



“Impact of Advanced Memory Technologies on CMP Industry”

CMPUG July 11, 2018

Mike Corbett

Linx Consulting Inc.

Outline

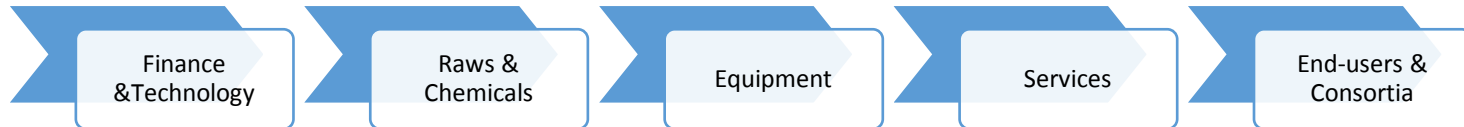


- Introduction to Linx Consulting
- Semi Industry Outlook
- CMP in Advanced Devices
- Conclusions

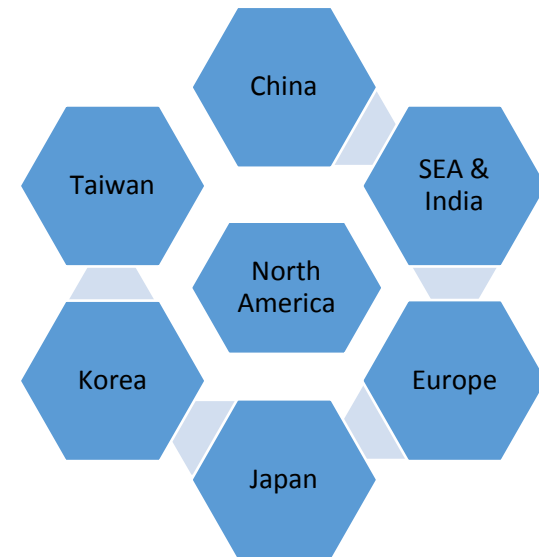


Introduction to Linx Consulting

Linx Consulting



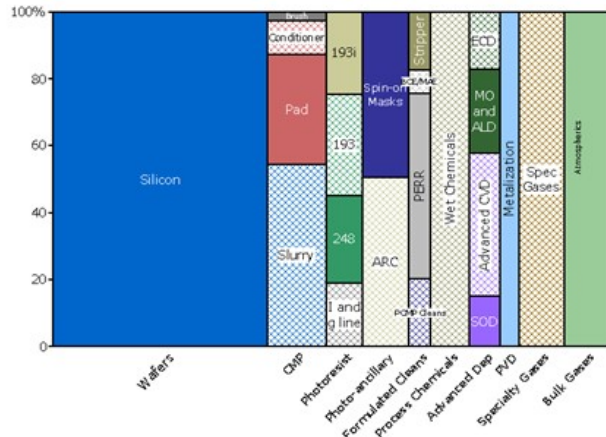
- 1. We help our clients to succeed by creating knowledge and developing unique insights at the intersection of electronic thin film processes and the chemicals industry on a global basis*
- 2. The knowledge is based on a core understanding of the semiconductor device technology; manufacturing processes and roadmaps; and the global structural industry dynamics*
- 3. This knowledge is leveraged to create advanced models, simulations and real-world forecasts*
- 4. Our perspectives are by direct research and leveraging our extensive experience throughout the global industry value chain*



MSI Breakdown & Forecasts



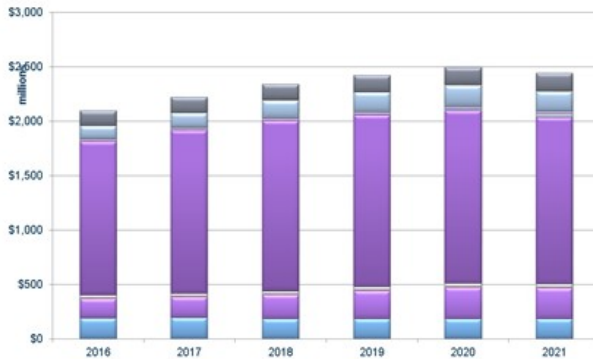
Market Knowledge



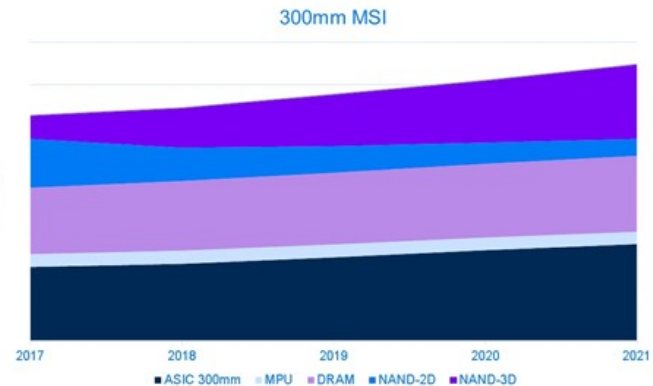
and Understanding



Accurate Forecasts



Insights on Evolution



Linx Consulting Service Portfolio



- **Full Service**

- Forecast Service
- Technology Trends

- **Multi-Client Reports**

- IC Materials
 - CMP
 - Deposition
 - Patterning
 - Cleaning
 - Gases
 - Bulk Chemicals
 - Packaging

- **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

With Hilltop Economics LLC

- **Cost Modeling**

- Client demand modeling
- Product development
- Bill of Materials quantification

