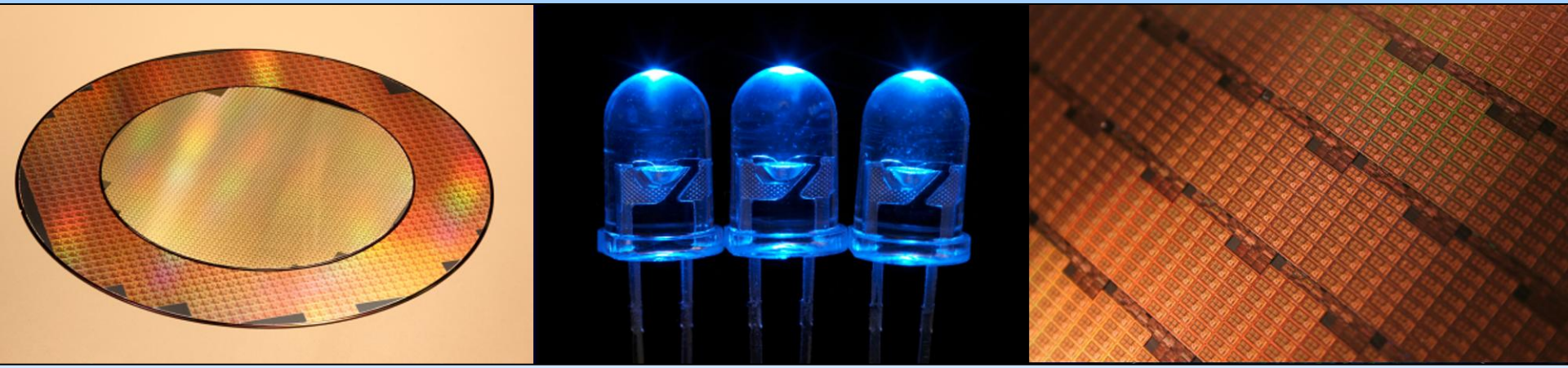

TRENDS IN CMP SLURRIES AND PADS FOR NEW DEVICES AND WAFERS

Michael Corbett
Linx Consulting
May 15, 2013
NCCAVS CMPUG @ CNSE

LINX Consulting
see beyond the horizon

SEE BEYOND THE HORIZON

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1. ***We create knowledge and develop unique insights at the intersection of electronic thin film processes and the chemicals industry***

2. ***We help our clients to succeed through our:***
   - Experience in global electronics and advanced materials and thin film processing industries:
     - Semi
     - Packaging
     - Nano Technology
     - LCD
     - PV
     - Other
   - Experience in the global chemicals industry
   - Experience at Device Producers
   - Experience at OEMs
   - Global network and capabilities
   - Advanced modeling capabilities

Industry Analysis Reports Offered

CMP Focused:

1. ***CMP Technologies and Markets to the 11nm Node (5th edition)***
2. ***Specialty Abrasives in CMP (4th edition)***
3. ***CMP in TSV (2nd edition)***
4. ***Wafer Polishing Technologies and Markets***

5. Advanced Thin Films for FEOL and BEOL Applications

6. Advanced Cleaning and Surface Preparation: Technologies and Markets

7. Advanced Patterning Forecasting

8. Chemicals and Materials for TSV Applications

9. ***The Econometric Semiconductor Forecasting Service***

10. ***Strategic Cost Model***

High Confidence Decision Support Services

PLANNING

Business Analysis

M&A / Due Diligence

Diversification / Expansion Planning

IDEAS TO MARKET

IP Development

Value Chain Analysis

Technology Assessment and Commercialization

SINGLE CLIENT SERVICES

SUPPPLY CHAIN OPTIMIZATION

Quality System Auditing Or Pre-audit Assessment

Supplier Quality System Benchmarking

Quality/Product Management System Set-up Or Augmentation

Excursion Management

MARKETING & SALES

Market Analysis/Monitoring

Market Forecasting and Modeling

Competitive Intelligence

Customer Perceptions

TRENDS IN CMP SLURRIES AND PADS FOR NEW DEVICES AND WAFERS

Semiconductor Macro-economic Model

- Demand-driven equation based on:
  - Global real GDP growth (from Consensus Forecasts)
  - Inventory-shipments ratio, computer & electronics
  - Financial crisis shock indicator to capture panic behavior in latest cycle
  - MSI reported by SEMI

- Captures >95% of the long run variation in semiconductors

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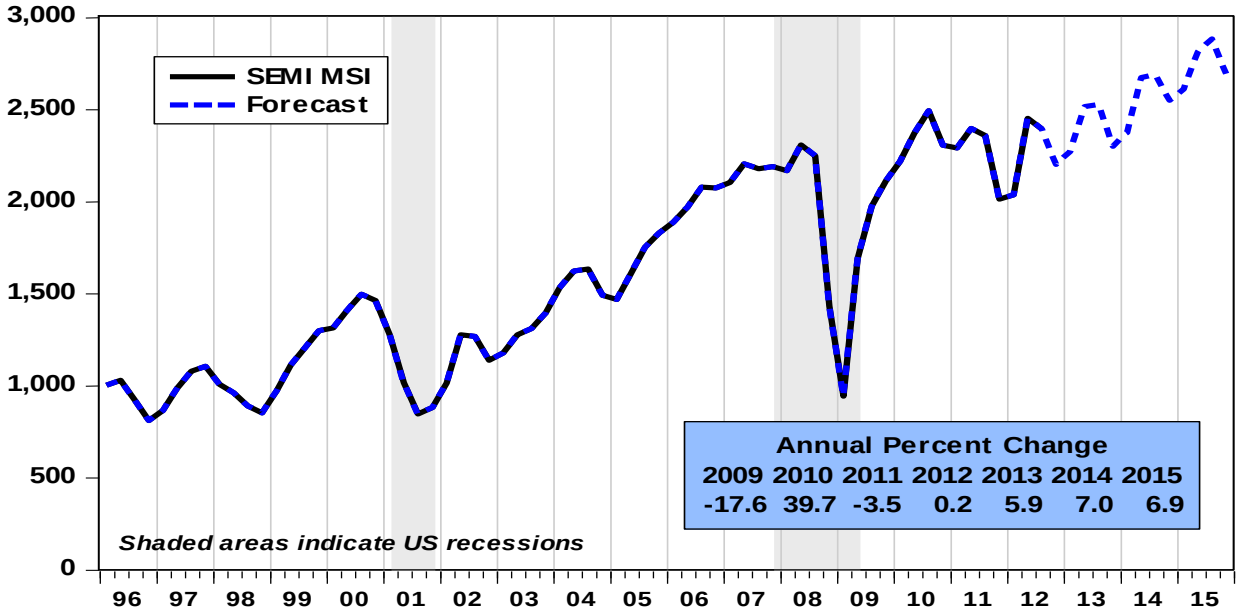
Model Based On Macro Economy



