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Multicolumn E-Beam Litho (MEBL)

A Dialog with e-Beam Initiative Friends

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eBeam Litho Has Long Been Dismissed. Why Now?

Market Inflections

Technology Breakthrough

Driving → **MEBL Emergence**

Mini-columns

Vector Writing

Modular Scalability

Enabling → **High Productivity**

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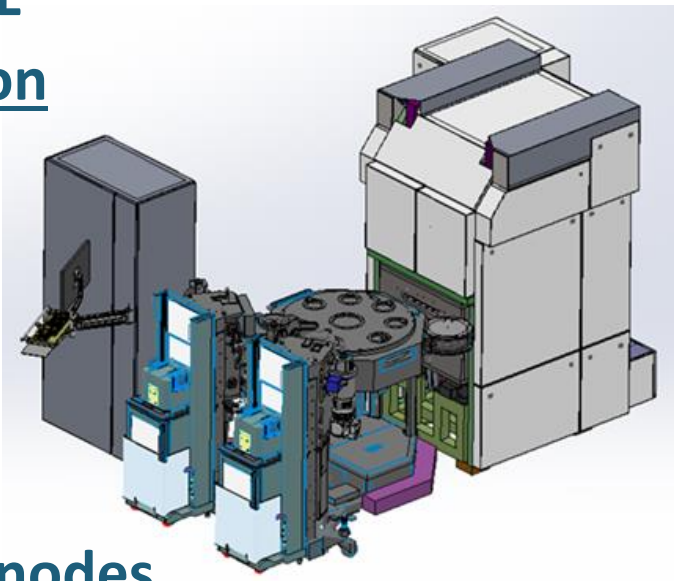
Multibeam Is Taking eBeam Litho from Lab to Fab

Objective

Develop and build ***HIGH-PRODUCTIVITY*** MEBL systems for rapid development and production



Strategy

1. Seek to complement optical litho
2. Initially target 200mm markets in mature nodes
3. Develop applications offering unmatched litho solutions

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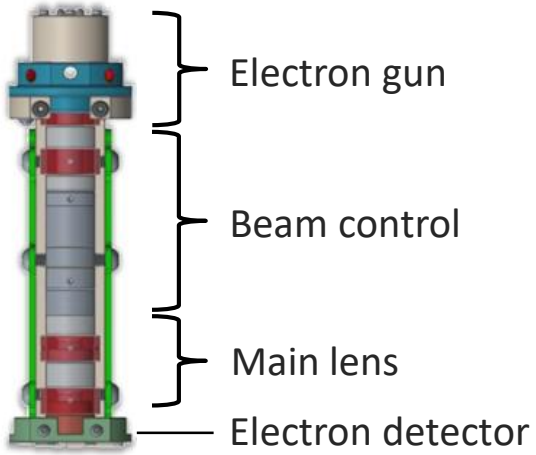
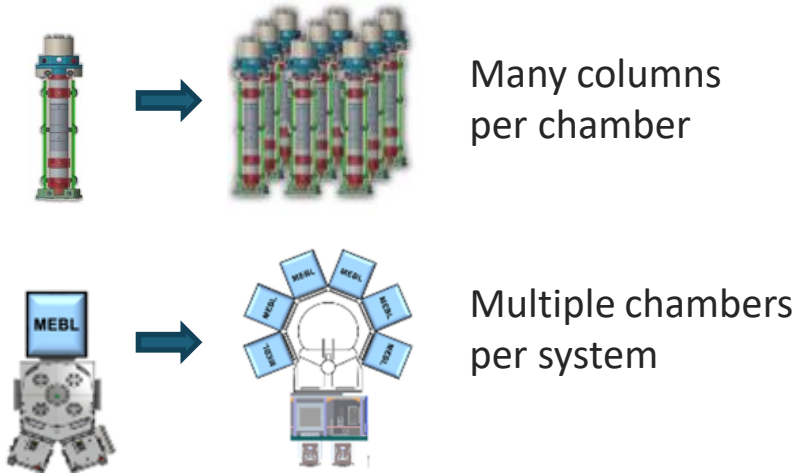
MEBL Basic 1: Multicolumn and Multi-Chamber

