TRENDS IN CMP AND IMPACT ON CONSUMABLES

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LINX Consulting
see beyond the horizon

Linx Consulting Service Portfolio

- **Multi-Client Reports**
  - CMP & Specialty Abrasives
  - Advanced Deposition
  - Patterning Materials
  - Cleaning & Surface Prep
  - Electronic Specialty Gases
  - Bulk Chemicals
  - ALE
  - Photomasks

- **Proprietary Projects**
  - Market Planning
  - M & A
  - Growth and Diversification
  - Supply Chain Optimization
  - Technology Commercialization
  - Strategic Planning
  - Voice of the Customer
  - Market Diligence

- **Econometric Semiconductor Forecast**
  - Financial planning
  - Sales and Operational planning
  - Forecasting & Scenario development

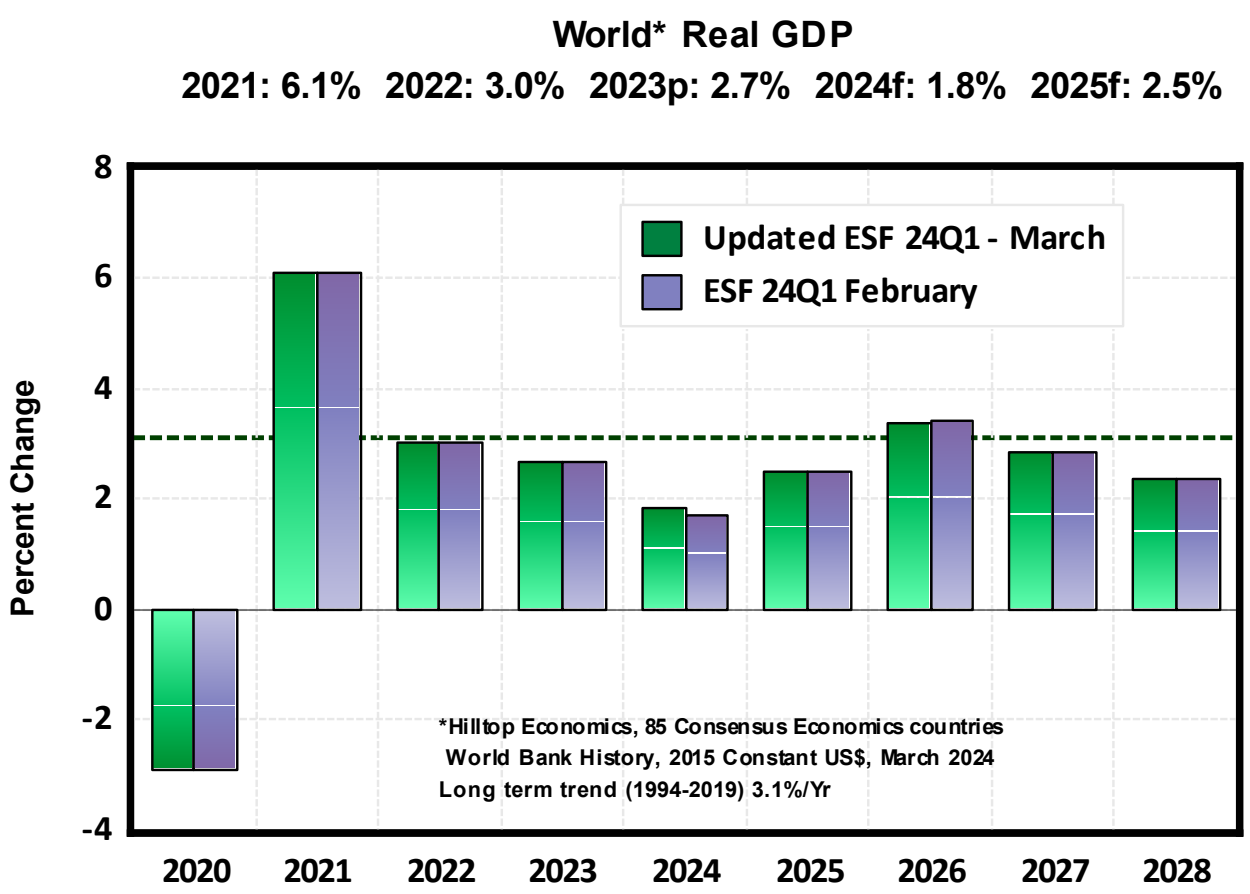
  With Hilltop Economics LLC

- **Cost Modeling**
  - Client demand modeling
  - Product development
  - Bill of Materials quantification