April 2013 Update	2013Q1F	2013Q2F	2013Q3F	2013Q4F
MSI	**2188**	**2433**	**2533**	**2369**
%Change	1.2%	11.2%	4.1%	-6.5%
50% Ranges	**2090 - 2286**	**2312 – 2554**	**2406 - 2660**	**2248 - 2488**
95% Ranges	**1938 – 2490**	**2123 – 2772**	**2165 – 2842**	**2072 - 2676**

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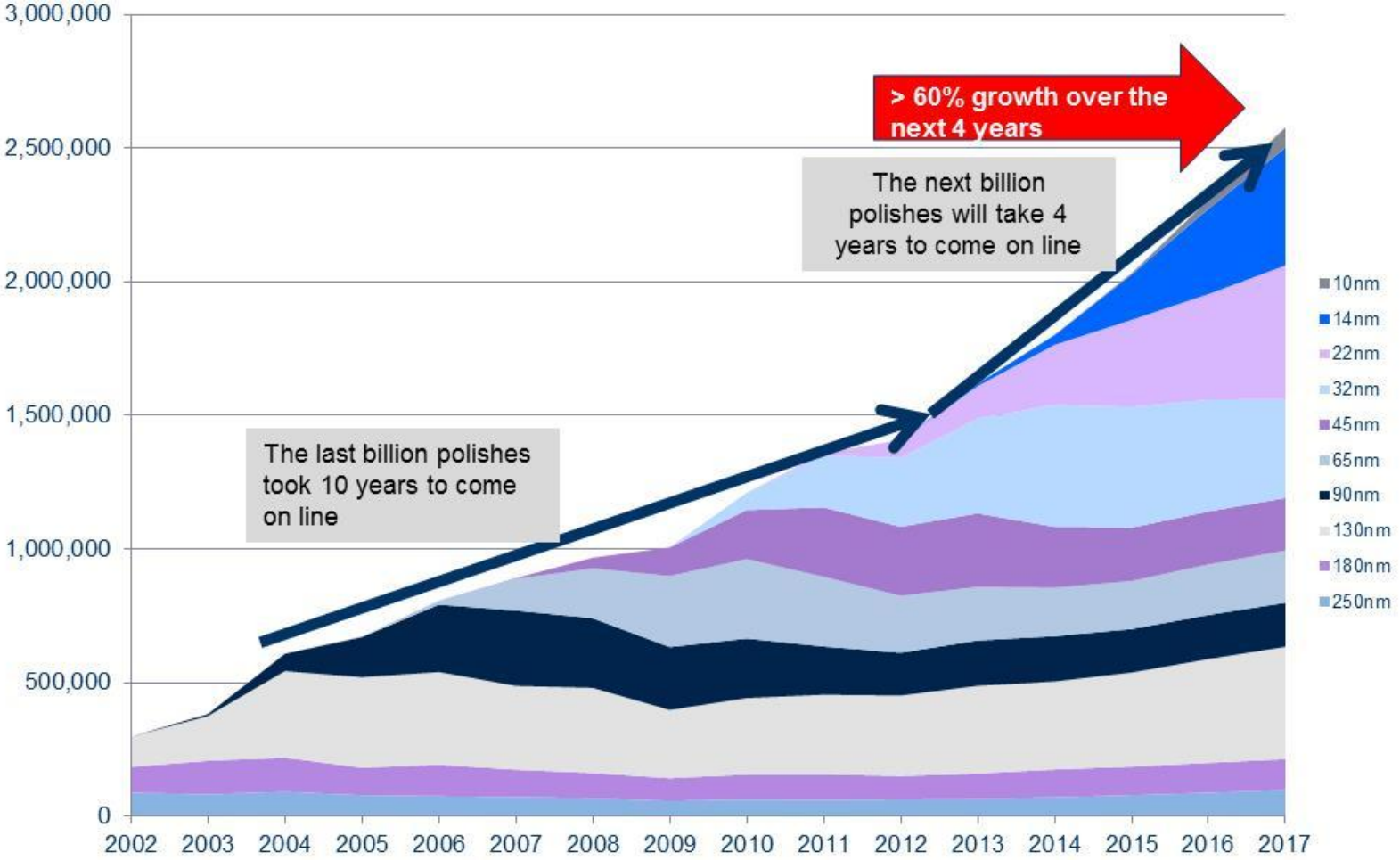
CMP Operations (1000s of Polishes) by Node



