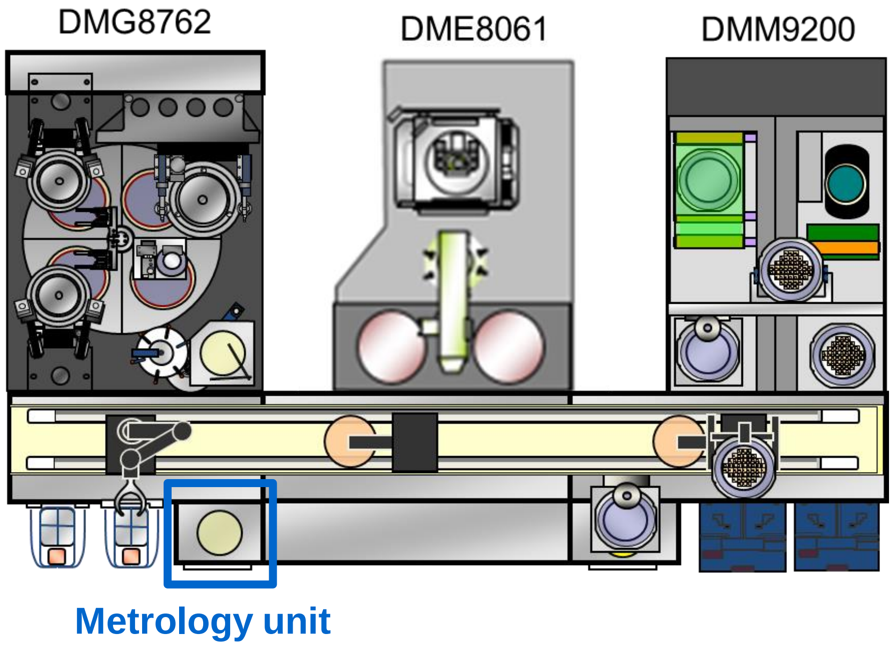
Equipment layout



W x D X H: 1,250 mm x 1,680 mm x 1,800 mm

DISCO

- **Built-in metrology unit for MUSUBI for wafers after backgrinding**
  - **Automated measurement of wafer condition after backgrinding**
  - **Possible to inspect all die, contributing to traceability**



Main body functions

- Thickness measurement (can be performed for individual die as well)
- DBG/SDBG kerf recognition
- Image capturing

Particle Reduction

- **Minimizes operator work through automation**
  - **Contributes to particle reduction in the process**

- **Automation means no cassette transfer between processes**
  - **Contributes to particle reduction by decreasing the number of times the cassette and frame come into contact**

Summary

- **Realizing zero defects as required by high value-added devices such as automotive devices**
  - **Maximized process performance + automation are required.**
    - **Highly-reliable processes (maximized process performance)**
      - **DBG**
      - **Short pulse laser**
    - **No variation (automated)**
      - **RoofWay / KKM-Link**
      - **Metrology**
      - **Automation tools (ABC, etc.)**

Generative AI: 2.5D Packaging

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Contents

*The process flow described in this document is not a complete overview of all processes required for 2.5D packaging.

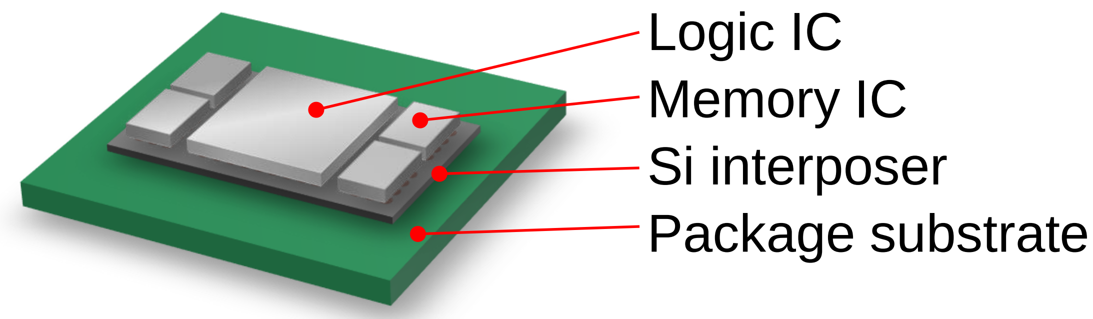
What is “Generative AI”?

- Generative AI:
  one type of AI (Artificial Intelligence)

Input	• Text • Audio • Images etc.	→	Generated	• Images • Code • Videos • Music • Sentences etc.

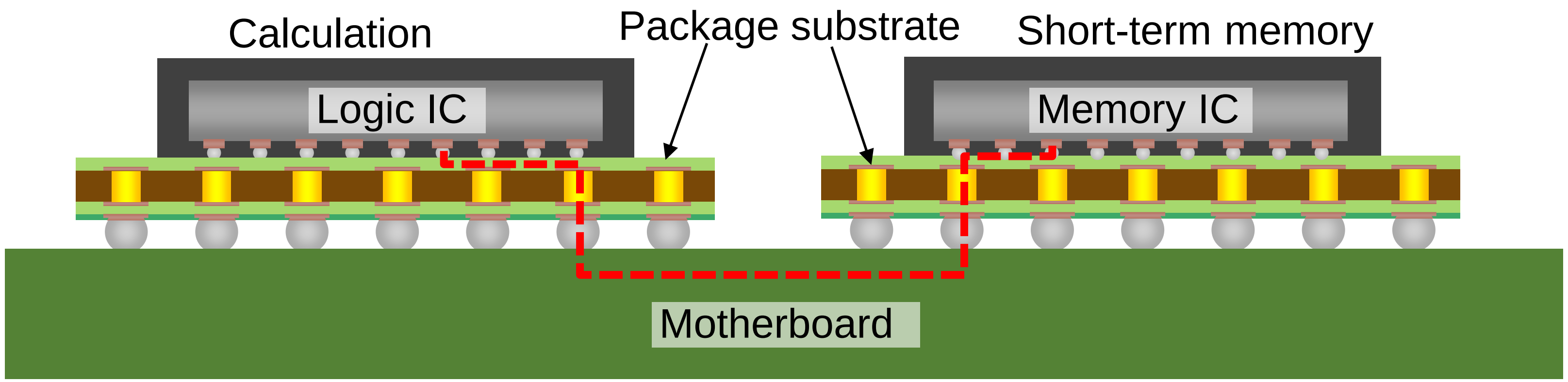
- Performance required for generative AI: high-speed, large-scale data processing and complex calculation
  →HPC (High Performance Computing)