- **Semiconductor Technology & Market Conferences**
  - The Business of Cleans & SPCC
  - Electronic Specialty Gases & Systems

- **Continuing Services**
  - Forecast Service
  - Technology Trends

Global Economic Background



Regional GDP Growth Forecasts

March Update *vs ESF 23Q4*	*2023 November*	**2023 ESF**	*2024 November*	**2024 ESF**	*2025 November*	**2025 ESF**	*2026 November*	**2026 ESF**
U.S.	*2.4*	**2.5**	*(0.3)*	**1.2**	*1.8*	**1.6**	*3.3*	**2.9**
Asia-Pacific	*4.1*	**4.2**	*3.1*	**3.4**	*3.6*	**3.6**	*4.5*	**4.4**
Europe	*0.5*	**0.4**	*0.2*	**0.2**	*1.4*	**1.3**	*2.4*	**2.3**
Latin America	*1.9*	**2.1**	*0.8*	**0.8**	*2.5*	**2.4**	*3.1*	**3.0**
Total World	2.6 ➡	**2.7**	1.3 ➡	**1.8**	*2.5*	**2.5**	**3.5** ➡	**3.4**

Source: Hilltop Economics

Outlook for MSI is Still Strong

	Y-on-Y Growth
2023	-14 %
2024	4 %
2025	15+ %

New Technology Challenges

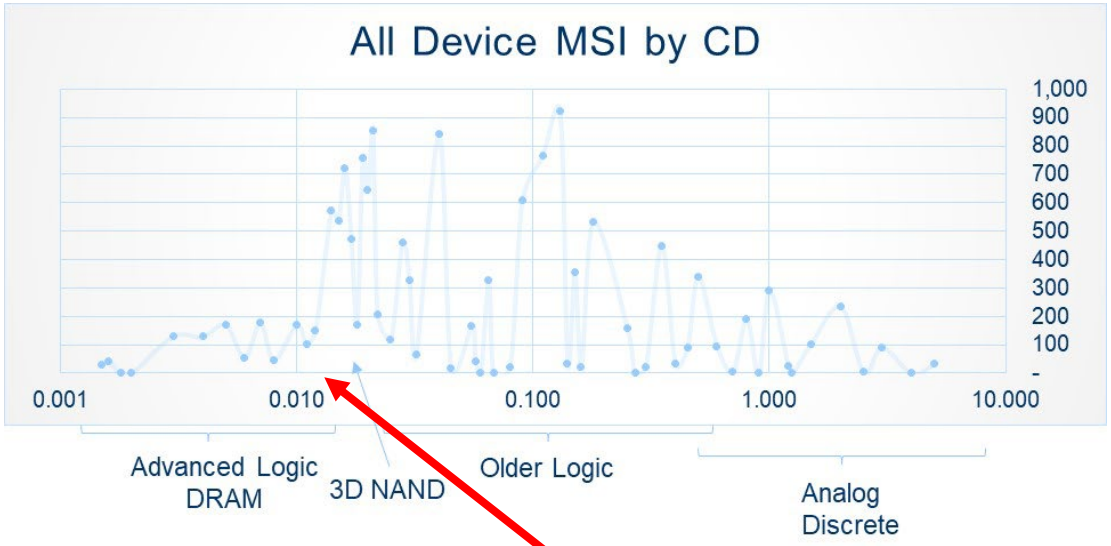
Technology Challenges

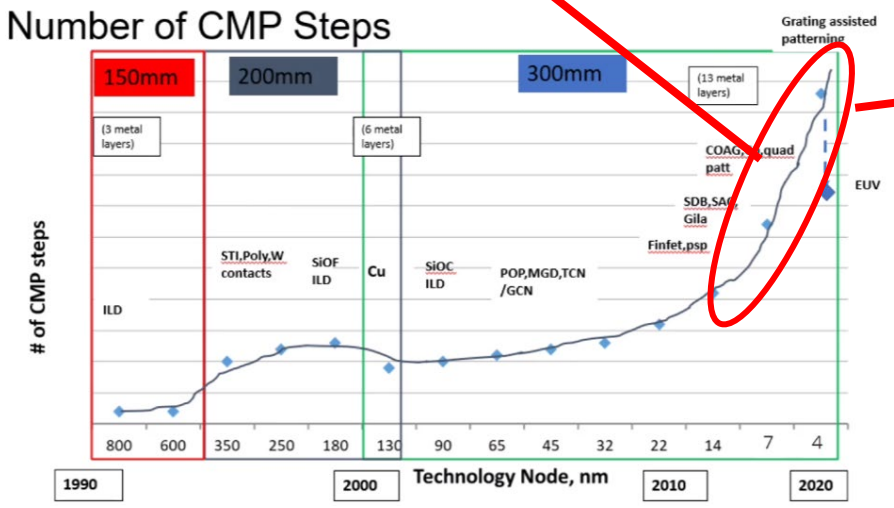
- EUV /HNA EUV pattern transfer
- Metrology gaps
- 3D Structure challenges
- Logic transistor architectures
- Backside power delivery
- Vertical DRAM stacking
- Heterogenous Integration

Novel Materials and Processes

- High NA EUV
  - Patterning approaches and materials
- CVD & ALD Metals for interconnect and power
- Atomic Layer Etch
- Area Selective Deposition
- Selective dry or wet etch, and subsequent cleans
  - GAA transistors
  - 3D NAND
  - Vertical DRAM