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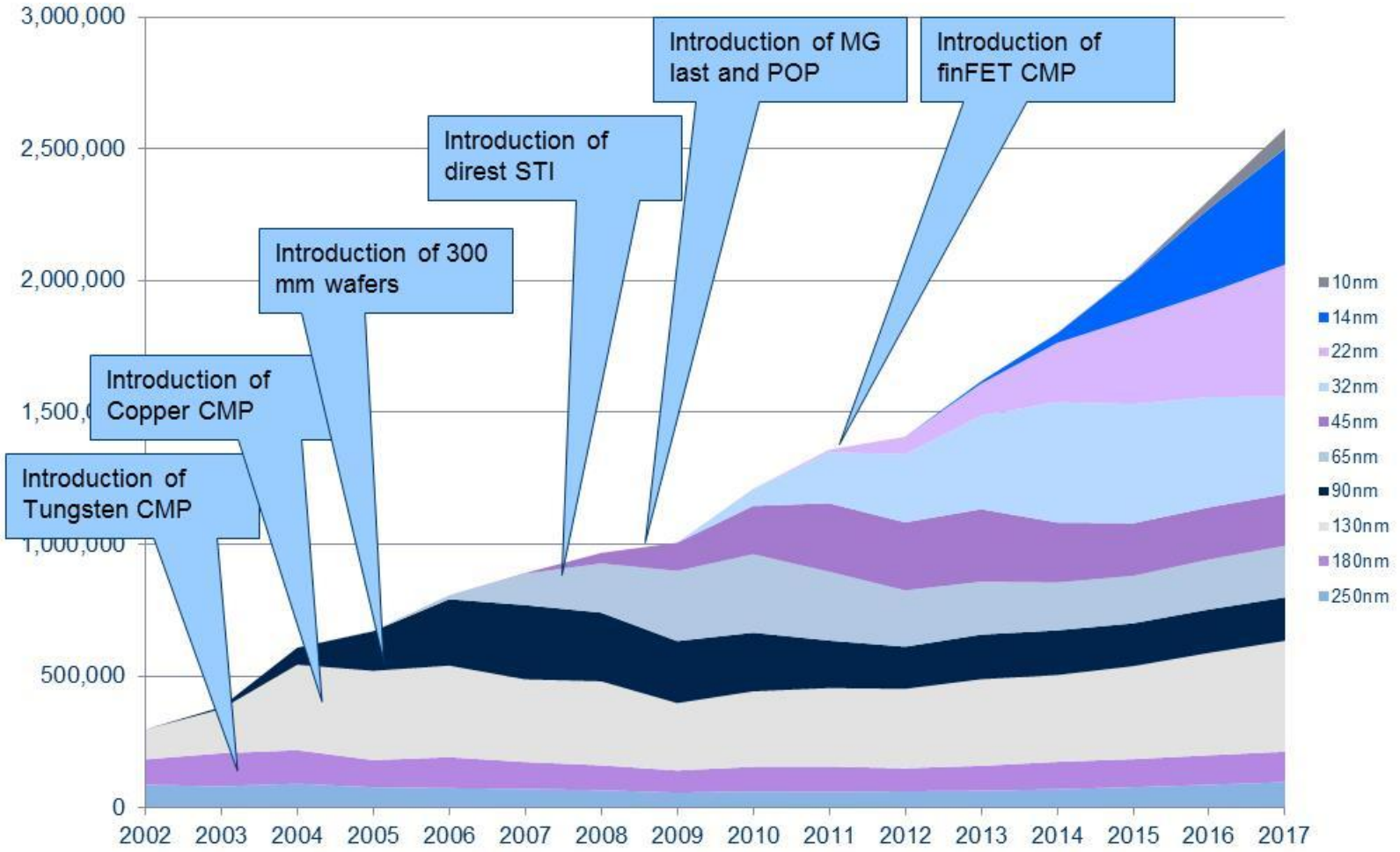
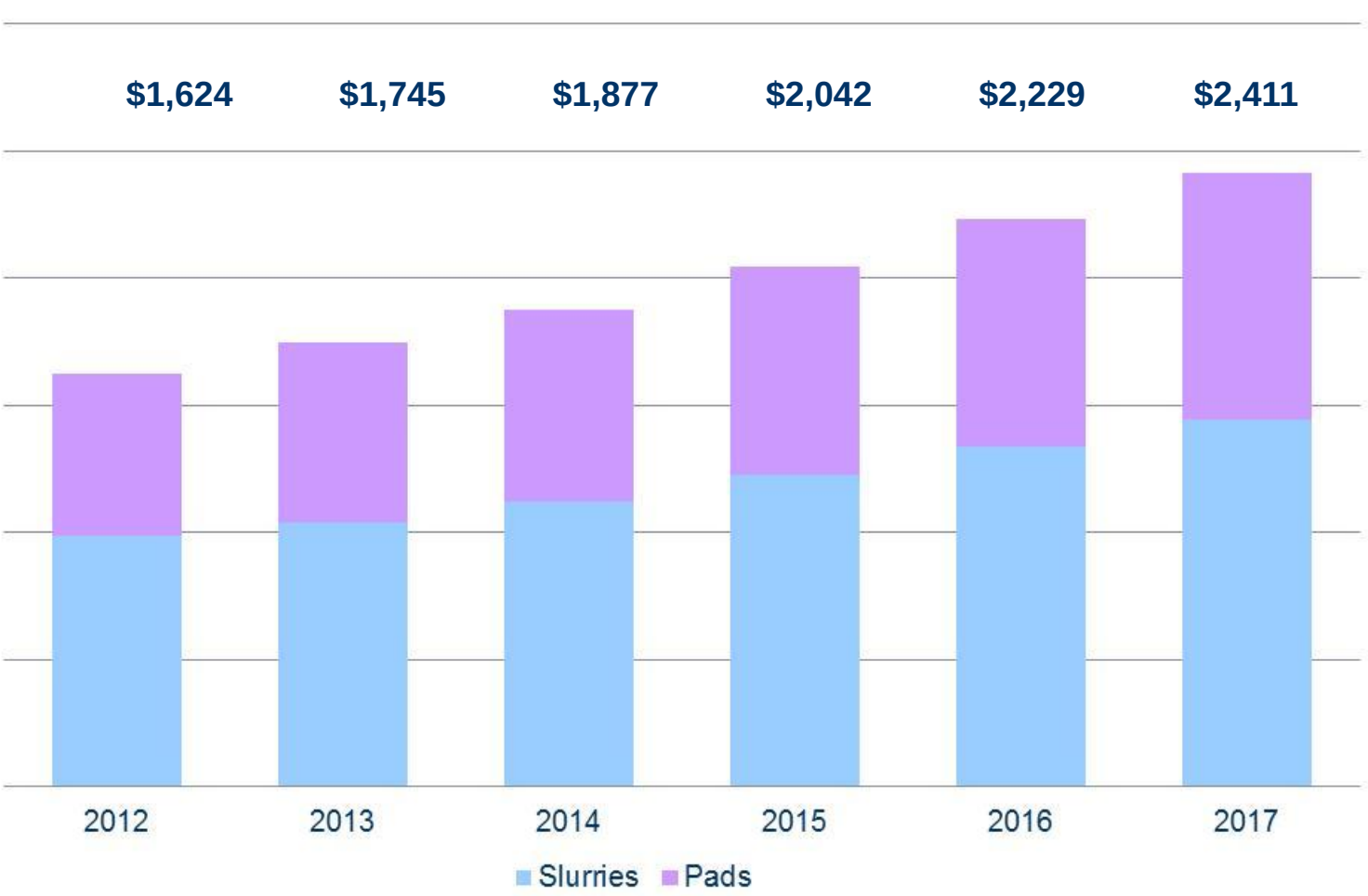
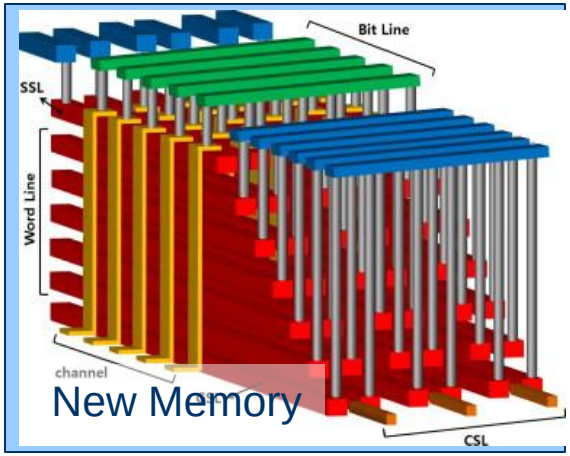
Major Developments in CMP to Date

