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Workflow Automation For High Volume TEM Data Production

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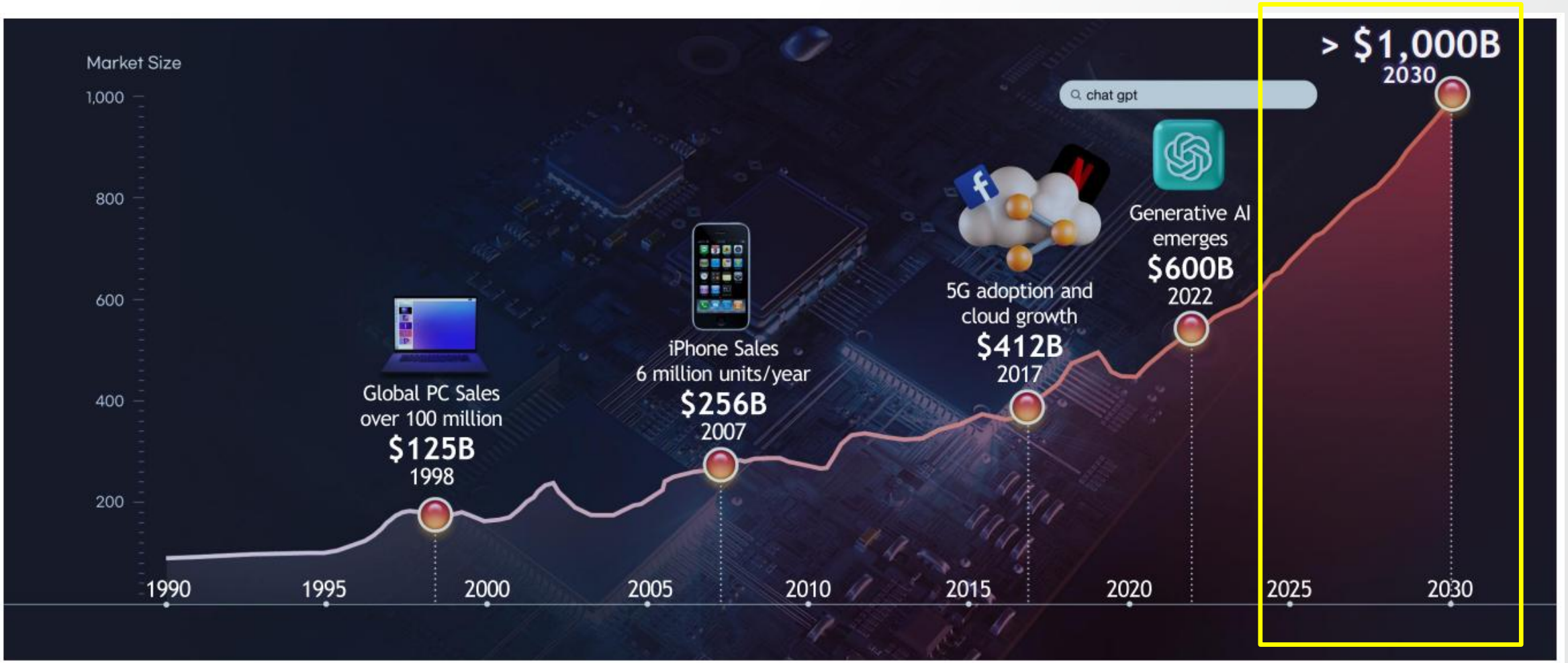
Agenda

1. Industry Trends toward Increasing TEM Usage
2. Challenges in TEM sample preparation
3. Process Automation in TEM Preparation and Imaging
4. How Automation is bridging the gap between Lab and Fab