- Packaging technology to realize HPC
  →2.5D packaging



2.5D Packaging

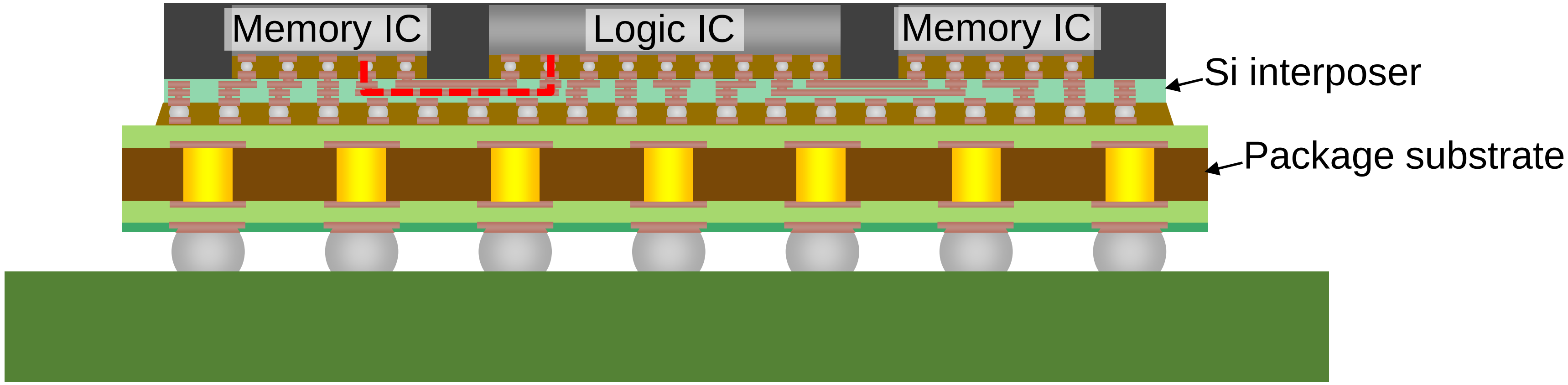
- Conventional Packaging: not suited for high-speed, large-scale calculations



- Logic IC
- Memory IC

Packaged separately
Connected through motherboard

- 2.5D Packaging: high-speed communication possible between logic ICs and memory through Si interposer

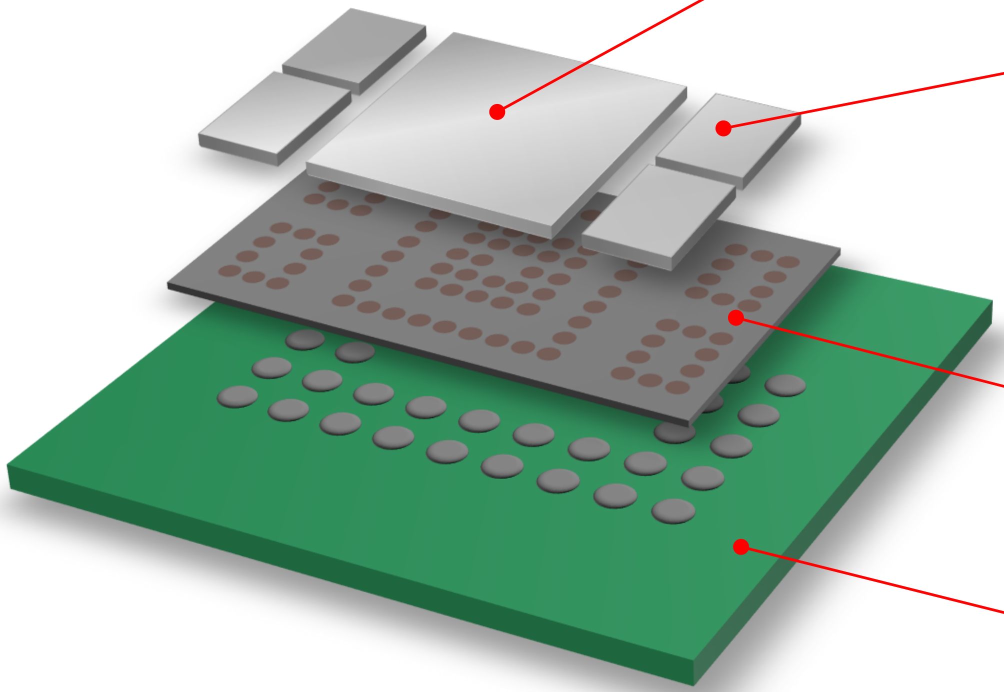


- Logic IC
- Memory IC

Packaged together
Connected within package

KKM for 2.5D Packaging

- Disassembled:



Logic IC

Low-k grooving

Memory IC (HBM: High Bandwidth Memory)

KKM for laminated TSV die

- Edge trimming
- Backgrinding (high-clean process)

Si interposer

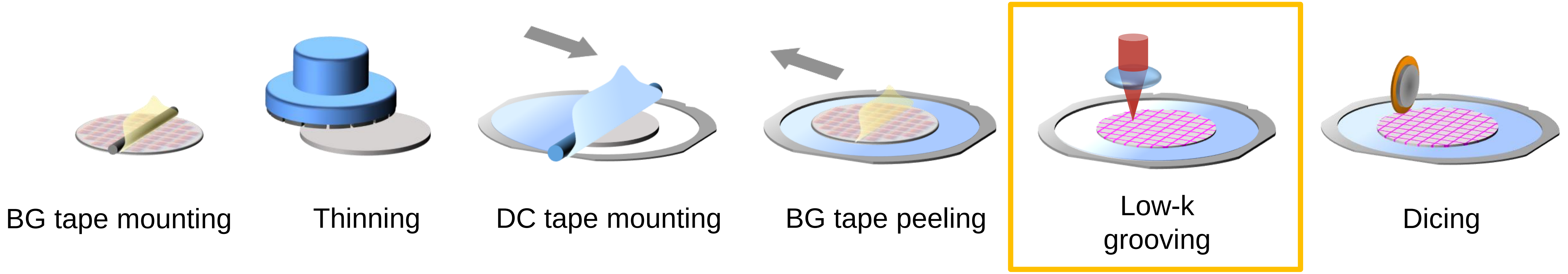
KKM for CoW (Chip on Wafer)