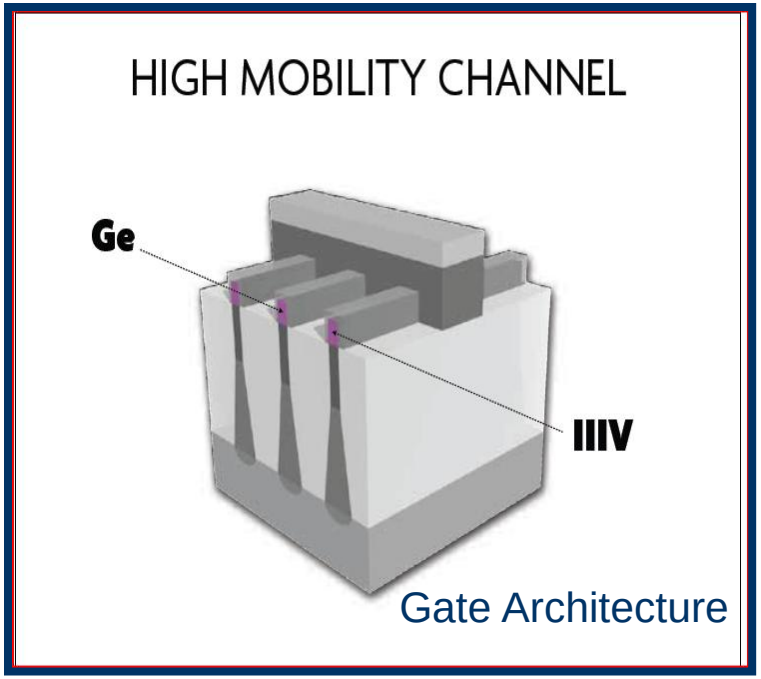


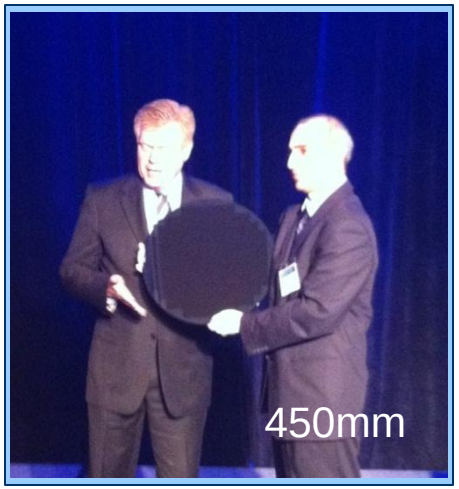
Growth in CMP Consumables ($M)

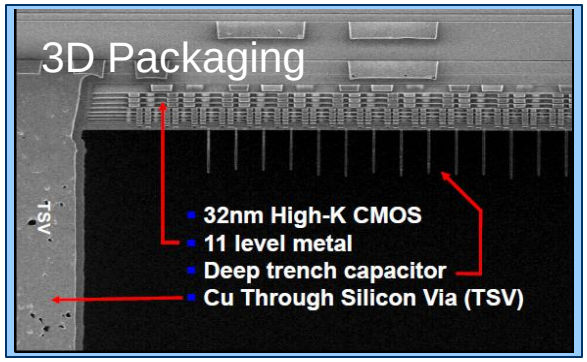


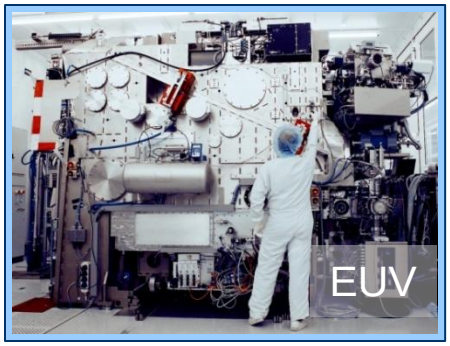
The Major Challenges For ICs











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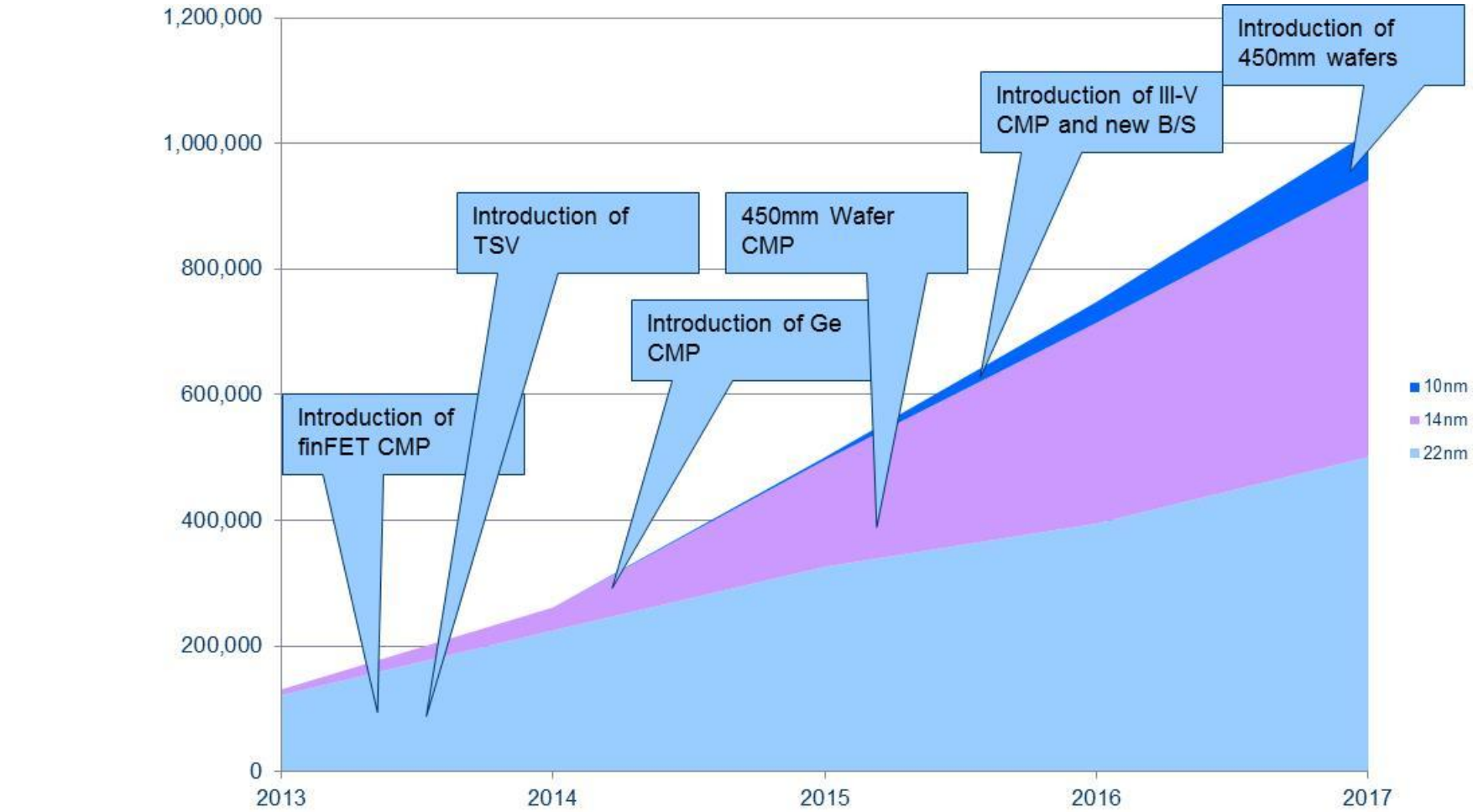
Major Developments in CMP Going Forward