- **One beam/column:** Mini-column is 5” tall, 1” in diameter
- **Write-on-the-fly:** eBeam writes while wafer-stage is in motion
- **Multicolumn action:** Multicolumn array covers entire wafer; all columns write in parallel
- **Vector writing:** eBeams are individually controlled and directed to exposure locations
- **High productivity:** Many columns, vector writing, and multi-chambers effecting higher throughput

Mini-column Vector Writing



Modular Scalability



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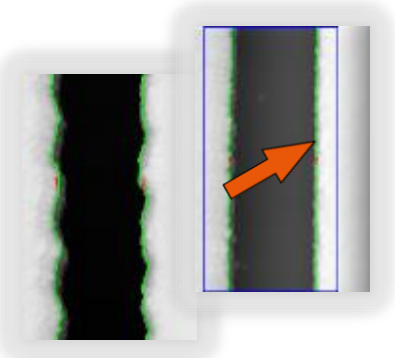
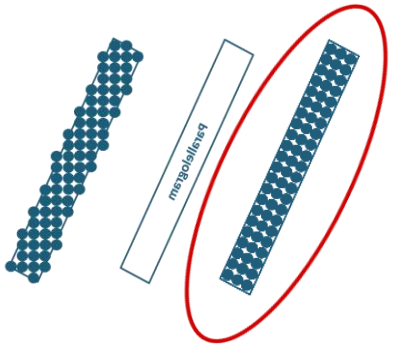
MEBL Basic 2a: Litho Factors and Vector Writing

Litho Factors

- **Proximity effect**: “A friend in need is a friend indeed.”
- **Line-edge roughness (LER)**: Controlled to < 10% (3σ)
- **Resolution**: Initially 45/28 nm node; extendibility proven
- **Depth of focus**: **> ± 10 µm (100x Optical DoF)**



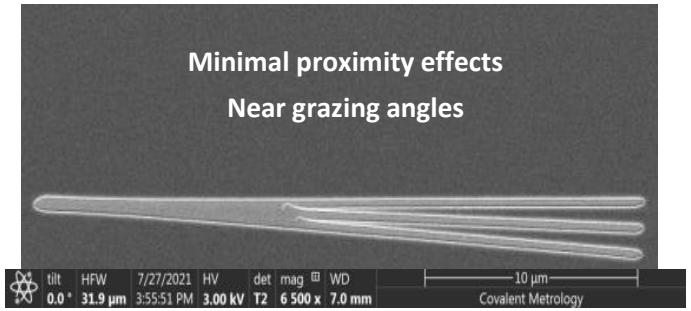
Line edge roughness (LER)



Radial lines, excellent LER

Vector Writing

- **Manhattan** patterns (x + y)
- **Radial** lines (arbitrary angles)
- **Curvilinear** lines
- Lines with **different CDs** (dial your CD)