Package substrate

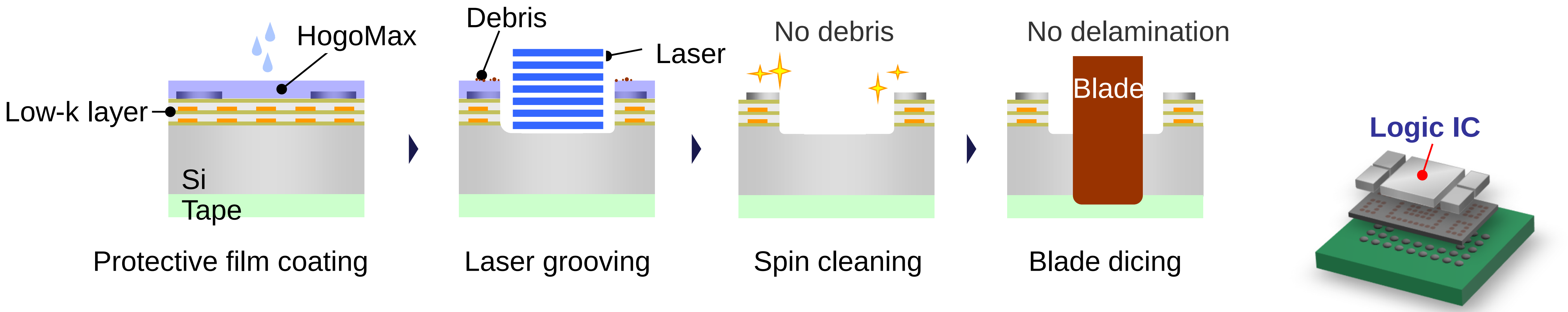
Large-size panel dicing

Contents

- Low-k grooving added to the conventional singulation process



- Possible to process without low-k delamination through use of ablation laser

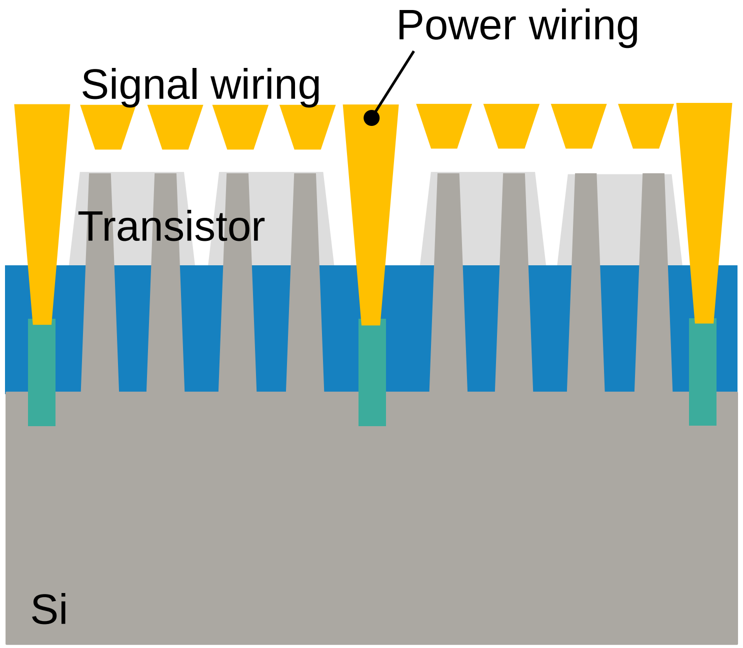


- Improvements to degree of integration for logic transistors: BS-PDN

Backside Power Delivery Network

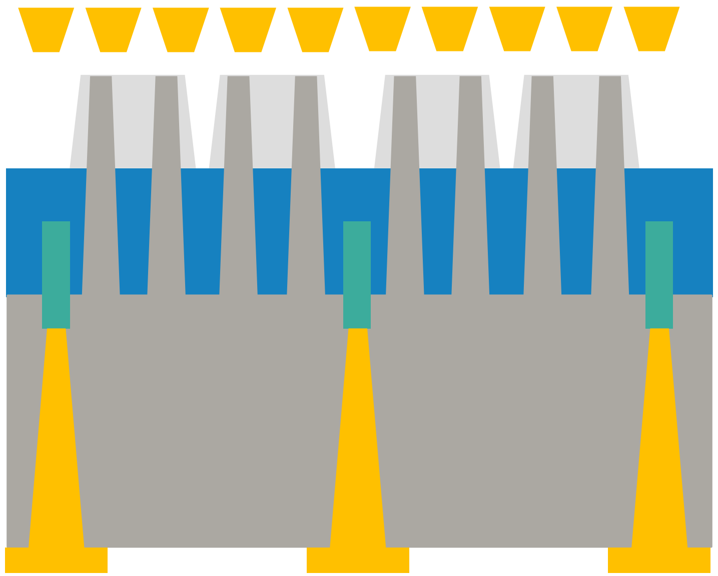
Conventional logic ICs:
signal and power wiring on the surface

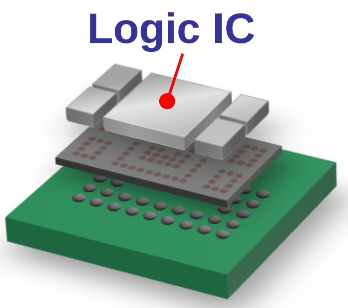
# of times thinning performed: 1
Backgrinding of patterned wafer