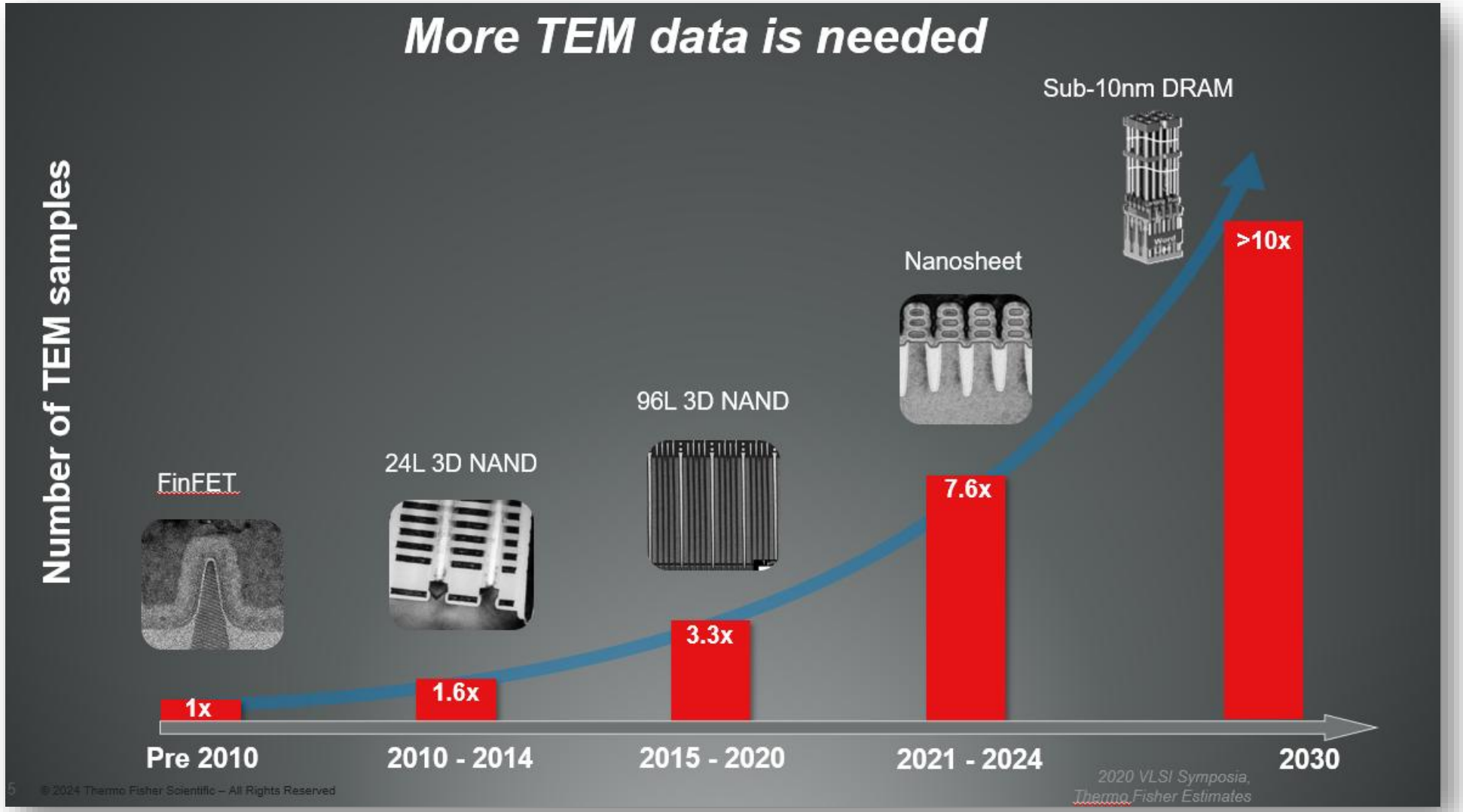
Rapid Growth in Semi is Mainly Driven by AI and HPC



Source: VLSI 2025 SC-1 (SK Hynix) - SEMI, VLSI, and Applied Materials

Ai is emerging and projected to drive the Market Size up to $1 Trillion by 2030

Customer Challenges – More TEM Analysis!



Device complexity is driving the need for TEM automation to meet growing sample demands