Extreme radial fan out

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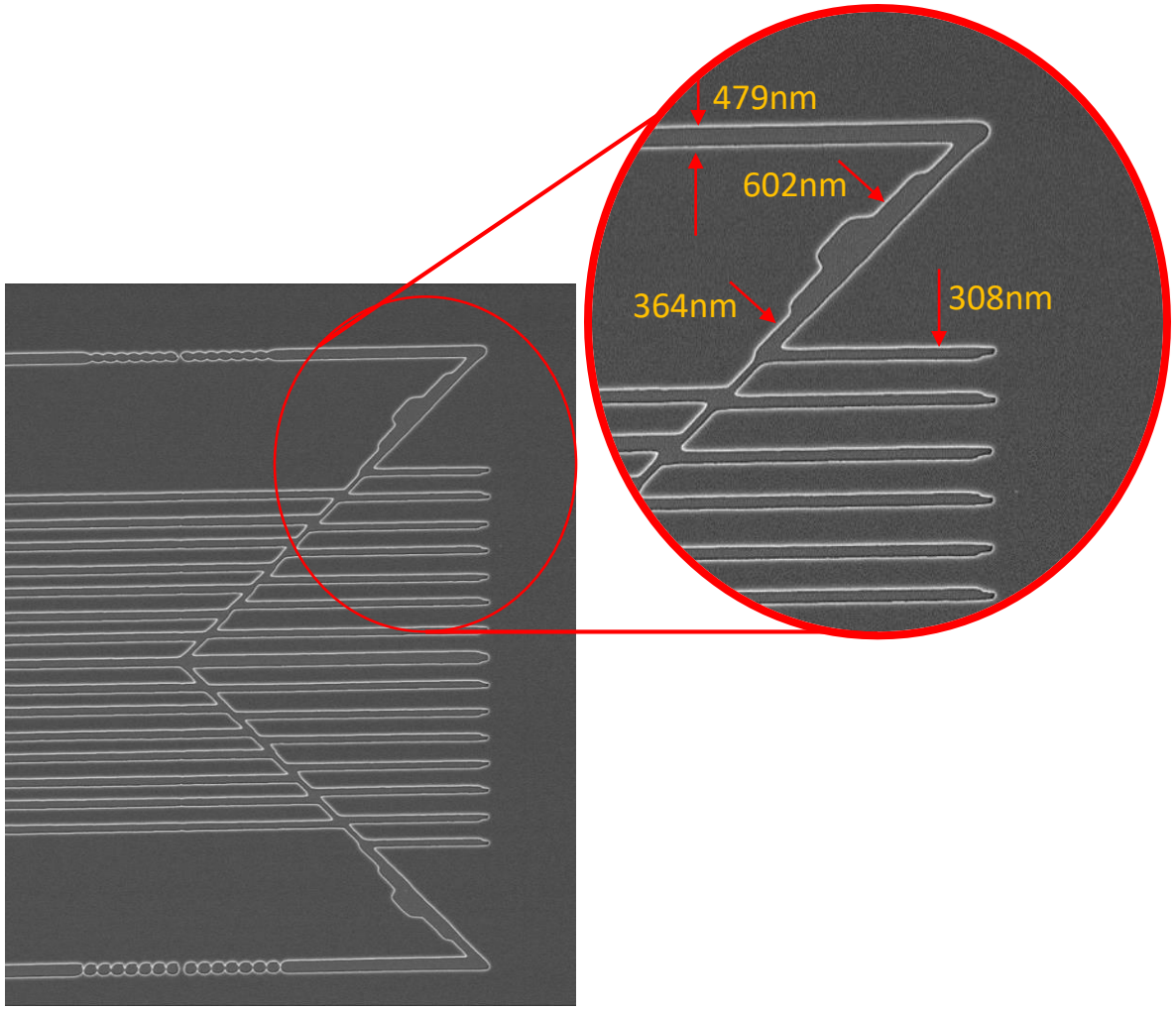
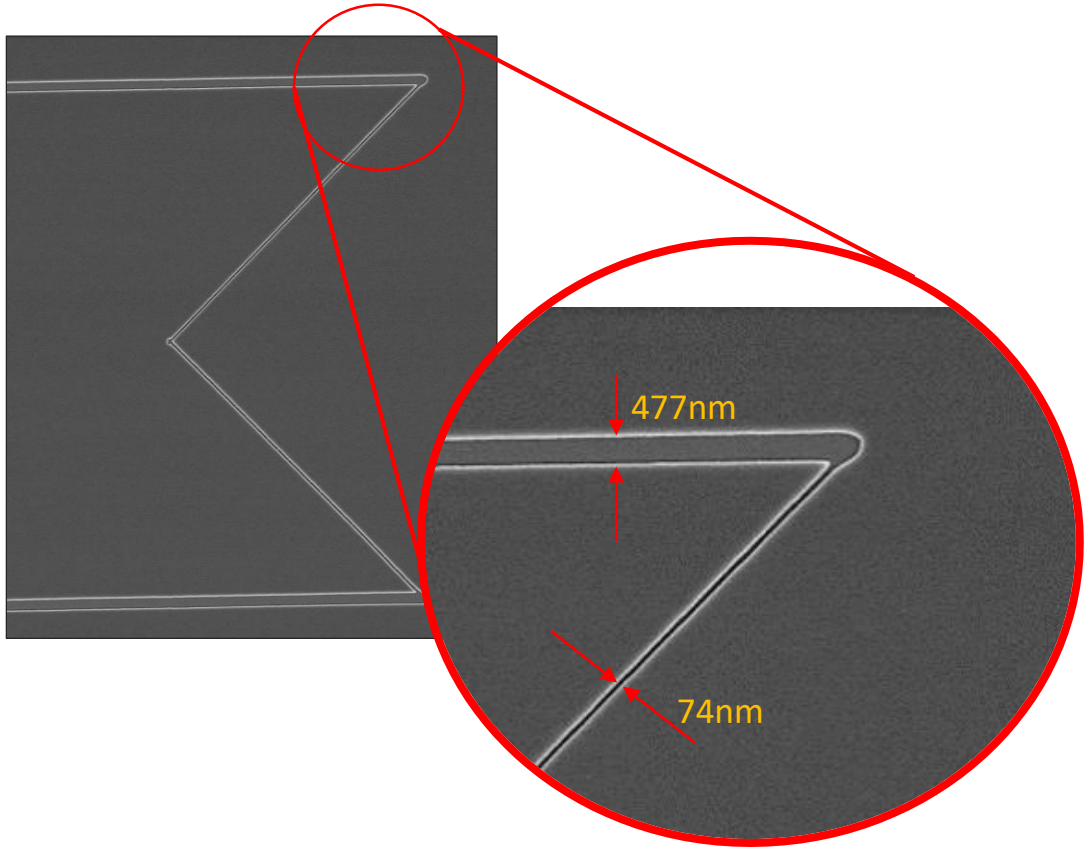
MEBL Basic 2b: Writing Quality – A Closer Look