BS-PDN logic ICs:
signal wiring on the surface, power wiring on the back

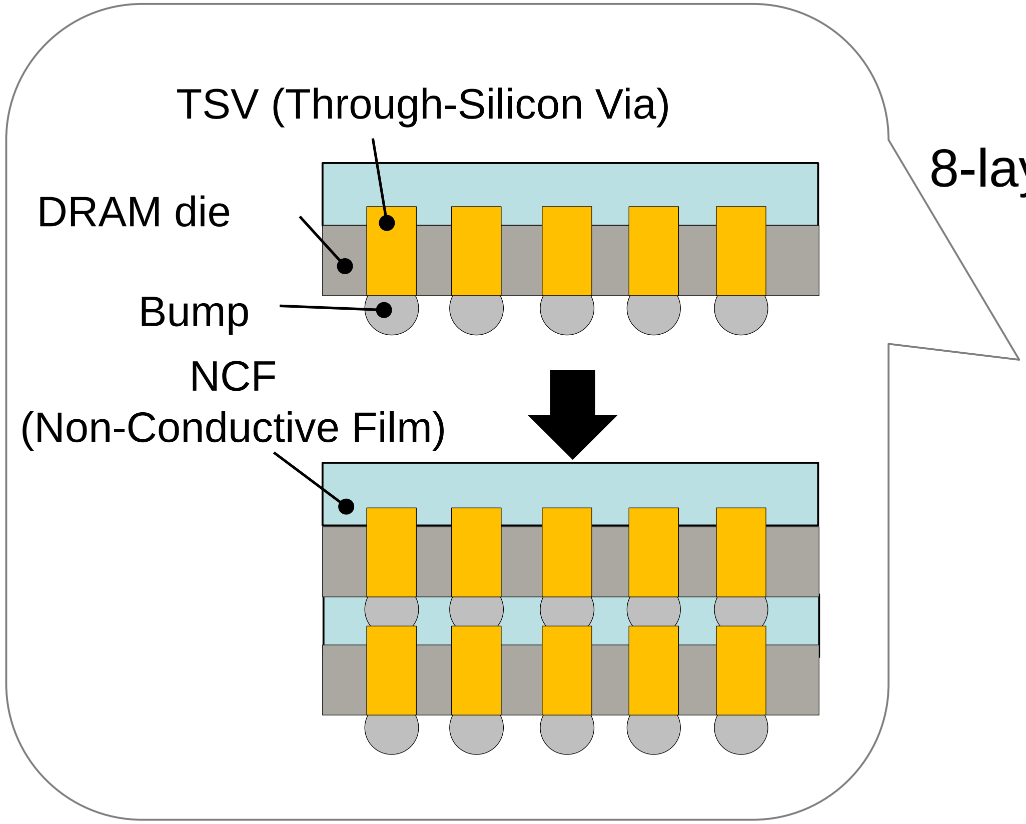
# of times thinning performed: 2
- High-accuracy backgrinding of patterned wafer
- Supports substrate grinding

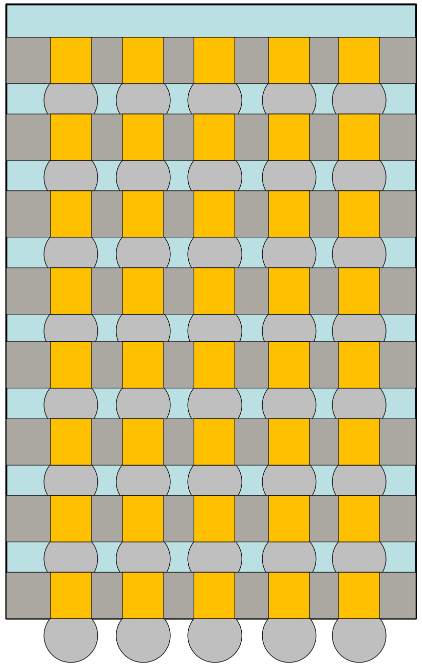




KKM for Memory ICs (HBM)

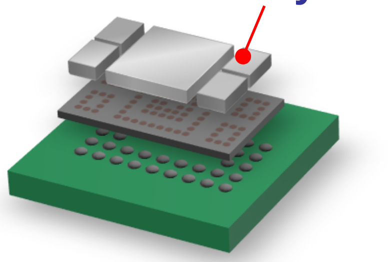
- HBM (High Bandwidth Memory): DRAM die lamination using TSV





Process

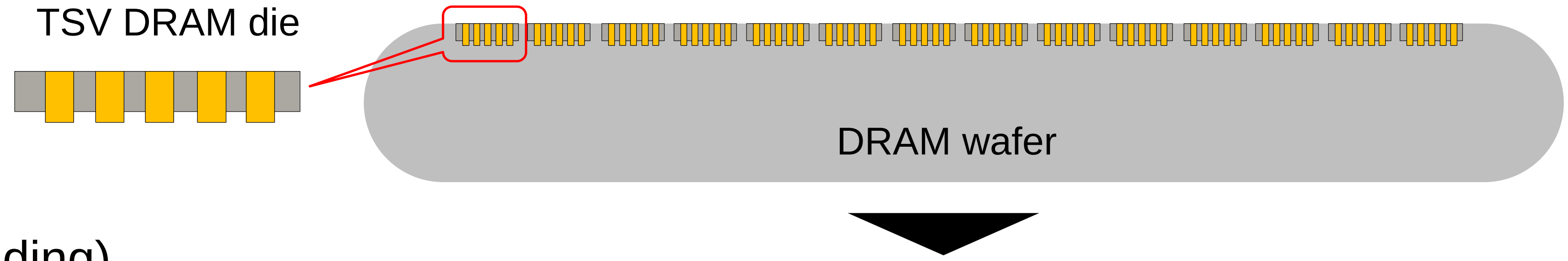
- Edge trimming
- Thinning (high-clean thinning)
- TSV reveal / bump formation
- Dicing
- Die lamination



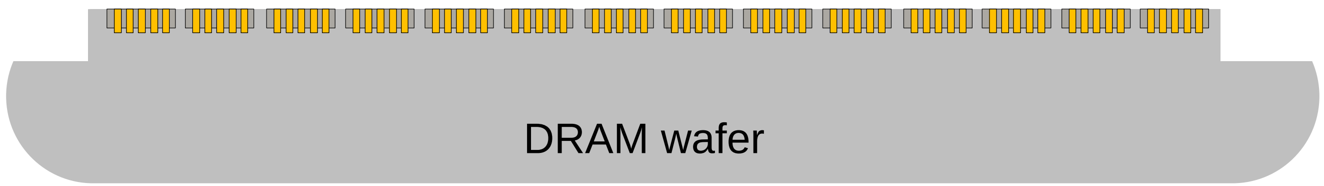
KKM for Memory ICs (HBM)

Process

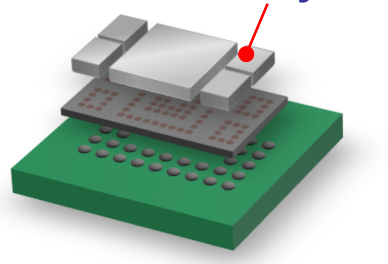
- **Edge trimming**
- Thinning (high-clean grinding)
- TSV reveal / bump formation
- Dicing
- Die lamination