Key Steps in TEM Metrology

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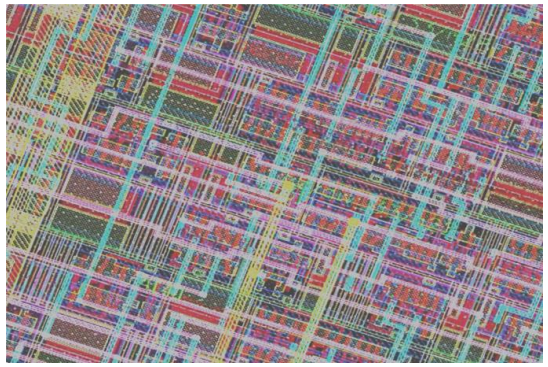
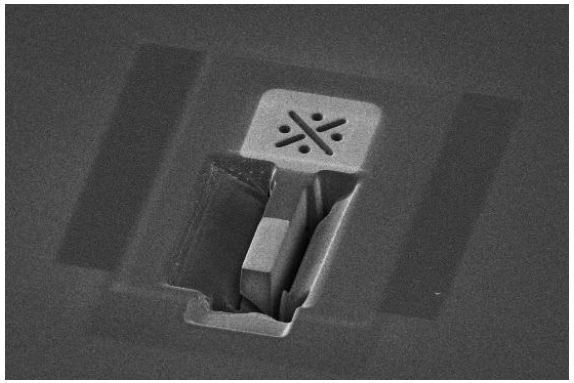
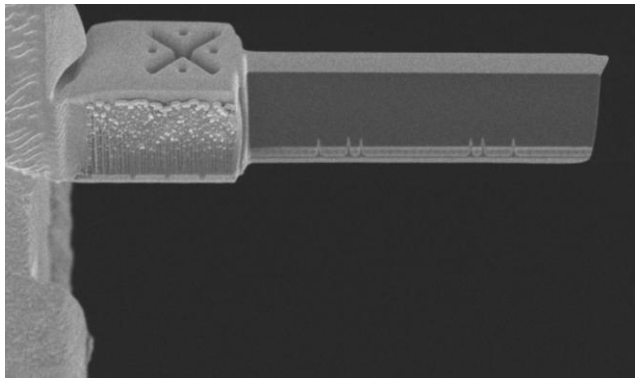
TEM Lamella Preparation and TEM Imaging



Wafer

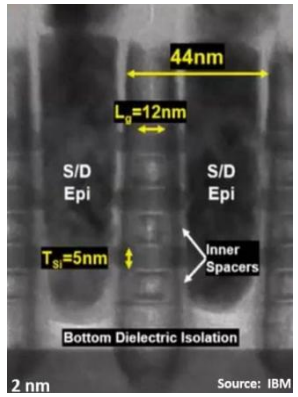


Lamella Milled on wafer



Lamella Welded to grid

TEM: Fin-view



TEM: Gate View

Sample (Lamella) Preparation tools

Imaging tools

Challenges in Sample prep for TEM Metrology

- Advanced logic: ~20-30 nm thick lamella
- 3D NAND / packaging: <70 nm, ; industry asking for >10um deep samples
- Robust, useful lamella
  - Centering and Thickness Accuracy metrics
- Operator Technical Expertise
- # of trained operators

Solutions

AUTOMATION!

Productivity
Faster cycle times and higher tool utilization

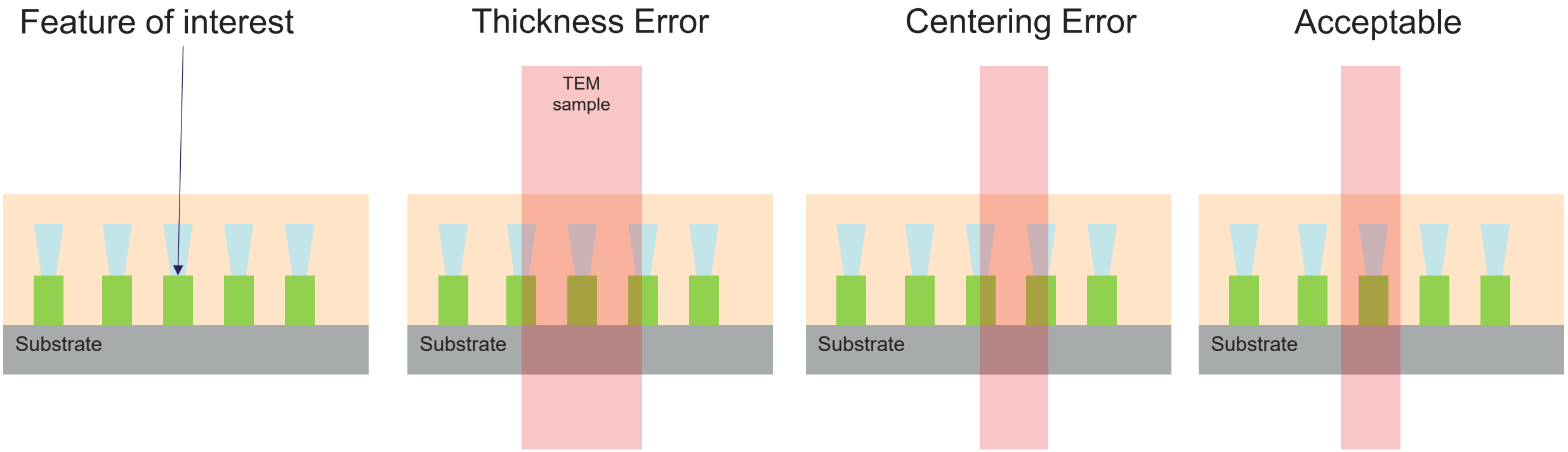
Yield
Automated workflows reduce process and Operator variability