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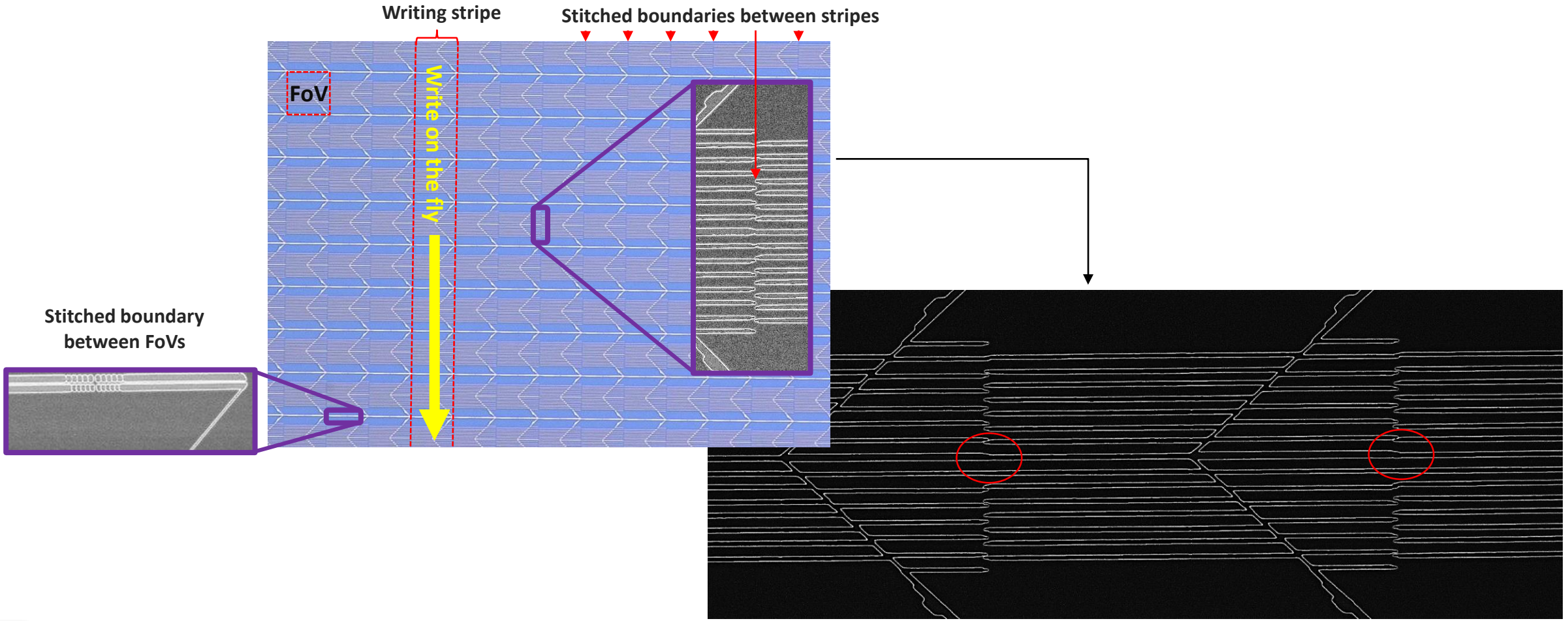
MEBL Basic 3a: Auto-Stitch – A Built-in Capability