Edge trimming on wafer edge using blade dicing before thinning

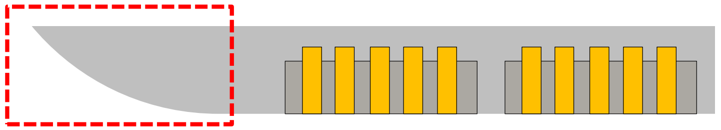


Memory IC



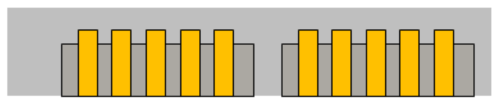
Without edge trimming

Sharp edge during thinning, causing cracking and breakage



With edge trimming

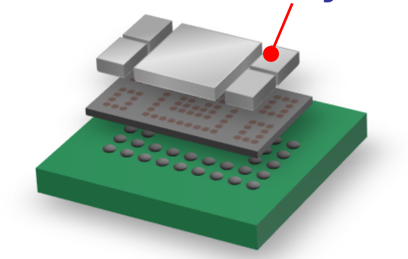
No sharp edge during thinning, reducing risk of cracking or breakage

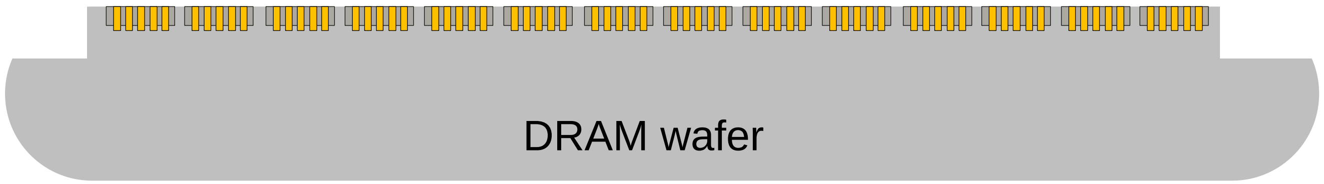


DISCO

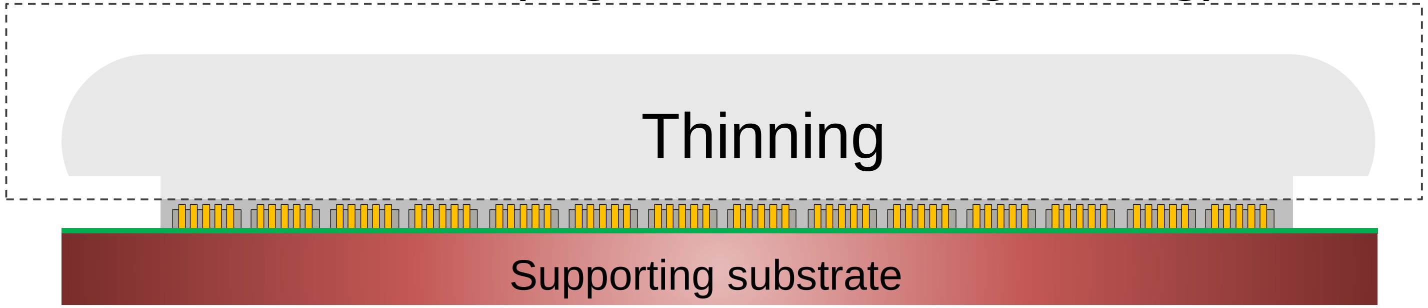
Process

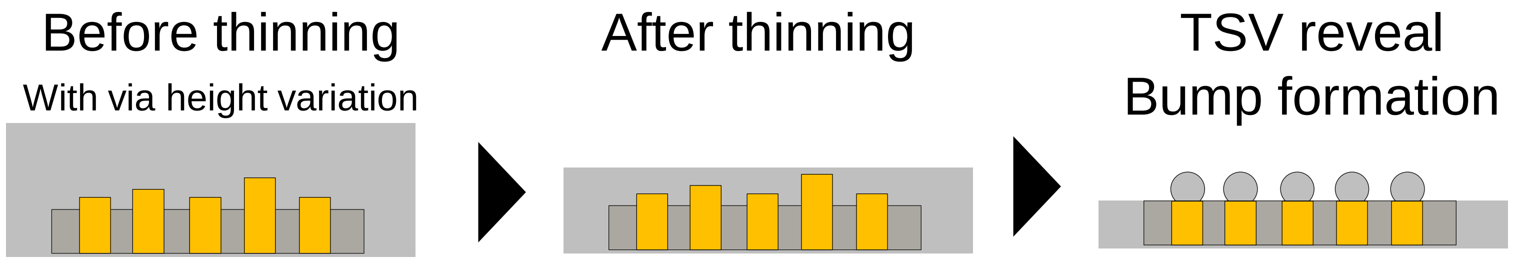
- Edge trimming
- **Thinning (high-clean grinding)**
- TSV reveal/bump formation
- Dicing
- Die lamination





For handling in the next process, the wafer is thinned while temporarily bonded to the supporting substrate (high-clean backgrinding)