Operating Cost
Lower OpEx through reduced labor and higher uptime

Automation is key to industrializing lamella production

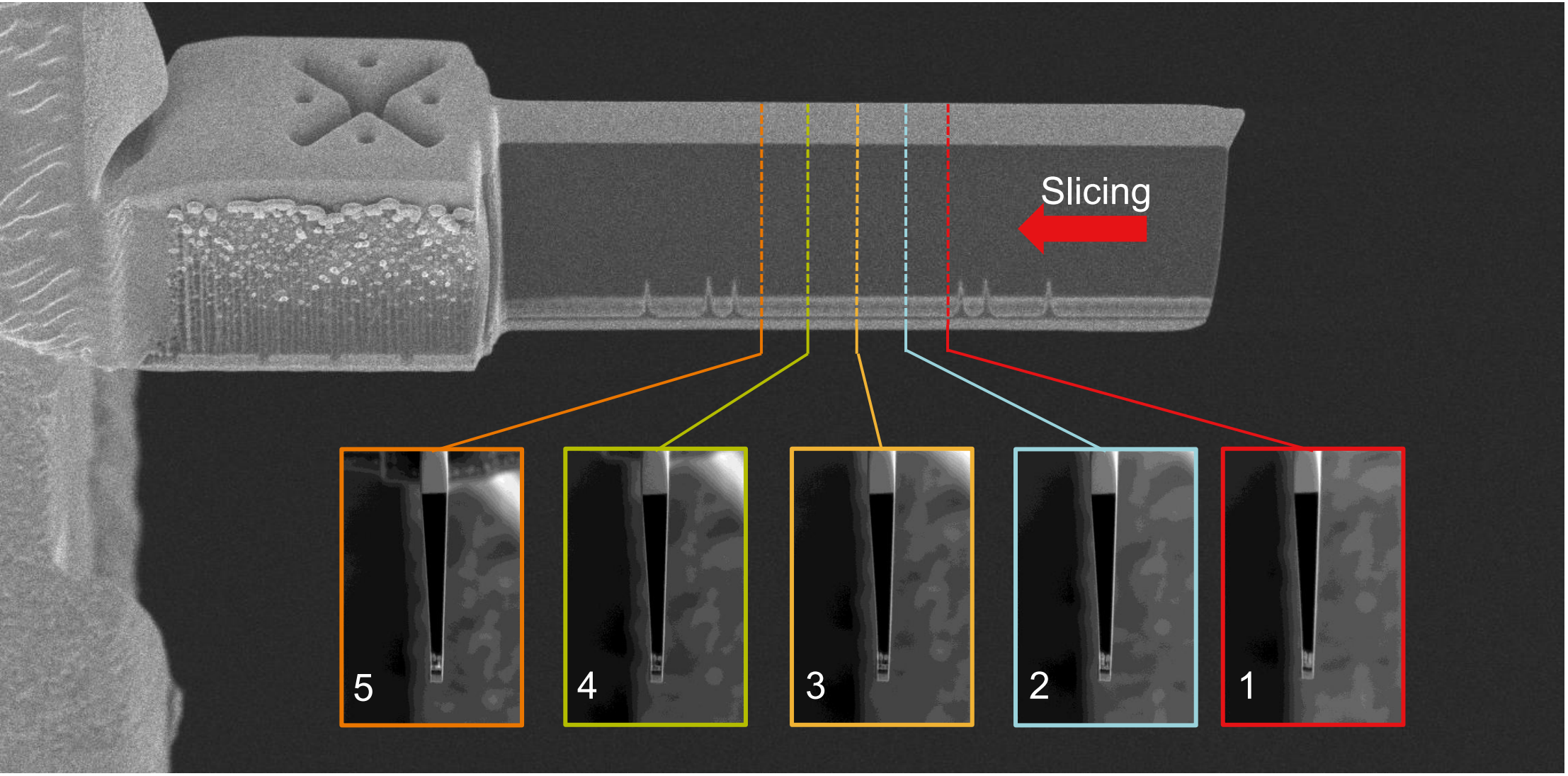
Critical Lamella Metrics

Lamella Centering Accuracy (LCA) & Lamella Thickness Accuracy (LTA)