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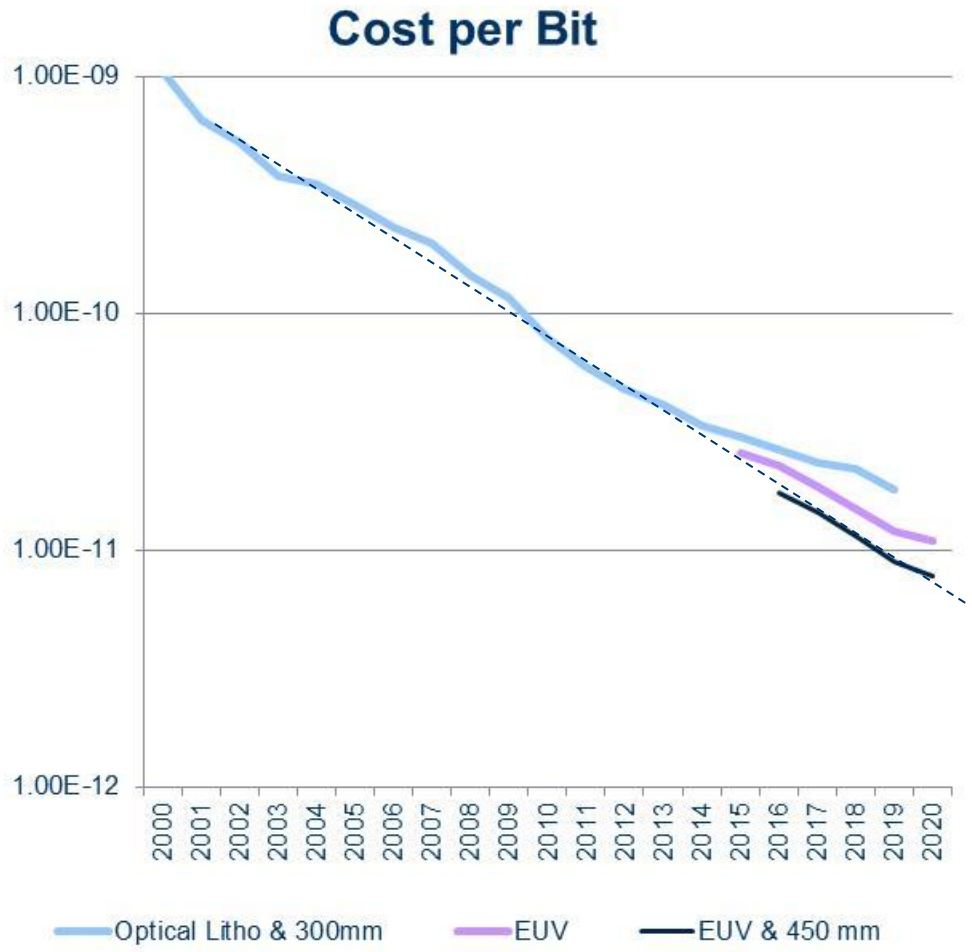
Is Moore's Law Broken?



- Current process technology diverges from the historic cost per bit curve as multi patterning and process complexity increase.
- EUV reduces this divergence by reducing litho complexity and saving some patterning cost
- Combining EUV with 450mm allows the cost per bit to stay on trend.

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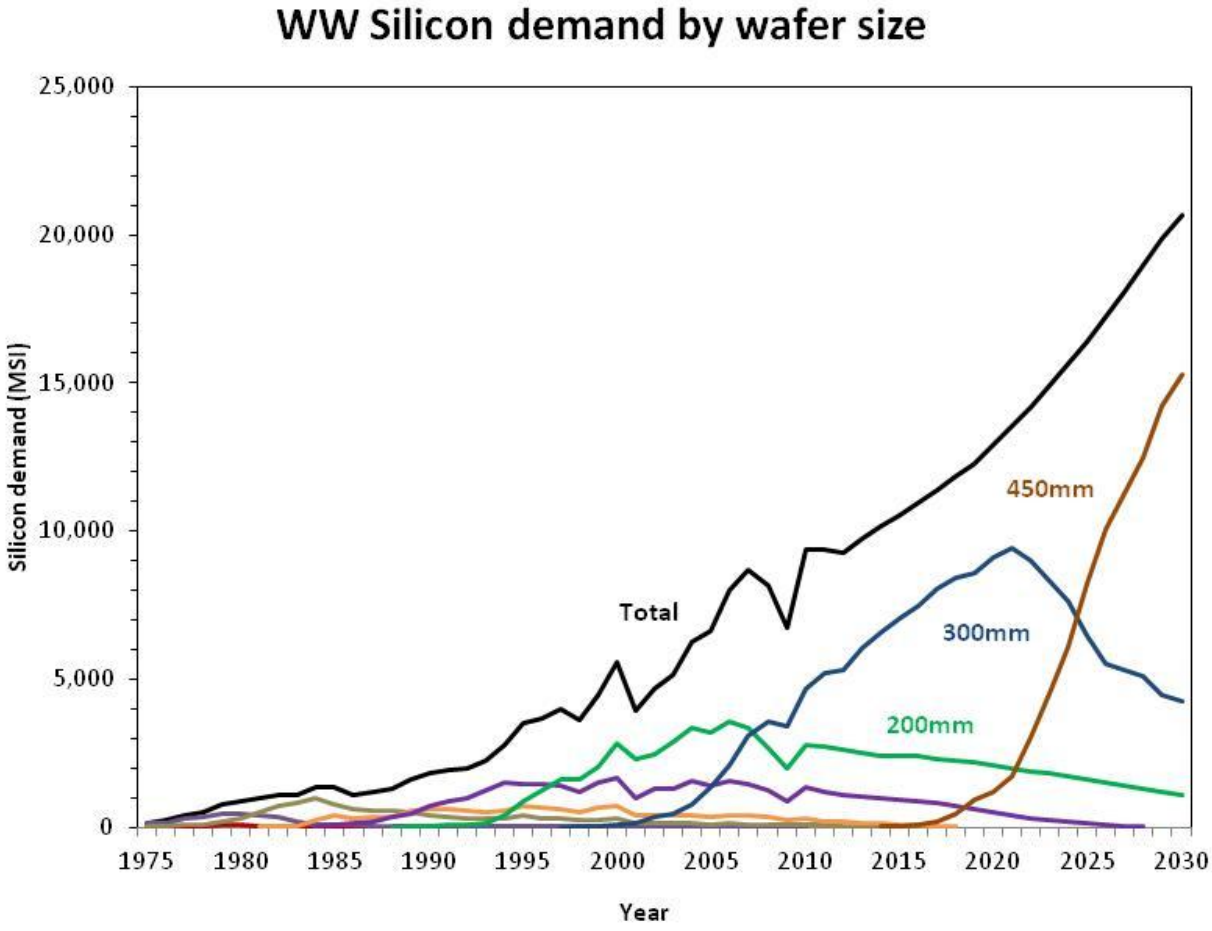
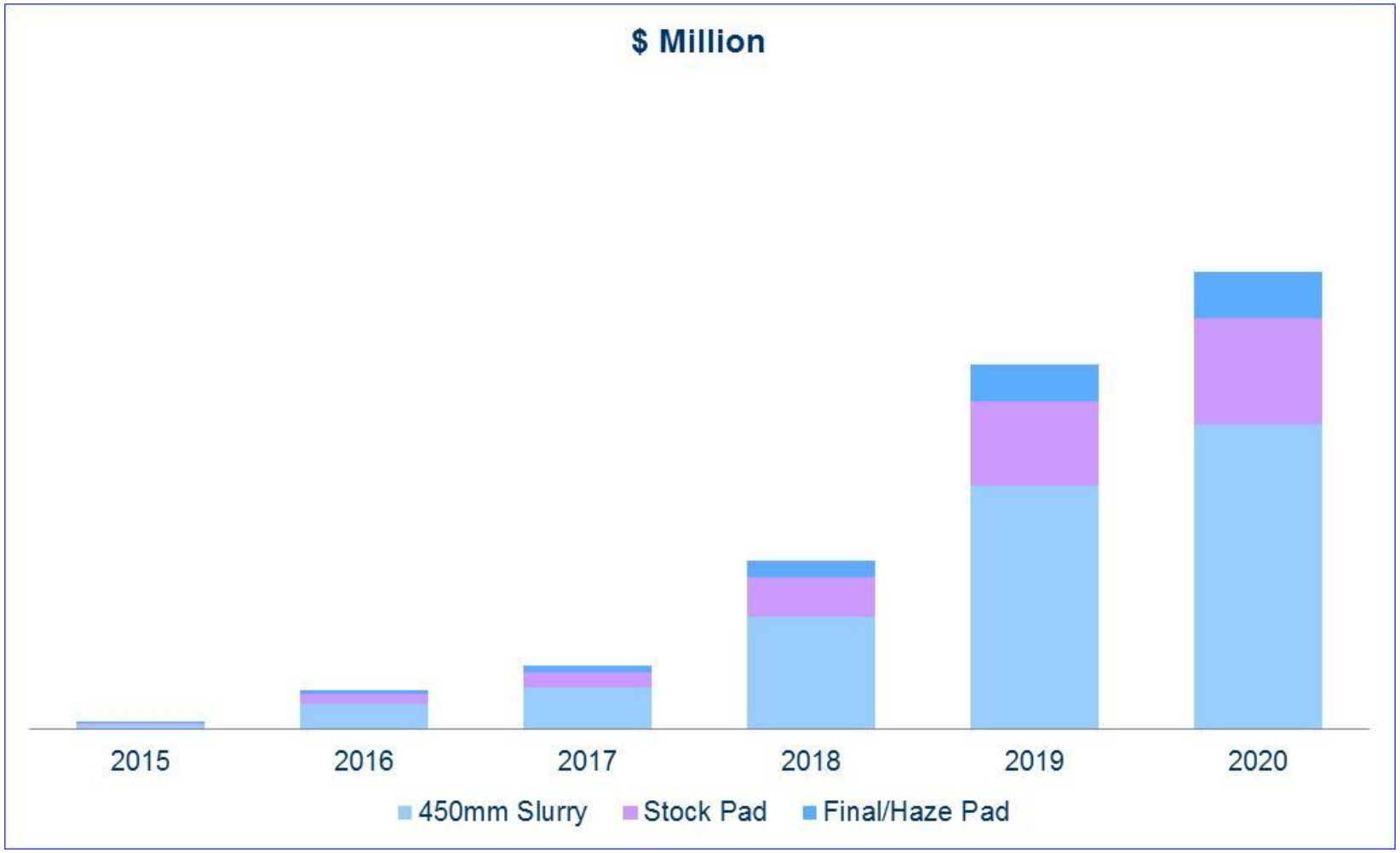
450mm Wafer Ramp Expectation