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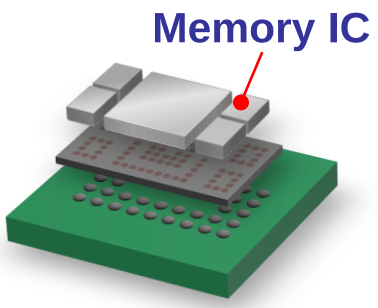
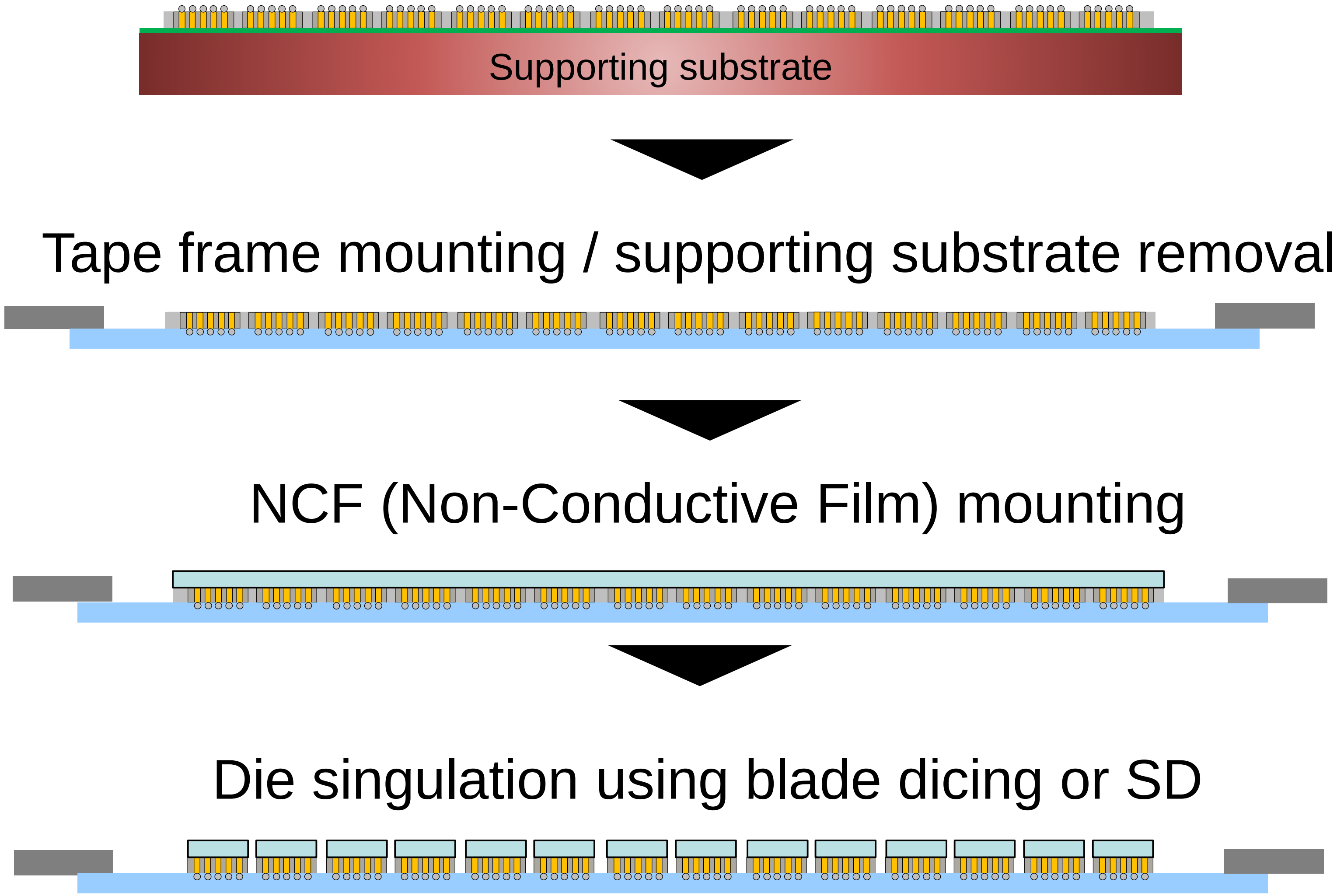
Process

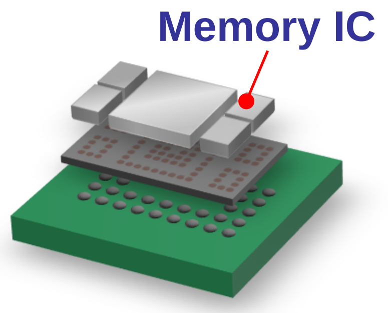
- Edge trimming
- Thinning (high-clean grinding)
- TSV reveal/bump formation
- Dicing
- Die lamination

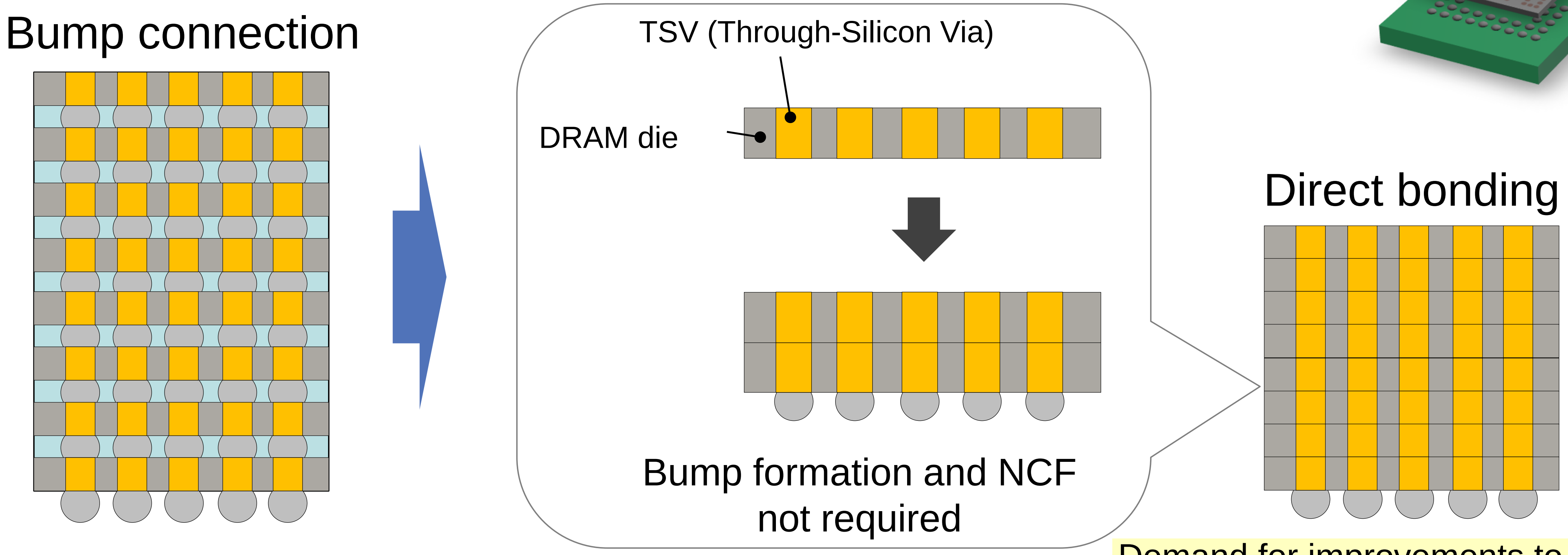




KKM for Memory ICs (HBM)