CMP Aligns With Advanced Nodes



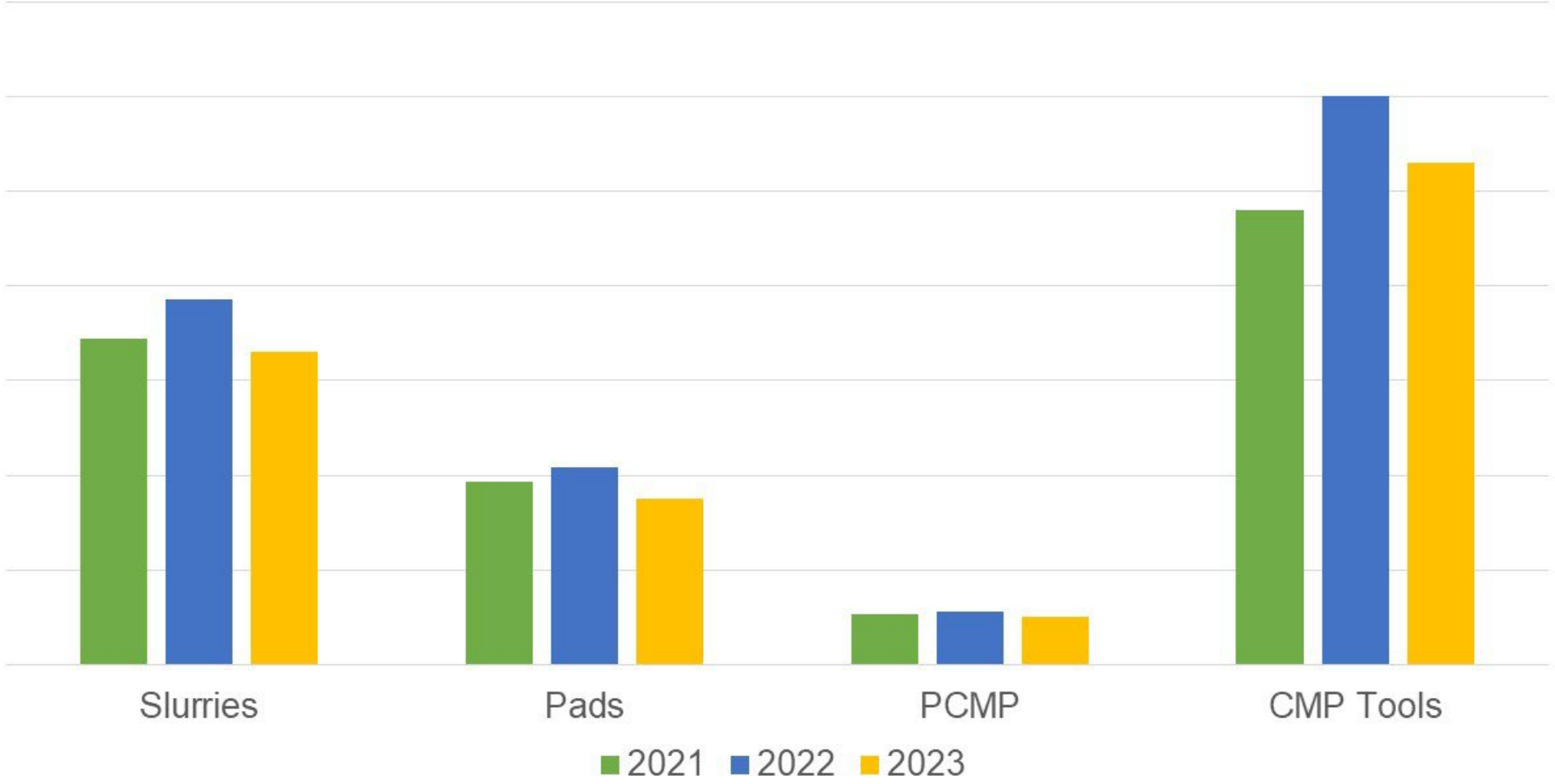


Growth of CMP Processing in Advanced Logic Nodes

- Litho DOF - Higher NA requires flatter surfaces
- Metal damascene
- Dielectric trench
- Smoothening
- Etchback does not sufficiently planarize
- Advanced pattering / grating
- TSV
- Power via
- BPR
- Wafer bonding
- Bridges

Source Price, Intel, ICPT2022

CMP Consumables ~ CMP Tools ($ basis)



Challenges Facing Materials Suppliers

Materials Supply Challenges

Geopolitical Influences

- Materials supply chain is becoming less efficient and more costly due to dual supply chain and localization (De-risking)
- Upstream raw materials uncertainties have caused interrupted supply
- Alternative sources and new source re-qualification process may cause higher raw material cost

Environmental Control Regulations

- Continued efforts to develop alternative greener chemistries for restricted materials such as GHG, PFAS, TMAH, NMP…etc.
- New ways for looking at shipping and container costs
- Recycling considerations
- Green inflation may be caused by extra resource requirements and high switching cost of alternative solutions

Materials Supply Challenges

Limited Supplier Options

- Longer supply lead time and possibly interrupted supply due to insufficient capacity on critical materials
- Quality system knowledge limitation of tier 2 suppliers
- Post-M&A concentrated supplier base in critical segments without alternative choices
- Increasing bargaining power of dominant suppliers and possibly price increase