With IC Knowledge, LLC

- **Conference Production**

- The Business of Cleans & SPCC

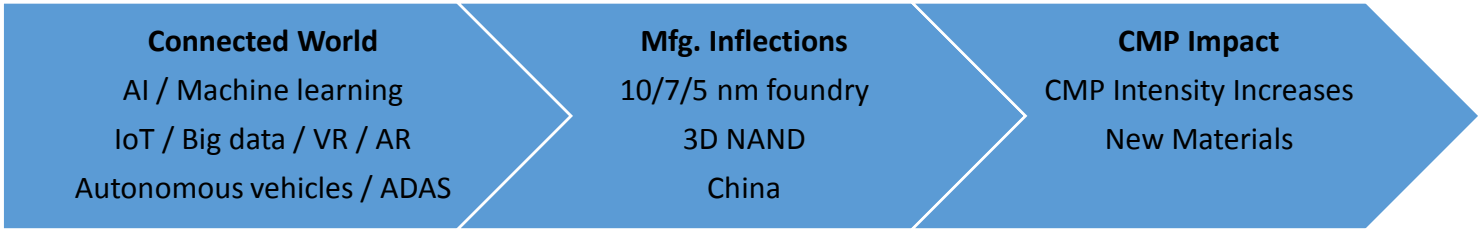
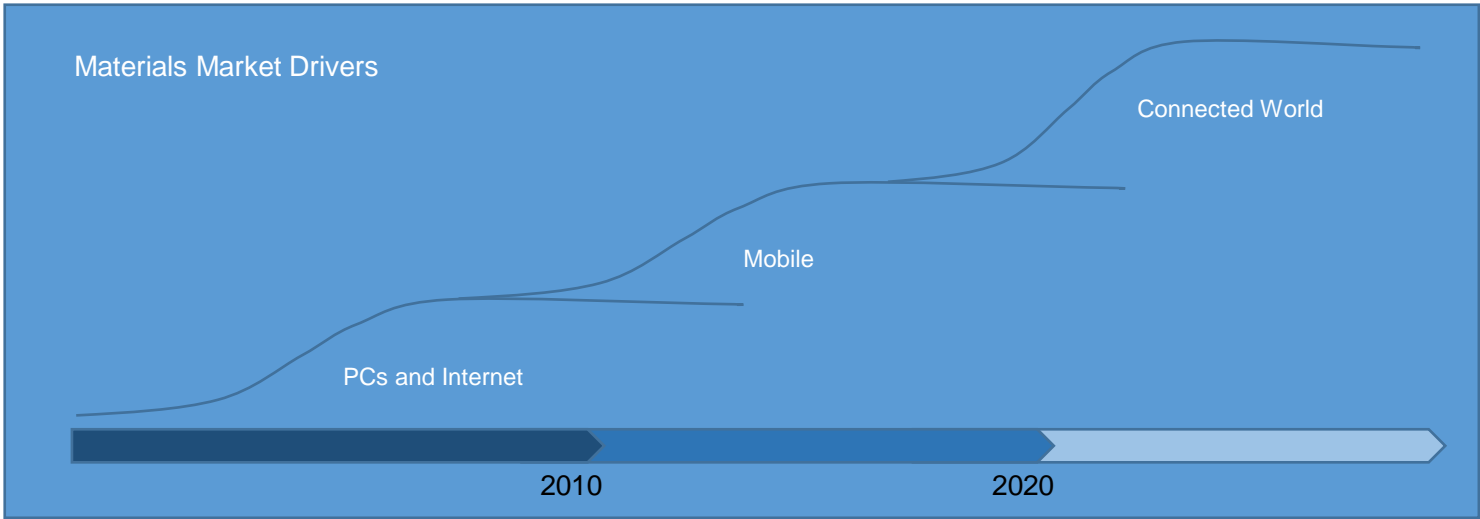
- **Wafer Start Demand Forecasting**

- Device type and technology node



Semi Industry Outlook

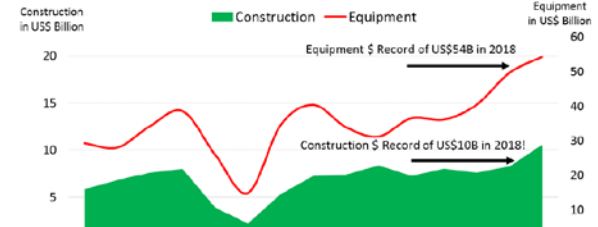
Market Inflections



Record Levels of Capex



Fab Spending shows Records!



Driven by NAND, DRAM and Foundry

NAND

- Samsung Pyeongtaek P1
- SK Hynix M14 3D NAND line
- Micron Building 60 (Lehi) and Fab 10X in Singapore
- Toshiba/Flash Alliance Fab 2, Fab 6 and new R&D Center
- Intel Fab 68 in China

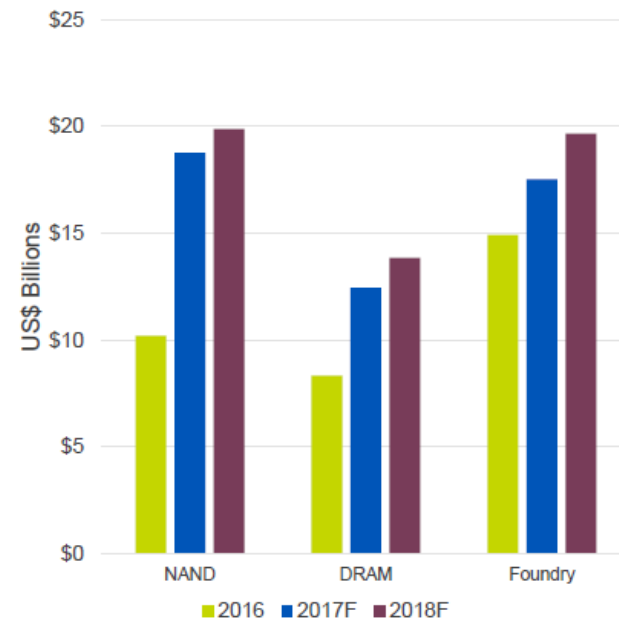
DRAM

- Samsung Pyeongtaek P1 and Line 15
- Micron Fab 15 (Hiroshima) and Fab 16
- SK Hynix M14