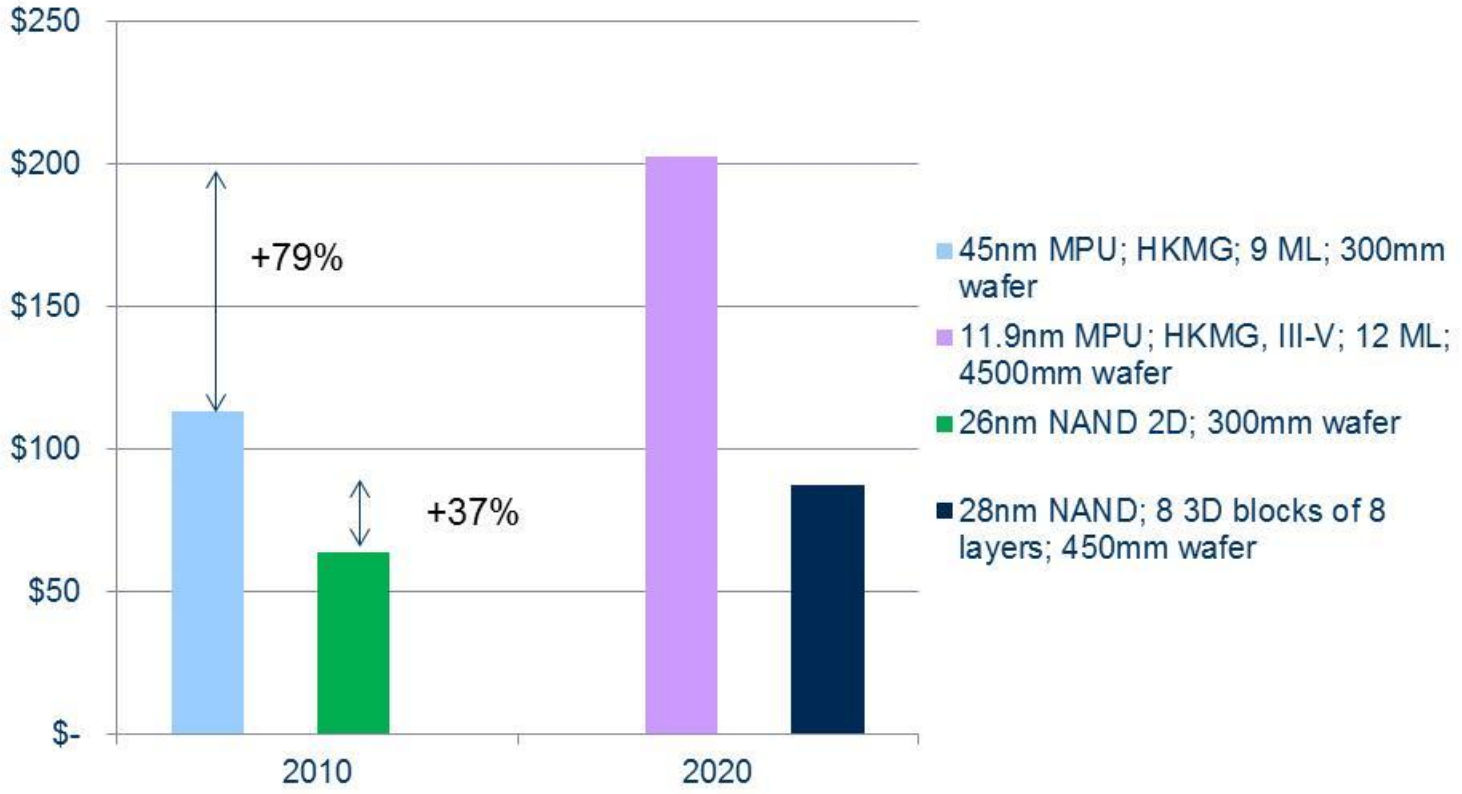


Silicon Area Growth MSI

450mm Wafer Polishing CMP Consumables

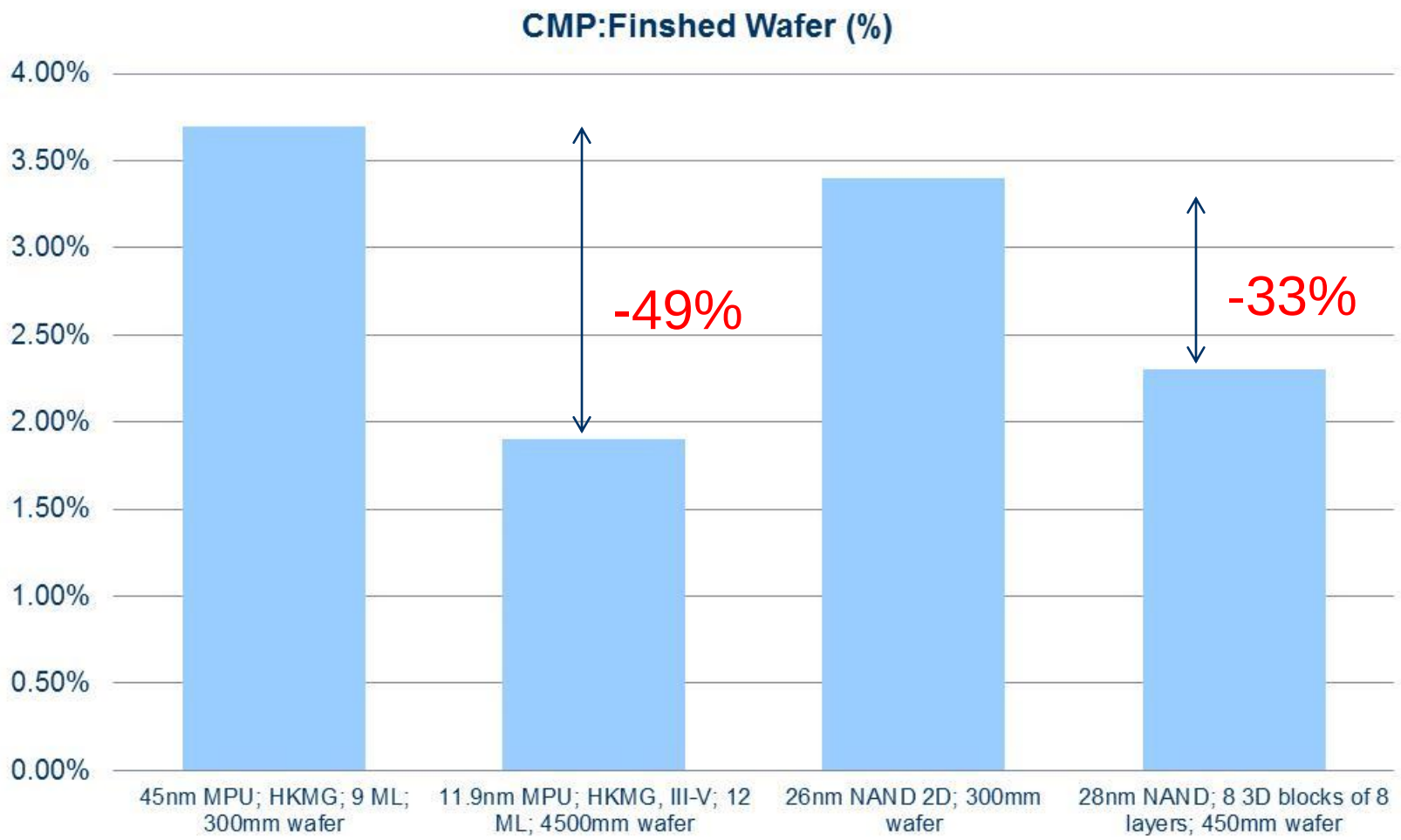


Cost of CMP ($/Wafer Basis)



Cost of CMP includes Depreciation, equipment maintenance, direct & indirect labor, facilities, test & Monitor wafers, consumables and yield loss

Cost of CMP ($/Wafer Basis)