- Enabling die connection through hybrid bonding





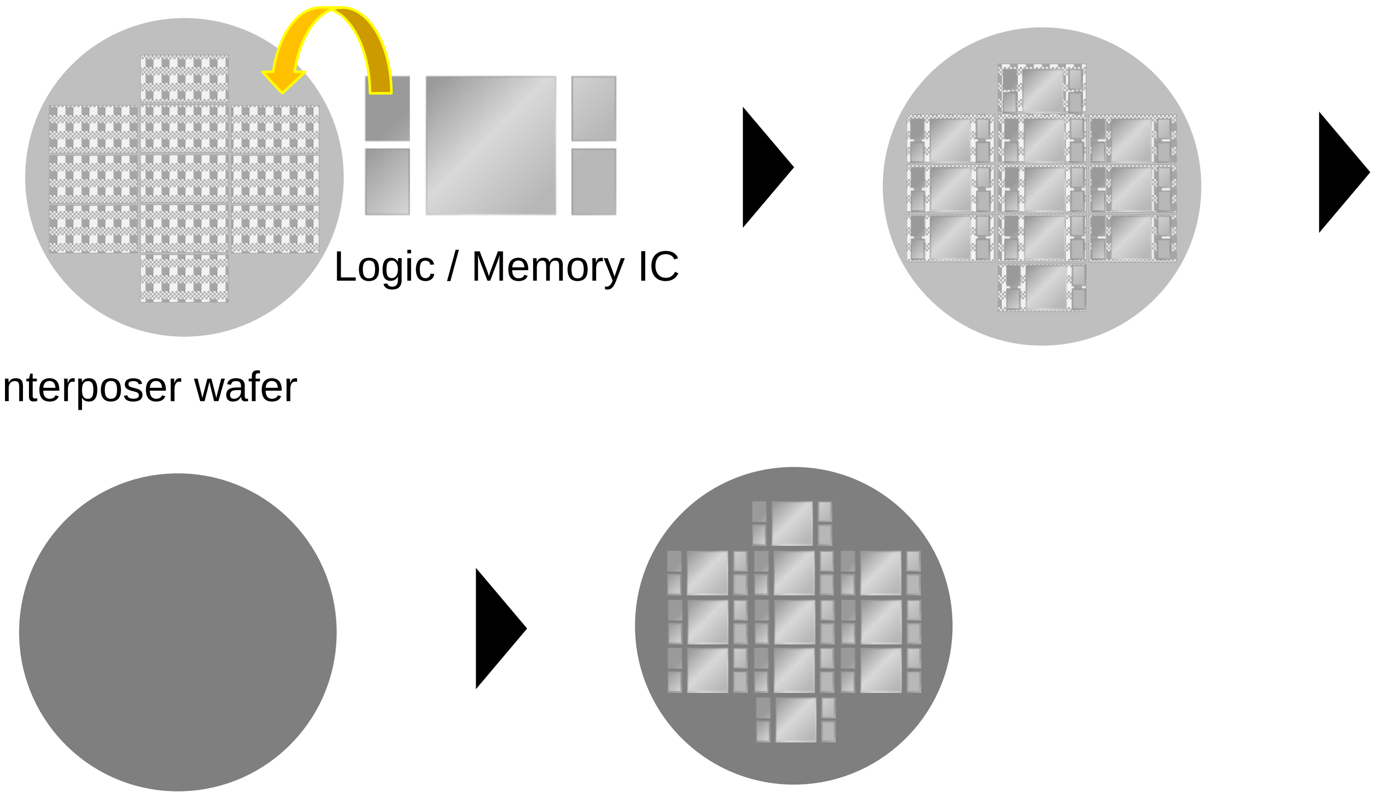
Demand for improvements to the following may increase.

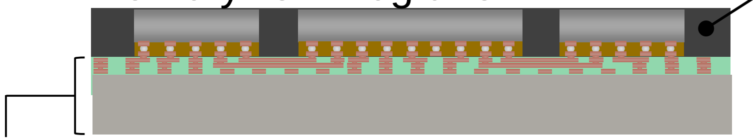
- Processing quality of backgrinding finish
- Cleanliness after die singulation

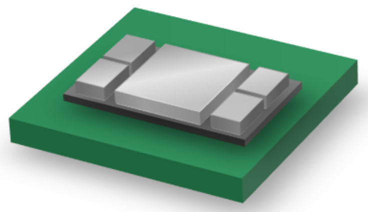
Contents

Process

- Interposer wafer Logic/Memory IC installation
- Mold sealing
- Mold resin grinding
- Interposer thinning
- TSV reveal / bump formation
- Wafer dicing
- Mounting to package substrate
- Substrate dicing