Foundry

- TSMC Fab 12, Fab 14 and Fab 15
- Samsung S2 and S3
- GLOBALFOUNDRIES Fab 1, Fab 8 and Fab 11
- SMIC Beijing B2 and B3, new Shanghai 300mm fab and Shenzhen 300mm fab
- UMC Fab 12A P5 and Xiamen fab

Fab Equipment Spending



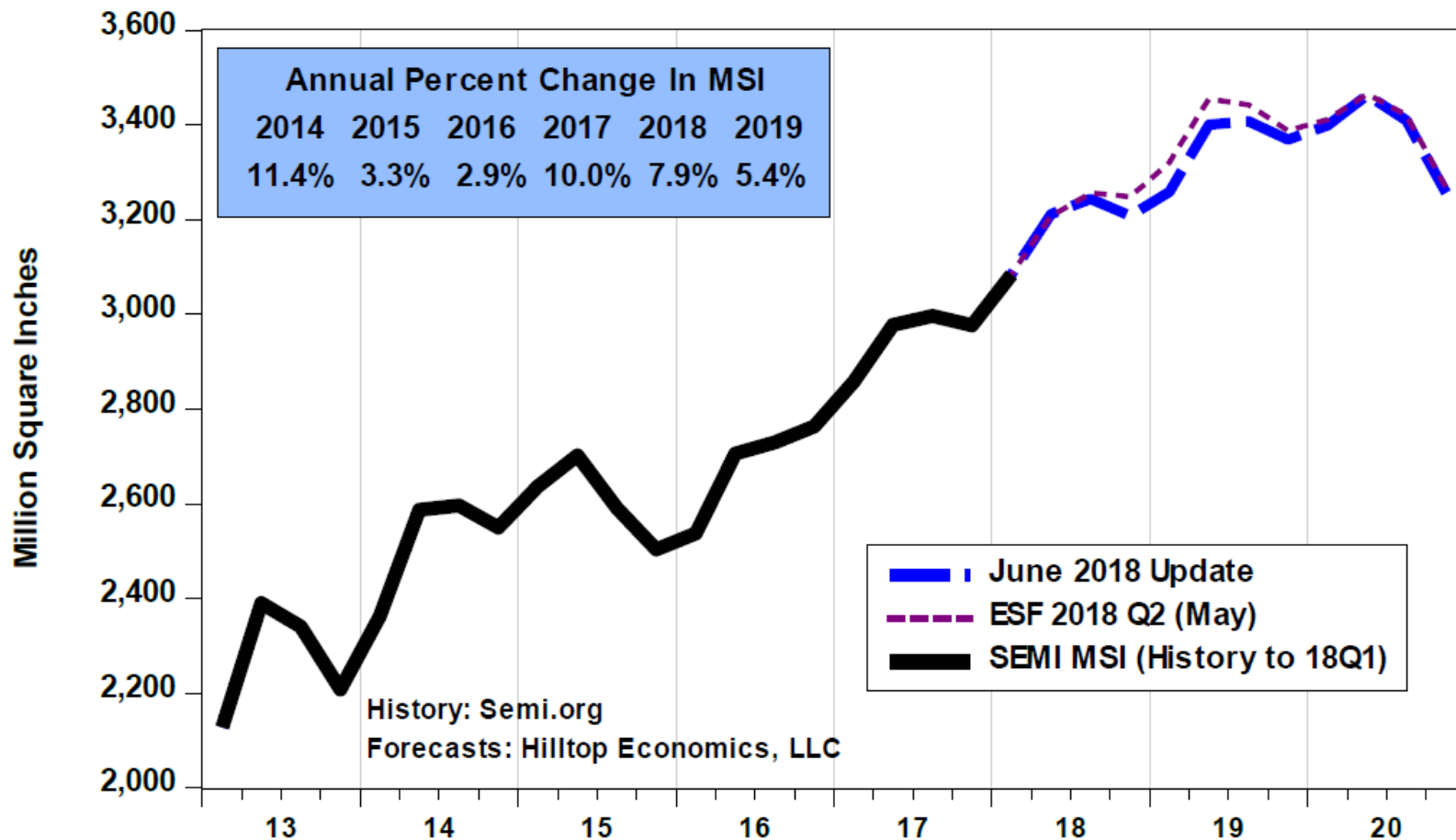
Source: SEMI World Fab Forecast, December 2017