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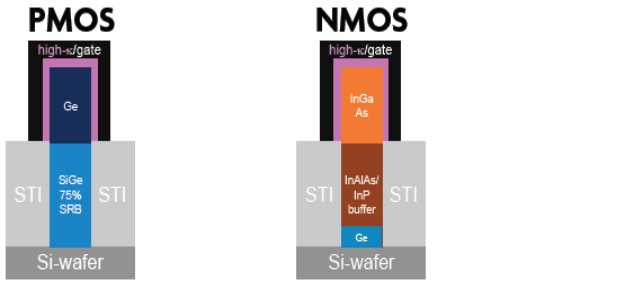
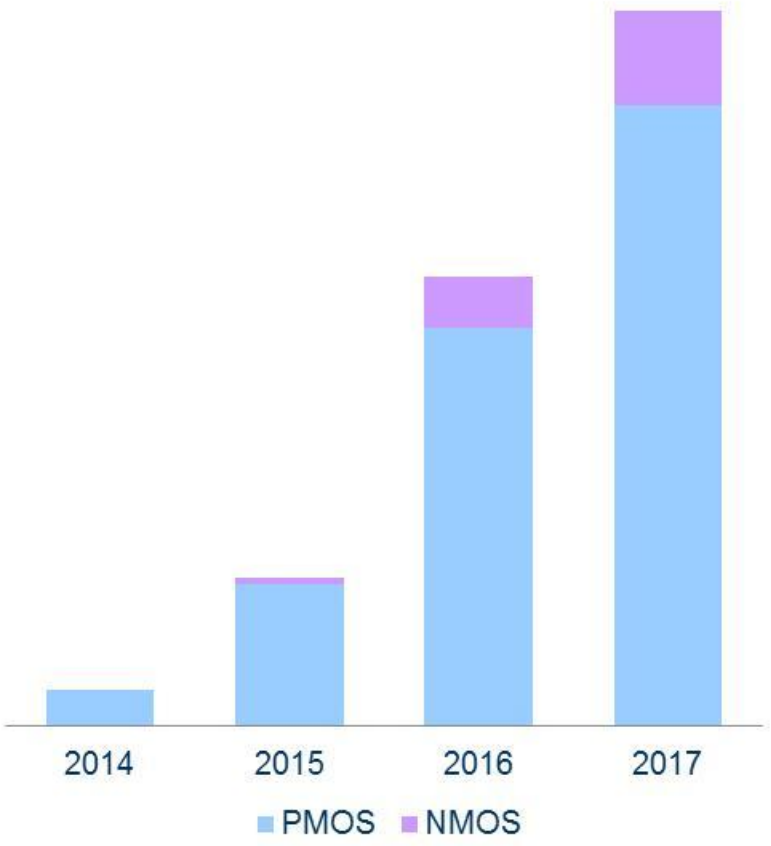
Slurries for High Mobility Channels

HIGH MOBILITY CHANNEL



	Si	Ge	InP	GaAs	$In_{0.5}Ga_{0.5}As$	GaSb	InAs	InSb
Hole mobility (cm^2/Vs)	450	1,900	200	400	450	1,000	500	850
Electron mobility (cm^2/Vs)	1,400	3,900	5,400	8,500	12,000	3,000	40,000	77,000