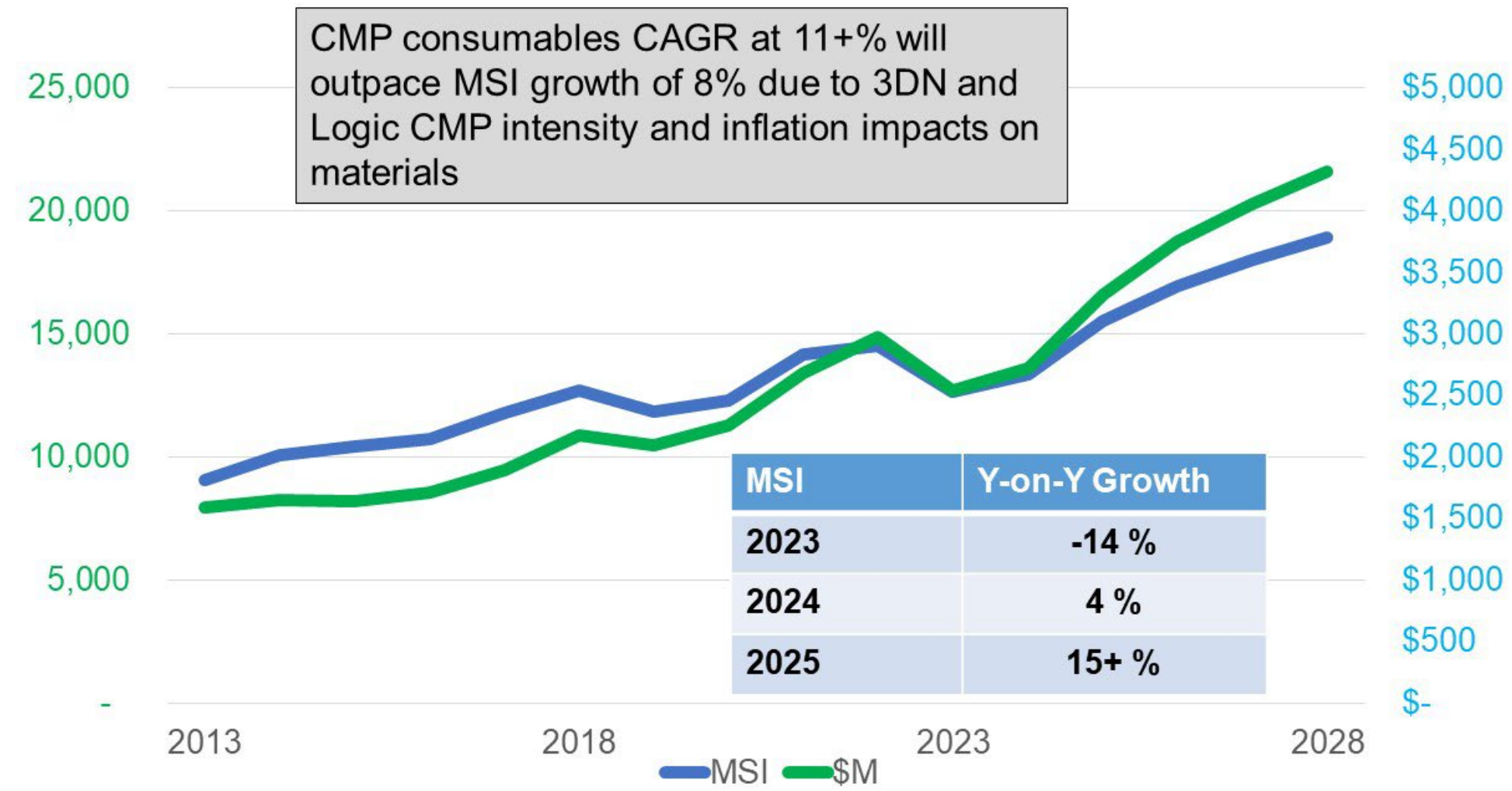
Governmental Support

- Global leading-edge semiconductor manufacturing has been recognized as a critical geo-political imperative, and national governments are incentivizing domestic capability for economic and strategic reasons.
- How will government support for advanced production in Korea, Japan, Europe, China and USA impact market?
- Impact on Materials Suppliers - Suppliers must balance technical capability and infrastructure with localized customer support

Challenges - Localization Barriers

	Raw Mats Supplier Breadth	R&D CT Criticality	Infrastructure : Revenue Cost	Applications Support Intensity	Supplier : Customer Density	Ease of Localization	Comments
Bulk Wet Chemicals	Broad	Low	Low	Low	Regional	Easy	Specialized Permitting Required. Costly to ship long distances.
Slurry	Unique	Medium	Medium	Medium High	National/ Site	Medium	Local Support Costs. Local Manufacturing Preferable.
Photoresist Advanced	Unique	High	High / Unaffordable	High	Site	Difficult	Innovation Costs Require Scale. Centralized R&D and Manufacturing

Outlook - CMP Consumables Grow Above MSI



MSI	Y-on-Y Growth
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Summary

Over the next decade per capita semiconductor demand will rise at double the global GDP growth rate, and increasing materials intensity for advanced chips will compound this growth to 10-15% AAGR for materials used in sub 5 nm technologies.

Global leading-edge semiconductor manufacturing has been recognized as a critical geo-political imperative, and national governments are incentivizing domestic capability for economic and strategic reasons.

2023 and 2024 will be challenging for both materials and equipment supply chains.

Government regulation may have an impact on materials availability for legacy and leading edge manufacturing.