Vertical scaling helps drive Materials Growth and CMP

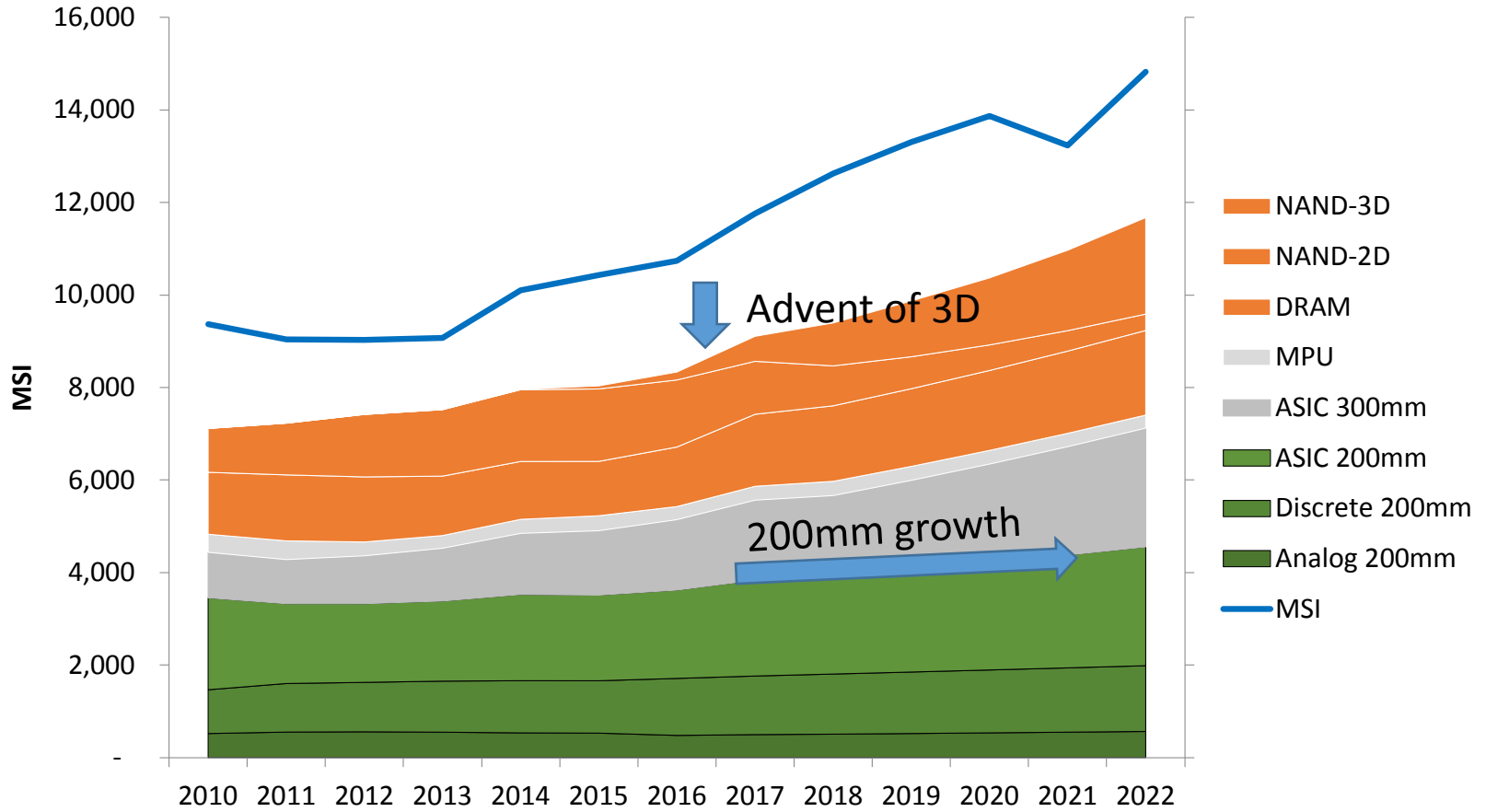
Latest MSI Forecast by ESF Model



Semiconductor MSI Outlook



Silicon Forecast

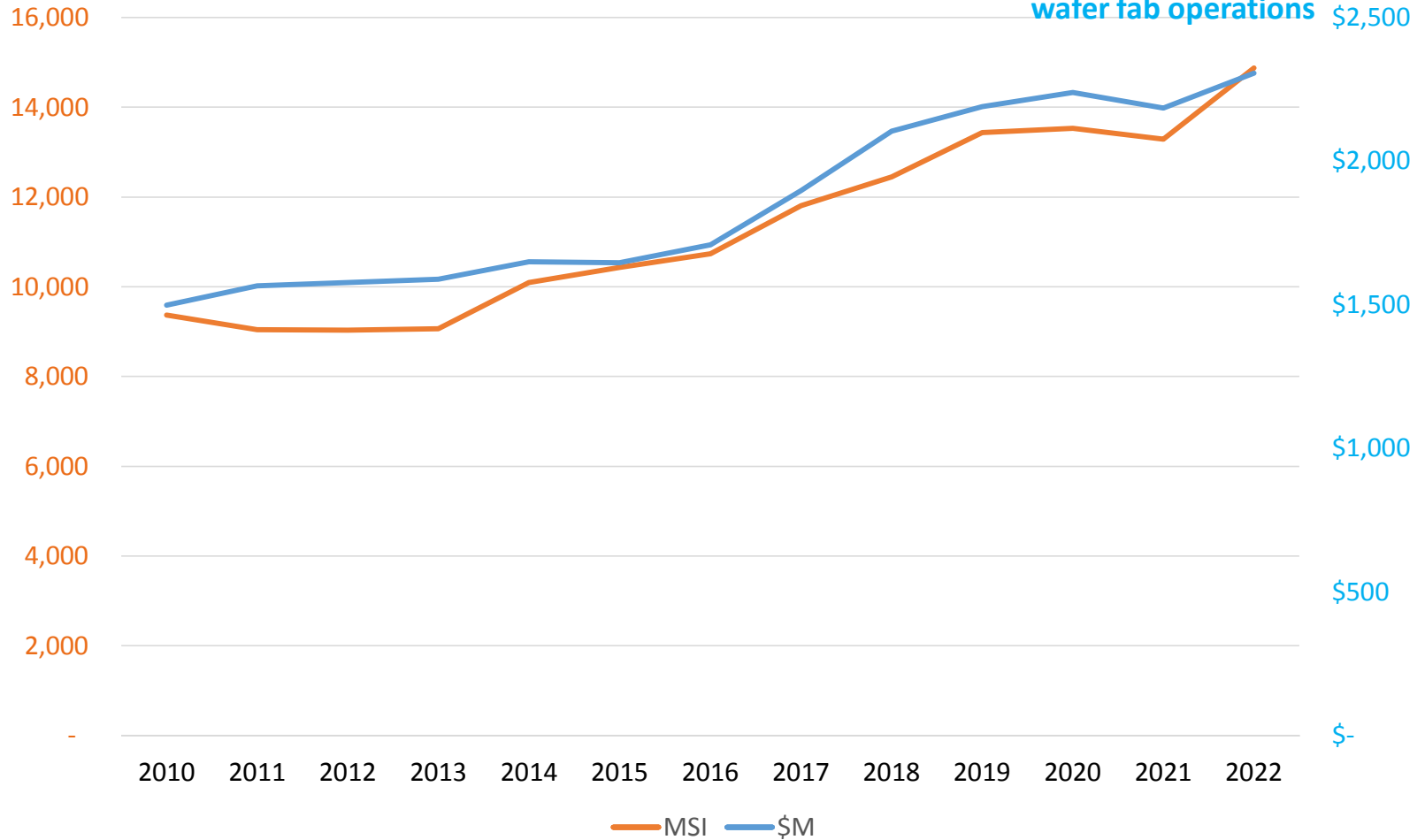


MSI Vs. Slurries and Pads

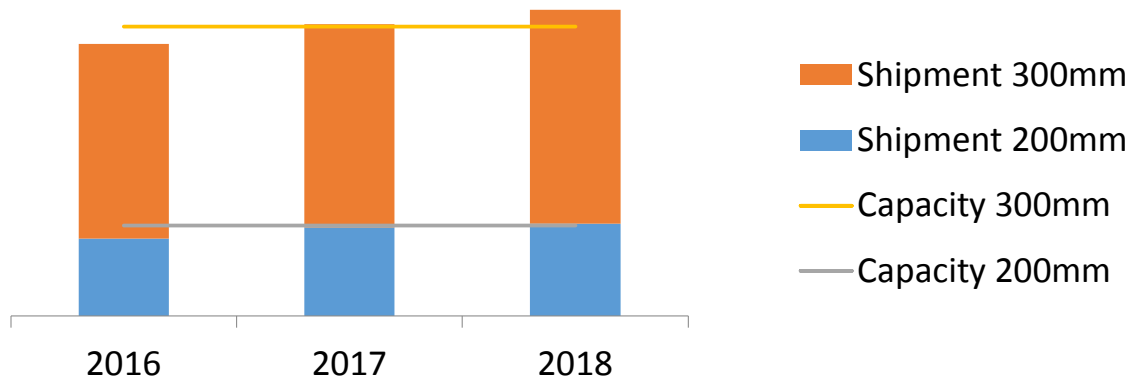


MSI

Slurry and Pad Market, Semi wafer fab operations \$2,500