Cross-sectional representation of a device to be analyzed with TEM metrology

Sectioning for Lamella Quality Assessment

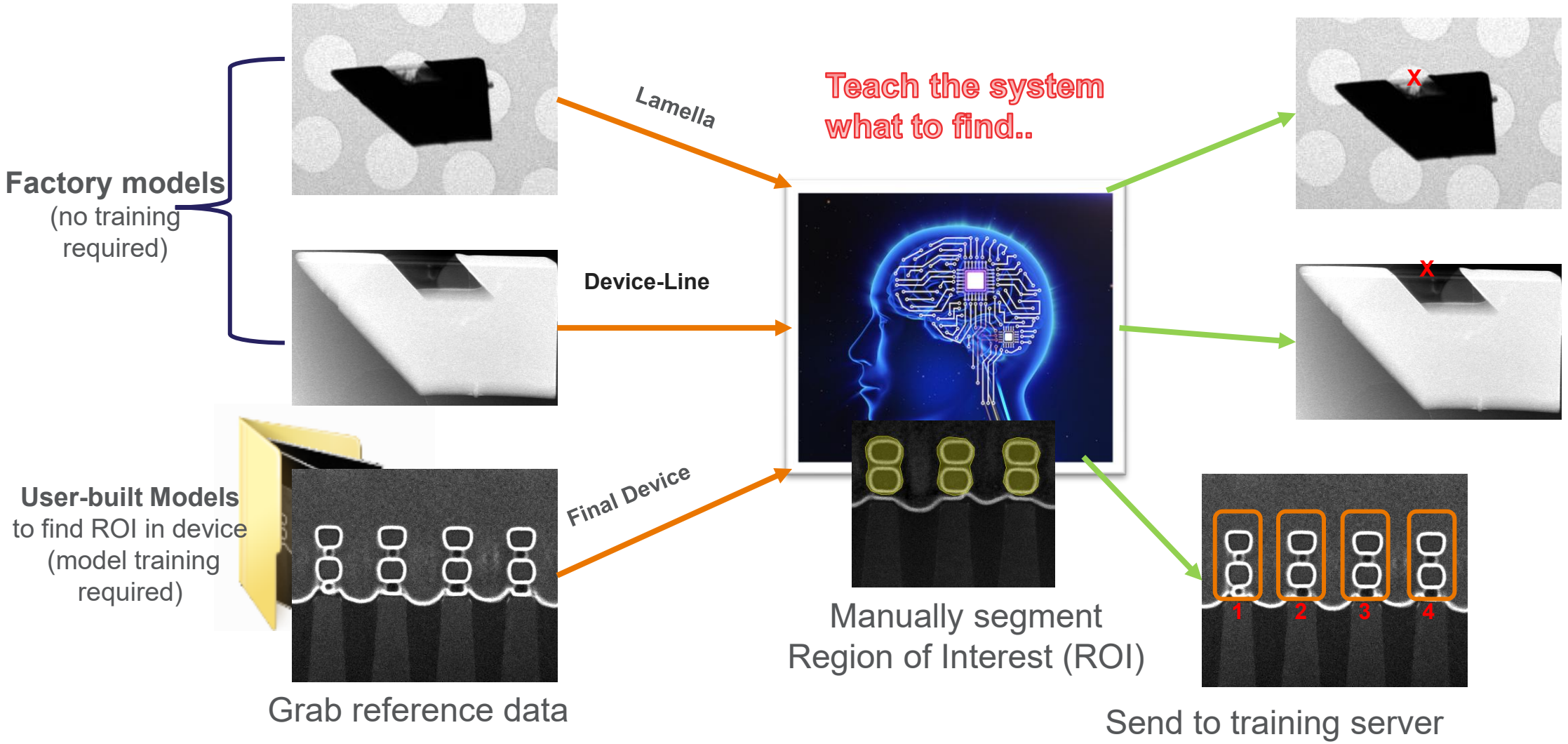


Automated End-point Detection Results

Automated Process Performance Metrics

Preparation Method/System	Typical LCA	Typical LTA
Manual Sample Preparation on Helios EXL	6nm, high operator dependance	6nm, high operator dependance
ExSolve G2 Automated TEM Sample Preparation	<4.4nm	<3.6nm
Vulcan Active Endpointing	<2nm	<2nm

Smart Automation

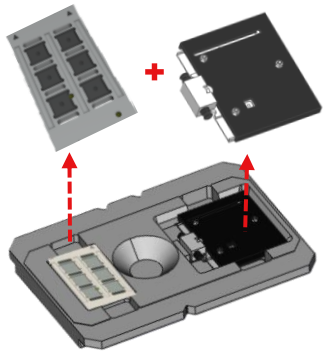


Automated Material Handling for TEM Samples

1 Fresh LCs are pre-loaded into Helios

FLCC LC