Auto-stitch ➔ seamless continuity of IC features



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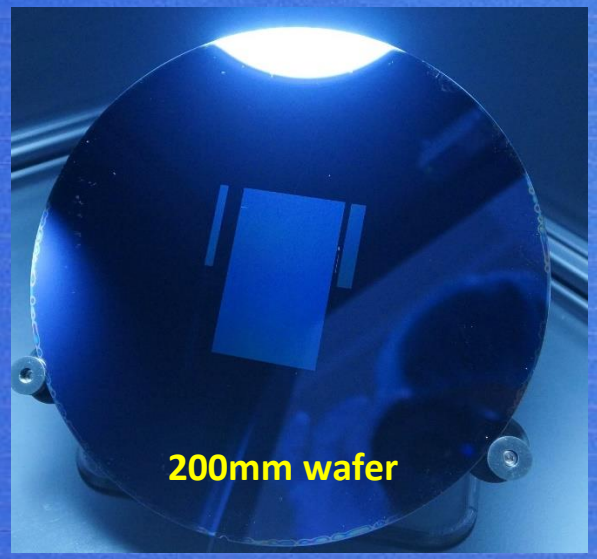
MEBL Basic 3b: Auto-Stitch – Key to Writing Large Areas



1.5 mm

3 mm

Three Applications Underscoring MEBL Capabilities

Advanced Packaging

Rapid Prototyping

Secure Chip ID

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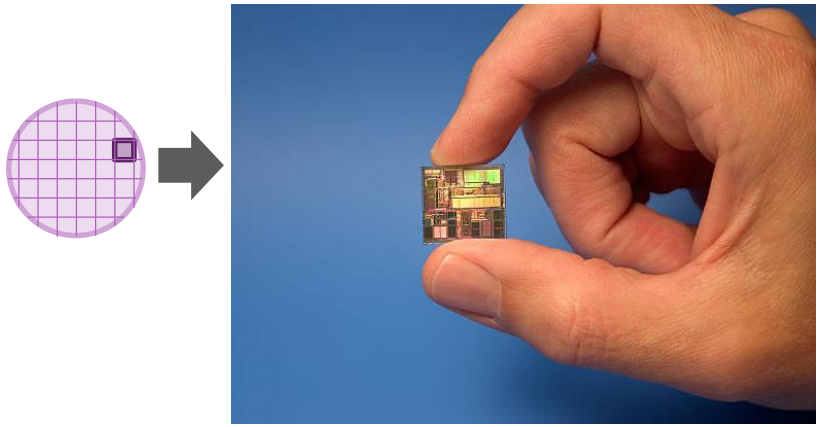
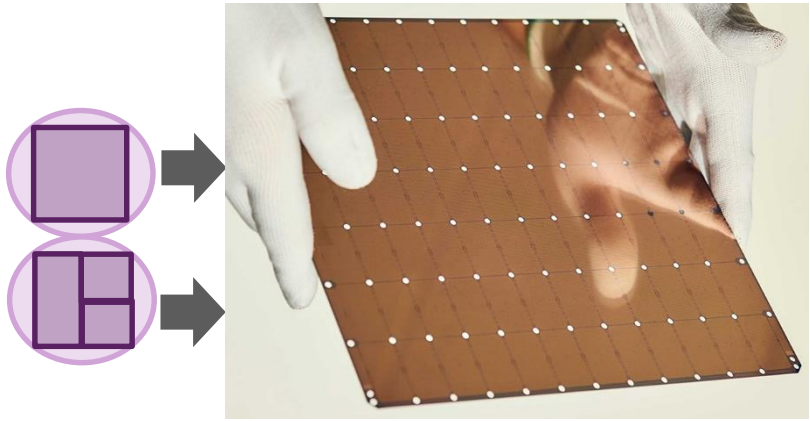
Advanced Packaging: Interposer vs Metaposer™



Today's Interposer*

- Small field of view (26 x 33 mm²)
- Reticle stitching required for larger size
- Smallest features ≤ 1 µm
- Difficult to pattern uneven surfaces