Wafer Supply May Cause Disruption



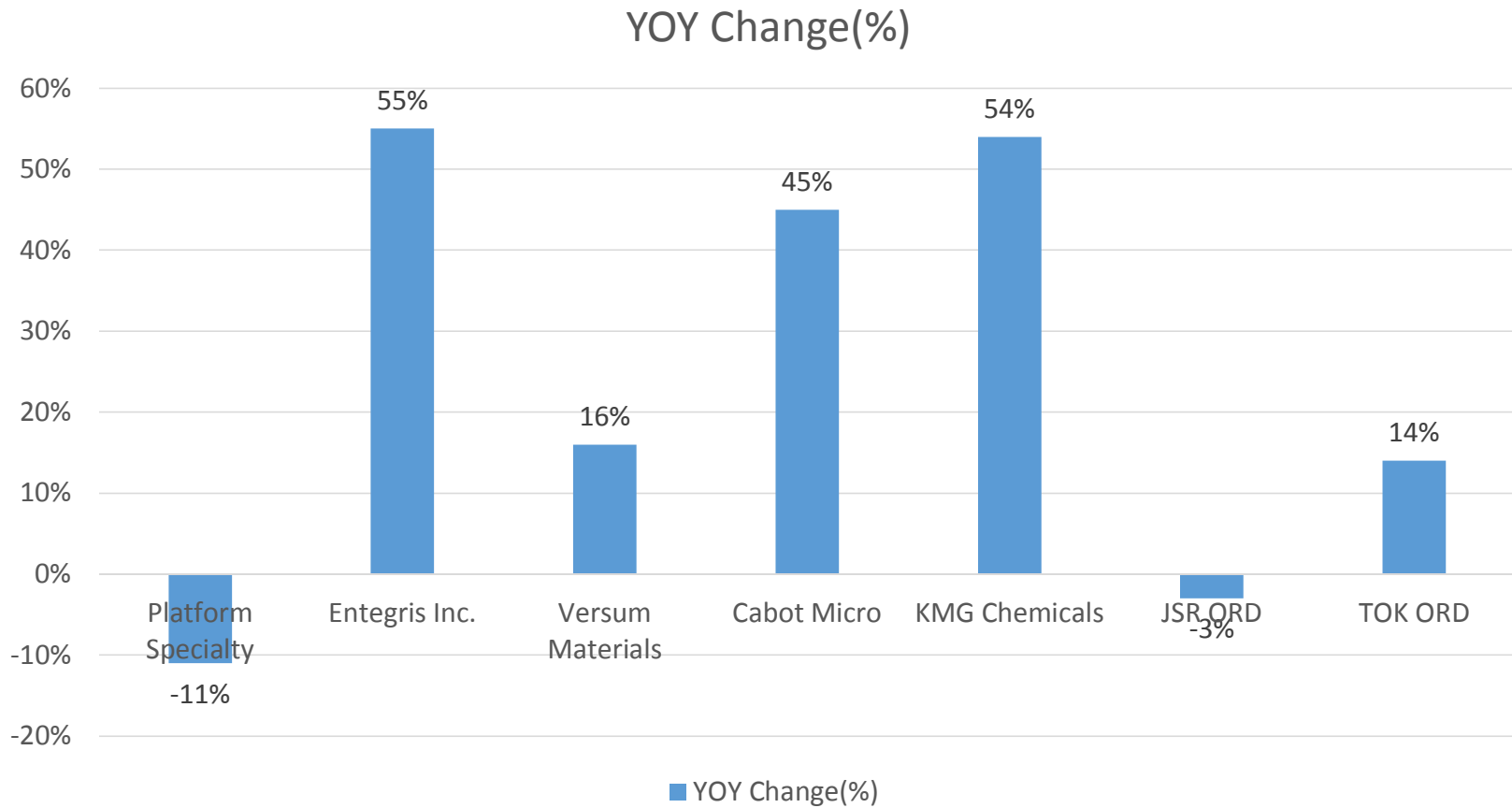
300mm

- Brownfield Investment is being made by leaders
- 300mm contracts are in place for larger end-users.
- China producers still need 3 to 5 years to quality
- Expect 300mm wafer shortages for smaller end-users
- Suppliers may not be prepared for growth