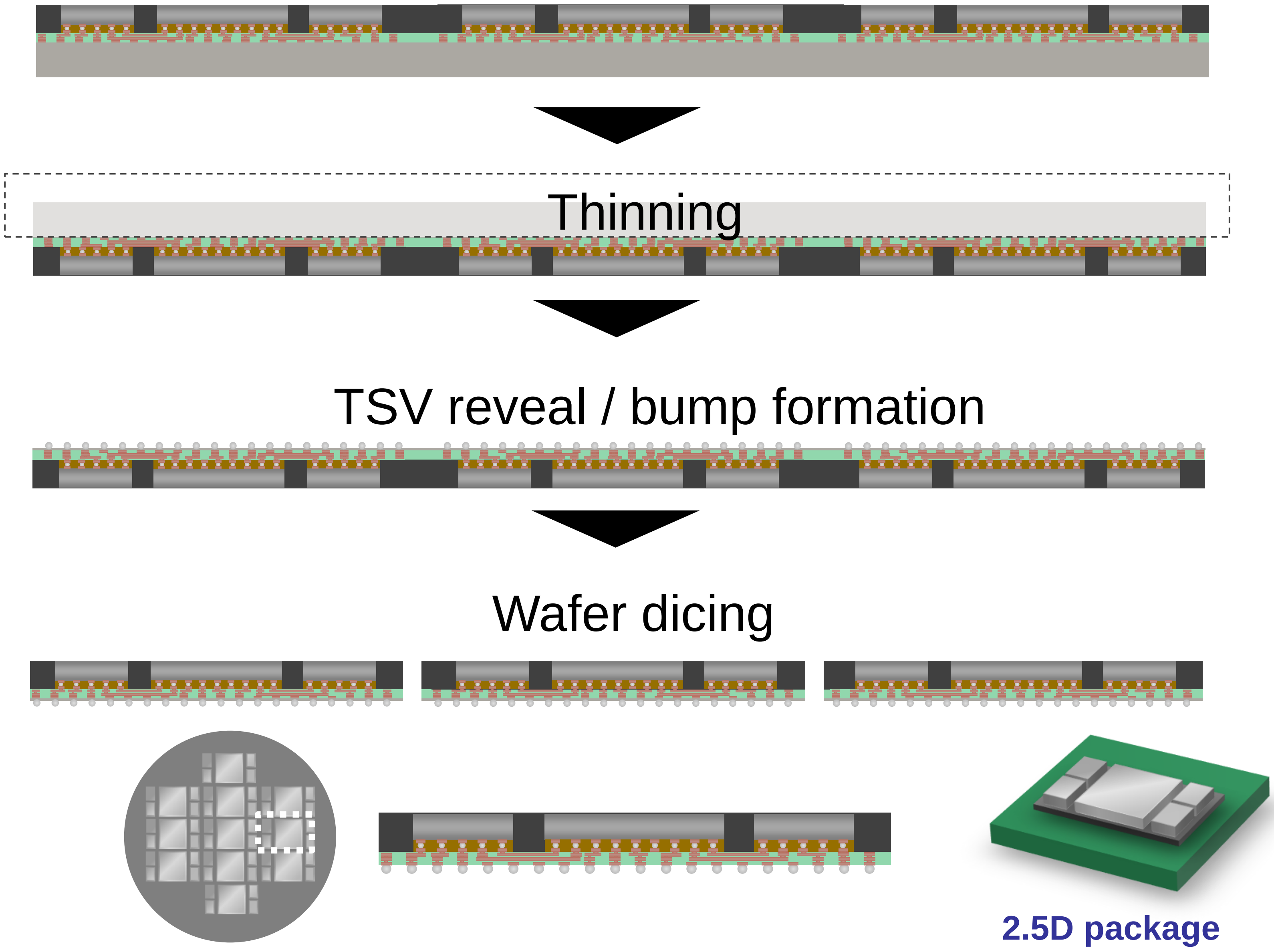




2.5D package

Process

- Interposer wafer
  Logic/Memory IC installation
- Mold sealing
- Mold resin grinding
- Interposer thinning
- TSV reveal / bump formation
- Wafer dicing
- Mounting to package substrate
- Substrate dicing



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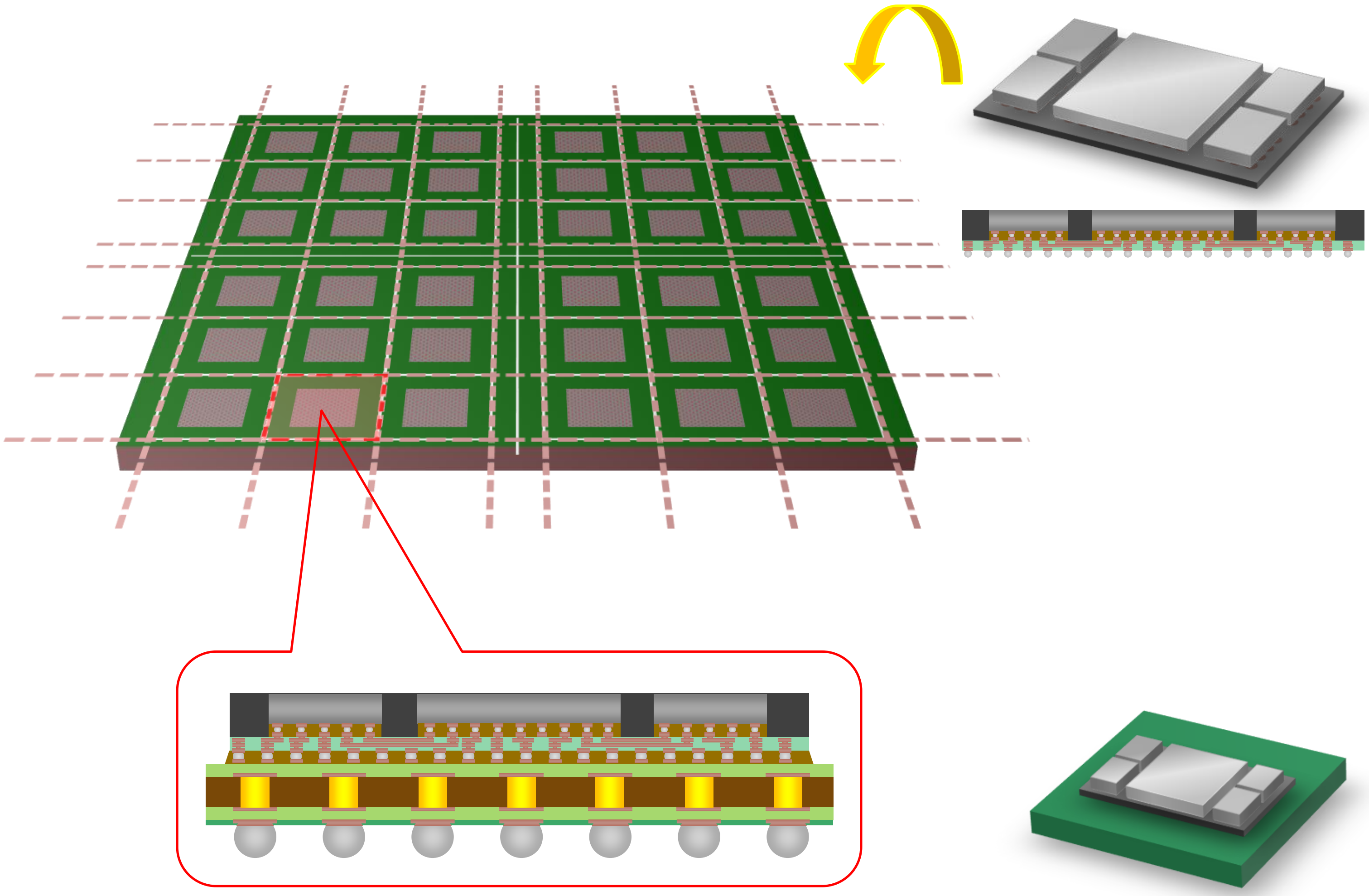
Process

- Interposer wafer
  Logic/Memory IC installation
- Mold sealing
- Mold resin grinding
- Interposer thinning
- TSV reveal / bump formation
- Wafer dicing
- Mounting to package substrate
- Substrate dicing



2.5D package

Summary

- Packaging technology for producing HPC for generative AI: 2.5D packaging technology

- 2.5D packaging: logic IC made into package by connecting logic and memory ICs using Si interposer

- Various types of KKM are being utilized for 2.5D packaging technology:
  - Low-k grooving
  - Edge trimming, backgrinding (high-clean process)
  - KKM for CoW (Chip on Wafer)
  - Large package dicing

- As BS-PDN and hybrid bonding evolve, further KKM expansion is expected.

This material

Below are the answers to questions asked during the one-on-one meeting with analysts and investors after presentation of the financial results. Although close attention is paid to the written contents, if there are any mistakes in the information and/or data tampering by a third party, DISCO does not take any responsibility. In addition, the purpose of this document is not for soliciting investment. Please invest based on your judgement.

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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