2 AMHS loads tray with die carrier and LCC

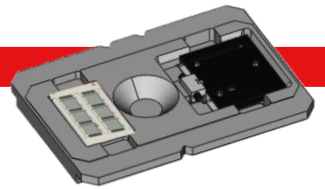


3 LC EFEM prepares shuttle and loads into Helios

Helios 6HXS With LC EFEM

4 Lamellae are created in Helios automatically

5 Filled Tray is transported by AMHS



Tray with LCC and die Carrier

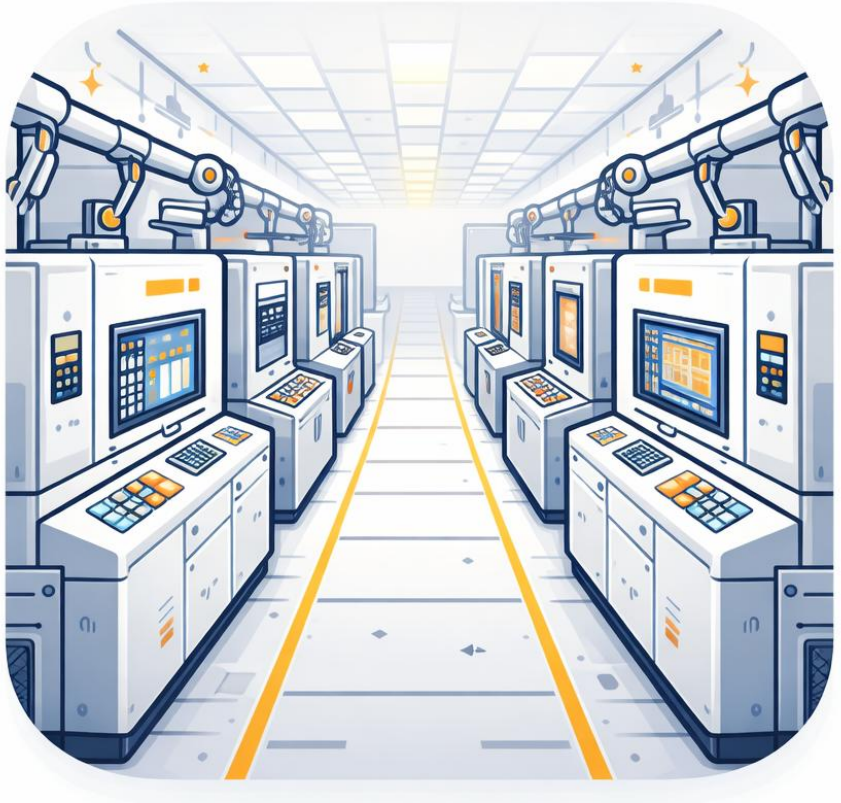
METRIOS 6S With LC EFEM

Summary

- **Market Pull**
  AI + advanced architectures are driving massive TEM demand

- **Manual workflows cannot scale to fab-level throughput**

- **Automation is the Solution**
  - Automated lamella production
  - Automated imaging
  - Automated Material transfer & Data Connectivity – From Fab to Lab



Thank you