200mm

- US and Europe have stronger than expected outlook
- Auto and IOT applications drive continued 200mm growth
- Fabs are using reclaim wafers for production
- 200mm shortages beginning in 3Q 2017
- Global Wafer has increased 200mm supply
- 200mm from China are of sufficient quality

Linx WFM Liquidity Index





CMP in Memory



CMP is Aligned with WFM Trends

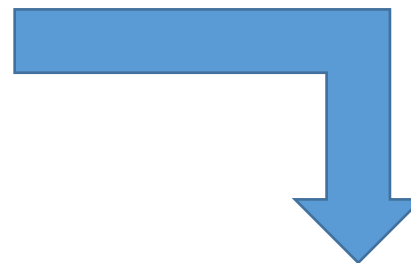
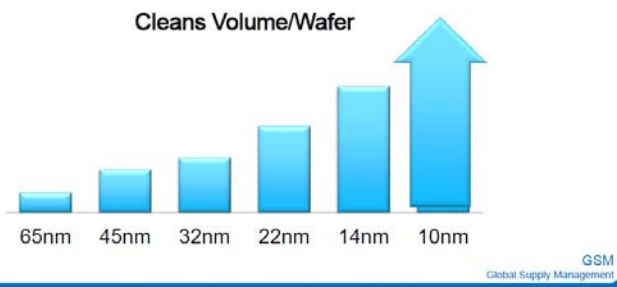
Increasing Chemical Consumption

Trends in Advanced Technology Wet Cleans

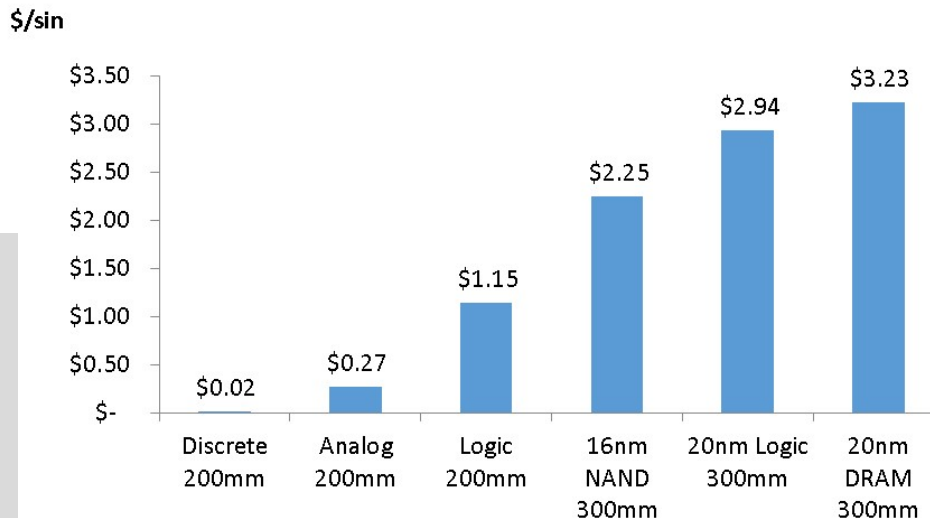
Wet chemical consumption per wafer is increasing

- Proliferation of single-wafer processing, higher number of layers
- Multi-step patterning, more complex process flows
- Defect reduction, less recycle

Larger volumes increase scrutiny on chemical cost (\$)