MEBL-Patterned Metaposer™ *

- Large field of view – up to full wafer
- Auto-stitch replaces reticle stitching
- Features > 1 µm – down to < 50 nm
- Large DoF makes uneven surfaces easy to pattern

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Rapid Prototyping 1: MEBL Is Most Efficient for Respins

Current Practice

- Multiple "respins" are common in prototyping
- Some masks, up to a new set, are required for respin (mask cycle **may take weeks**)
- This may increase cost and time for developing new products

Using MEBL

- Data Prep System (DPS) plays the role of masks
- DPS converts IC layout into MEBL shot map
- Respins require only DPS updates (**~1 hour**)
- MEBL improves cost and time-to-market for new products

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Rapid Prototyping 2: Selective Customization and More

Selective customization

- Multi-Project Wafers (MPW) are common in early-concept prototyping
- **Selective Customization** allows **die-by-die** layout adjustment of **individual chips** on any layer of the MPW
- This unrivaled flexibility is **built-in** and **unique** to MEBL

Transition to production

- Same MEBL system can transition from prototype MPWs to pilot production
- **Identical writing chambers** can be added to the MEBL system to scale productivity
- This efficient transition helps **speed first wafer** to market

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MEBL Does What Optical Can't

All chips are identical if made from the same reticle or mask

MEBL can individualize each chip

IN FULL DISCLOSURE: *Stock photos were taken from public domain for illustration purposes; MEBL did not bake these yummy cookies.*

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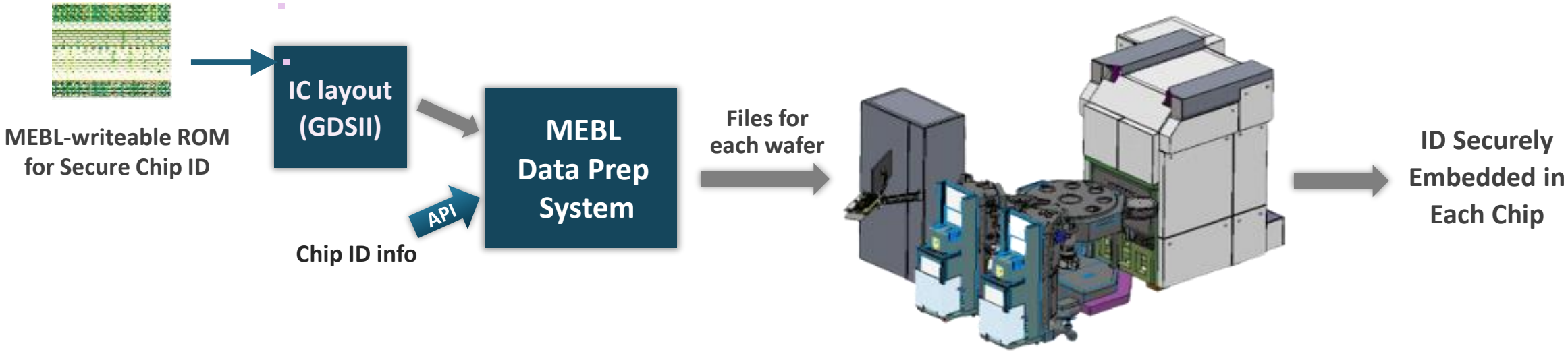
Secure Chip ID 1: – MEBL Is the Only Litho Capable

How MEBL hardcode unique data in each chip:

- Data pertaining to Chip ID is incorporated in the DPS through the API
- Chip ID info becomes part of the data to be written on wafer
- Throughput for embedding chip ID is more than **> 25 wafers/hour per chamber**