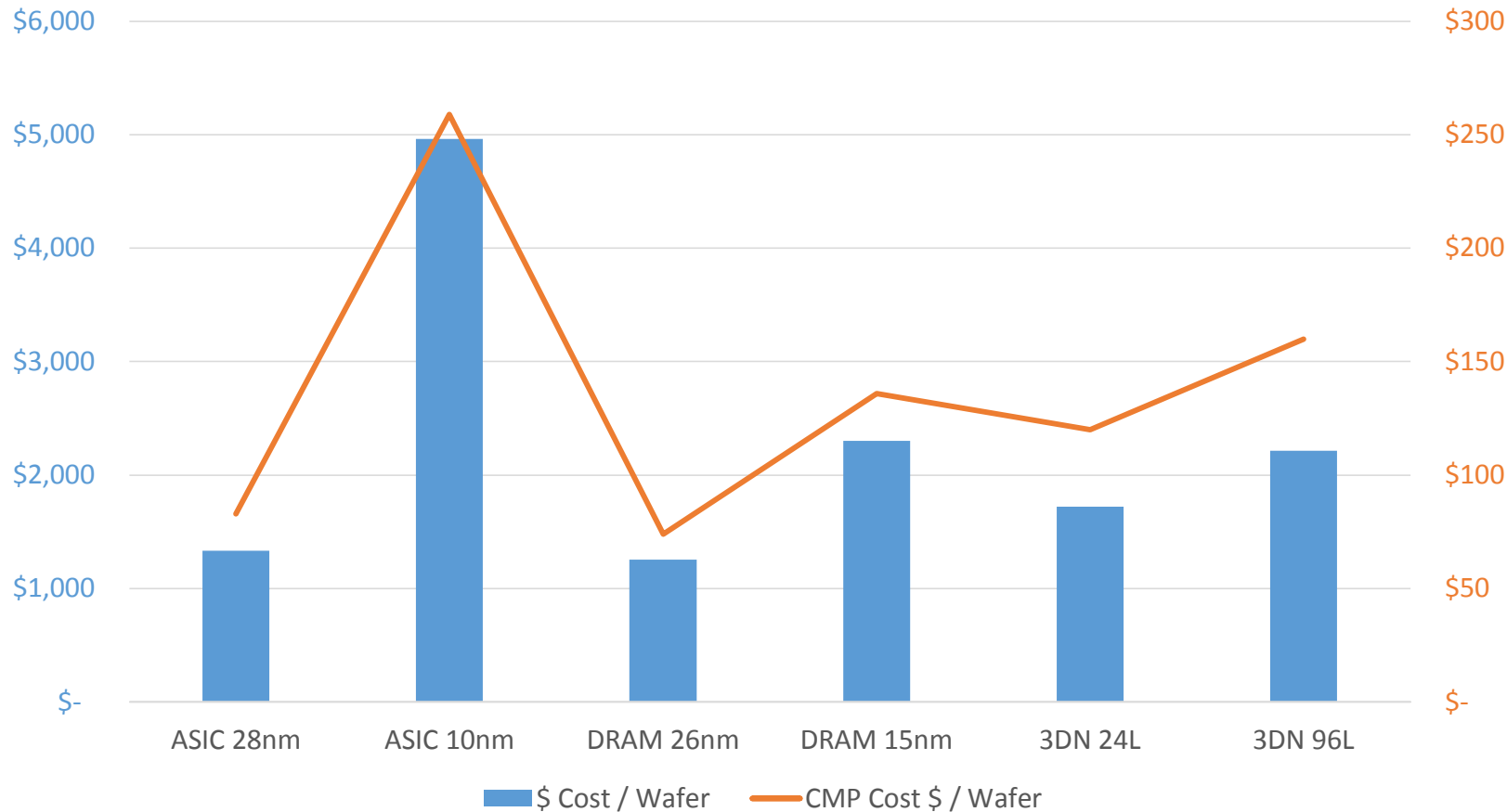
Bill of Materials – Si not Included



Trend driven by:

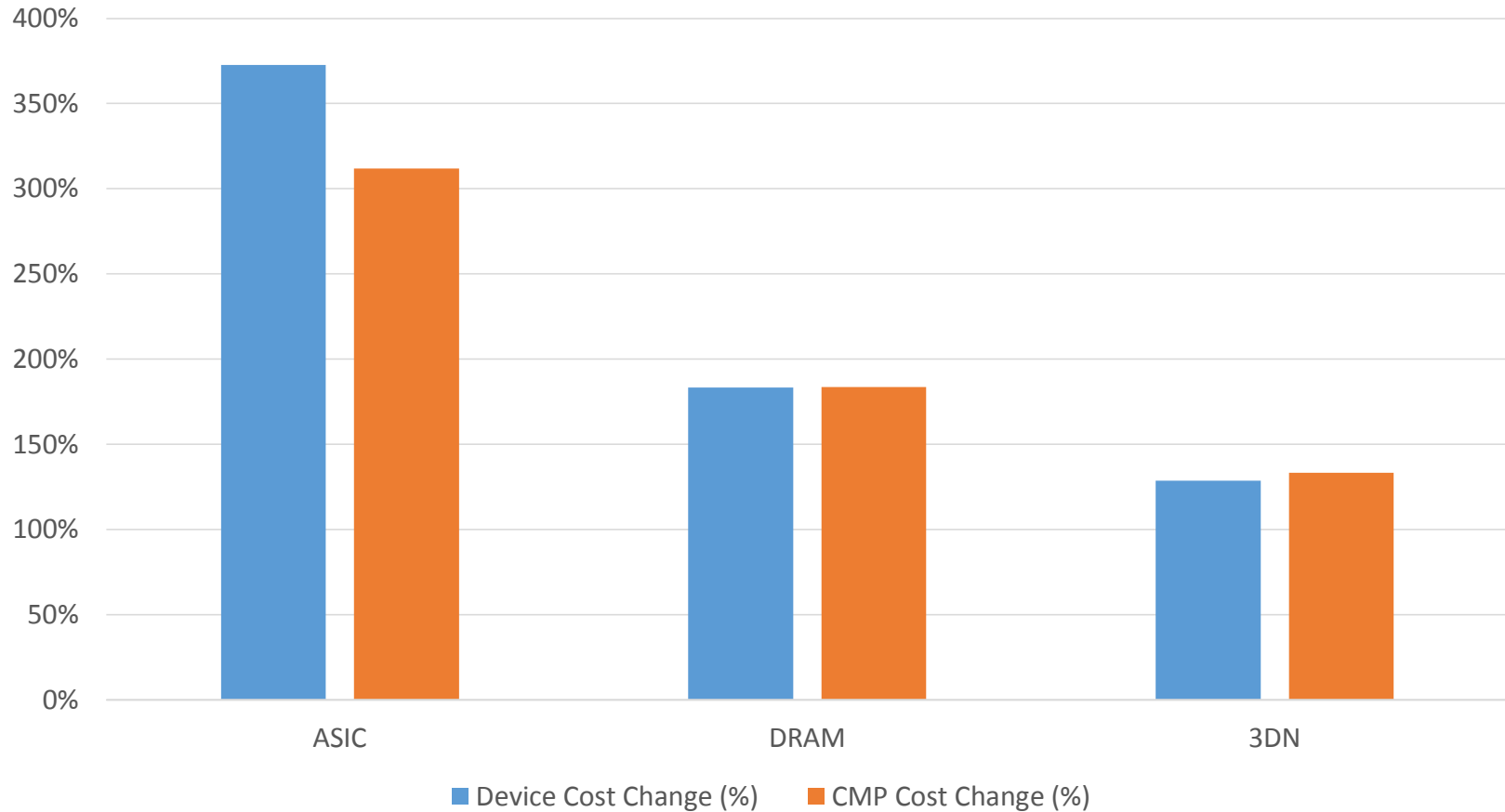
- Increased # of interconnect and FEOL layers
- RMG process
- Multi-Patterning
- New materials integration