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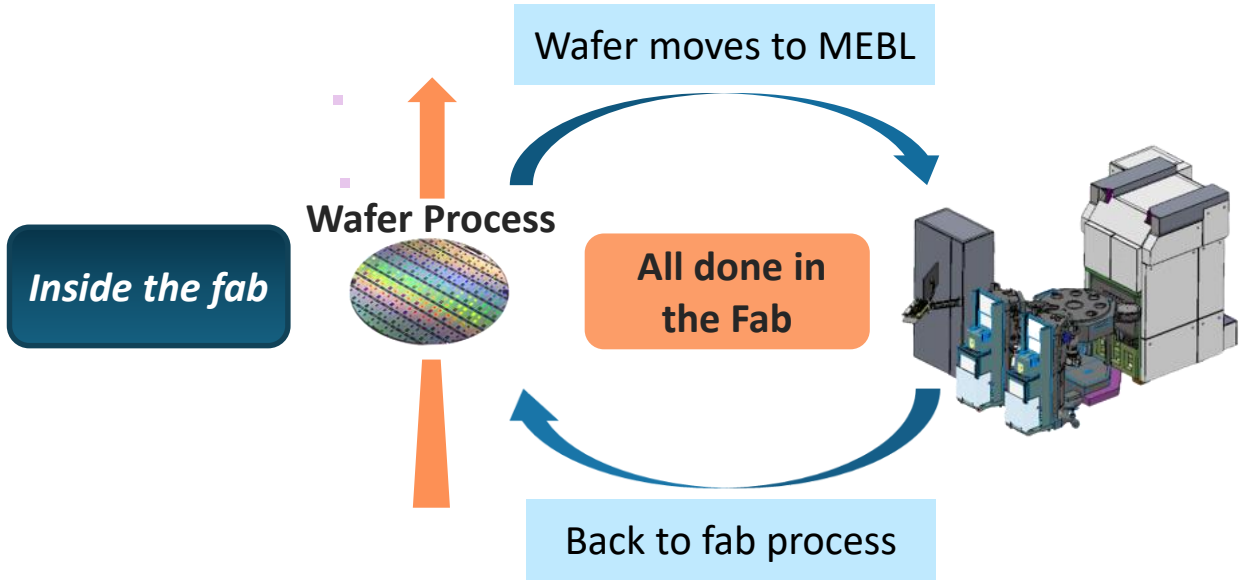
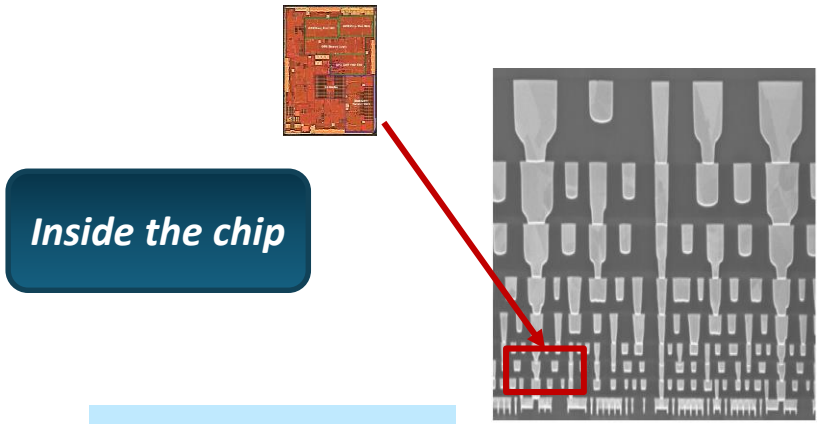
Secure Chip ID 2: Implementation and Benefits





** IC cross section from public domain for illustration purposes*

EVERY die has unique ID
Secure, tamper-proof, etched at silicon level

No impact on die size or chip function
Can be hidden within layers

Implemented in wafer fab
Can be stored in the ROM inside chip

Can't be reverse-engineered or altered without destroying the chip

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A Few Things I Didn't Know MEBL Could Do So Well

	State-of-the-Art *Optical Litho*	High-Productivity *MEBL*
DoF	~100 nm	± 10 µm ("3D litho")
Proximity Effect	Challenging	Can be beneficial to LER
Auto-Stitch	No	Yes
FoV	Limited to 26 x 33 mm^2	Full wafer
Hardcoding Chip ID	Can't do	> 25 wafers/hr per module

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A Good Time to Launch MEBL? What Will MEBL Be?

Market inflections are helping MEBL adoption:

- Diverse applications at mature nodes
- High-mix production in modest volumes
- 200mm renaissance

What will MEBL be when it grows up?

- Complement Optical; boost success of both technologies
- Be an indispensable tool in every fab's litho toolbox

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The Joy of Full-Wafer Patterning

MULTIBEAM logo
written with
100 nm e-beam pixels
across a 200 mm wafer

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Thank you.