Overall Processing & CMP Cost Per Wafer



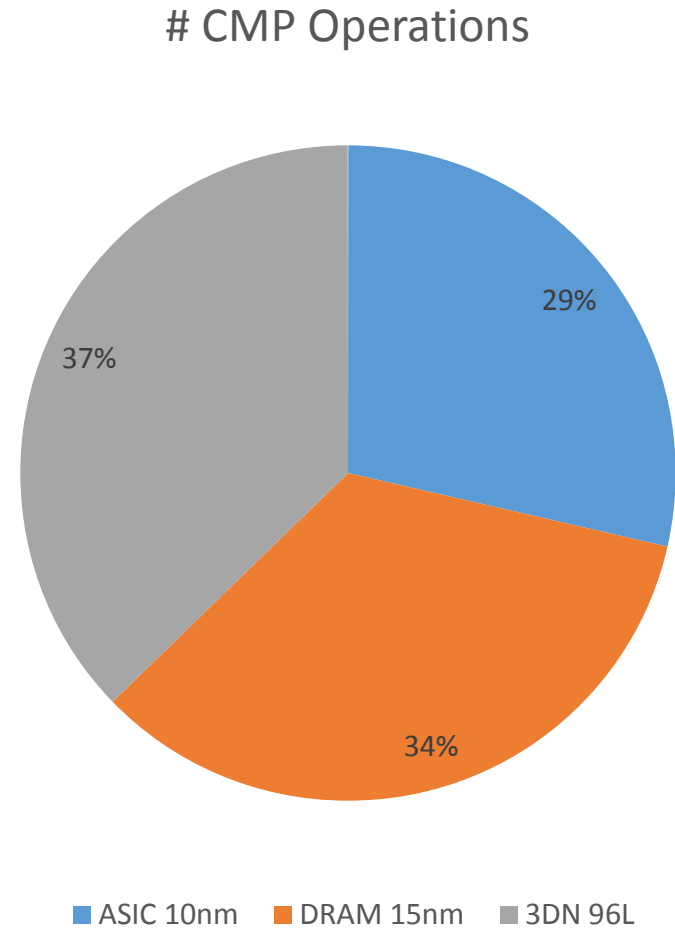
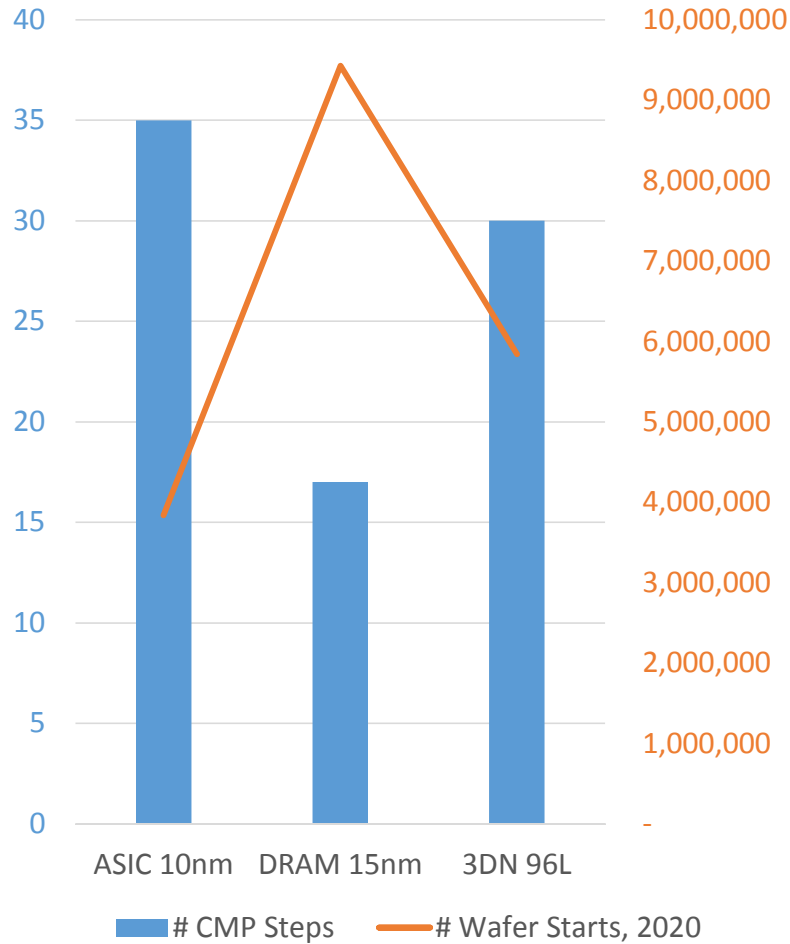
Source: ICKnowledge, Strategic Model

CMP Costs are In-line with Wafer Processing Costs



Source: ICKnowledge, Strategic Model

CMP Intensity in Memory, 2020





Conclusions

Conclusions



- Sustainable strong growth outlook anticipated for several years
- 3D structures and new materials will continue to drive semiconductor technology advancement at 1Xnm and beyond.
- 200mm and older wafer fab is expected to remain at high levels of capacity utilization over the next several years. Productivity will be a major driver
- Memory will account for a greater share of 300mm CMP spend going forward