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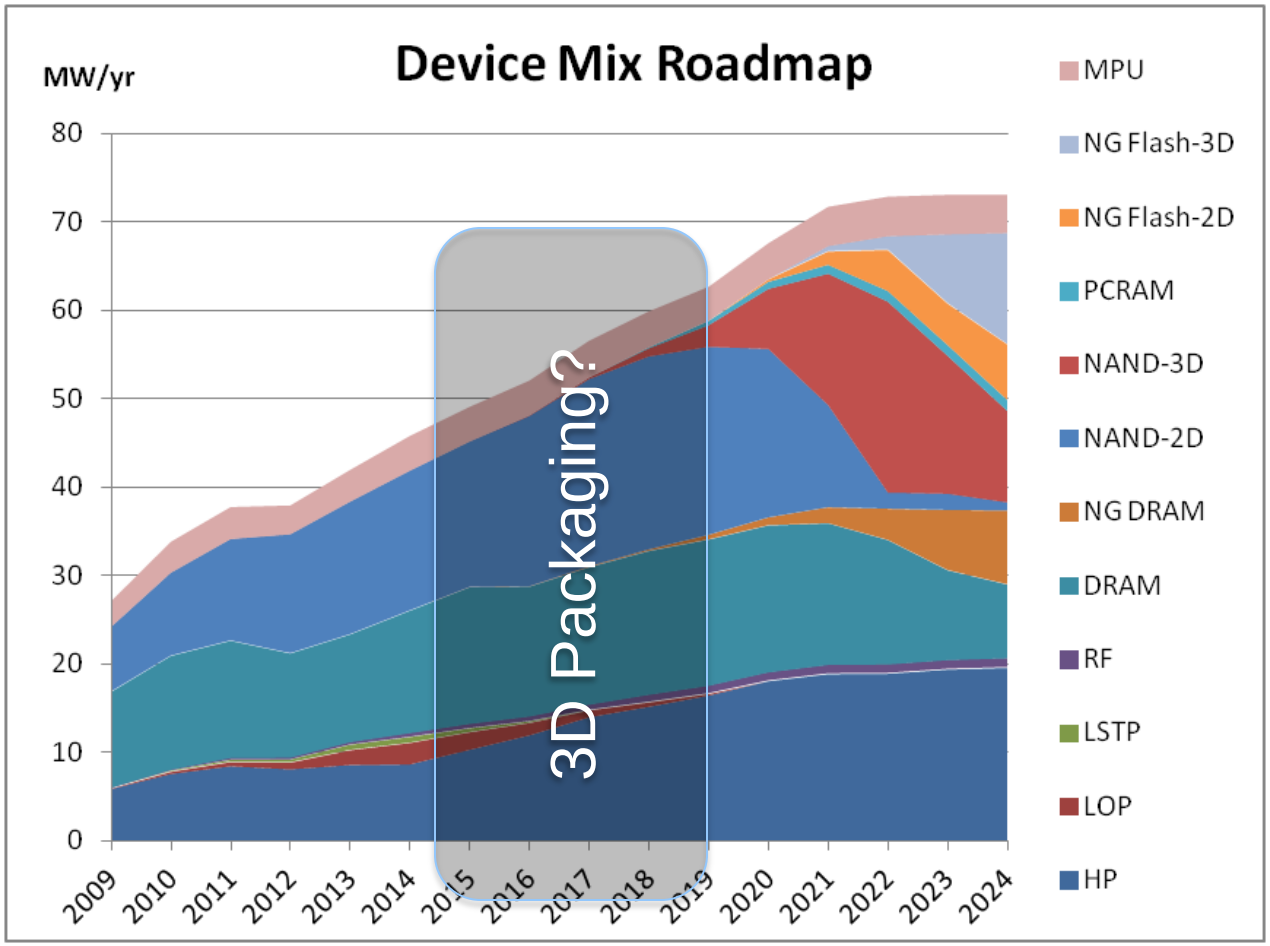
Long Range Device Mix Forecast



Total 300 and 450mm wafers

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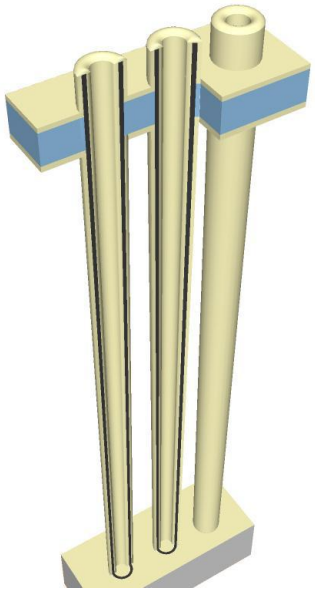
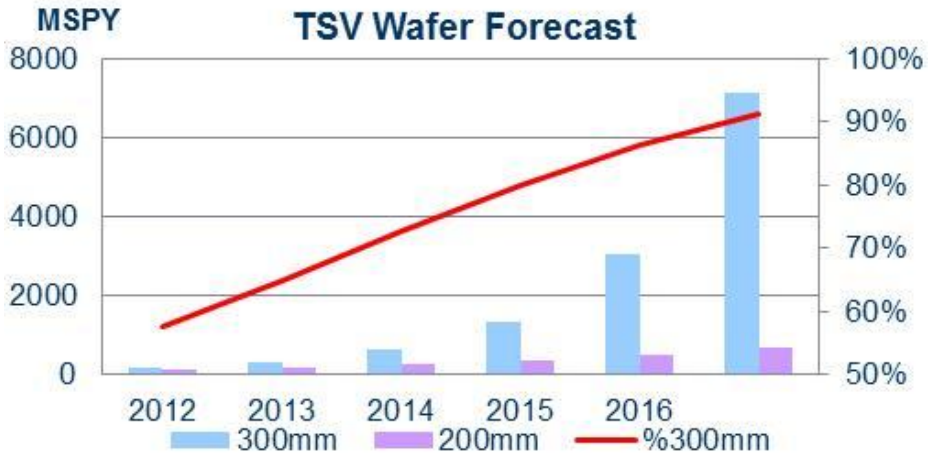
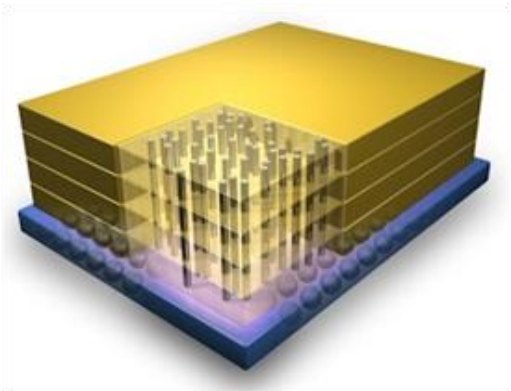
TSV Scenarios – More Moore

OTHER DRIVERS:

- DRAM is expected to reach physical scaling limits within 5 years
- Lower power consumption in data centers/server farms
- Wide I/O required for mobile devices
- DRAM and Logic
  - Enhancement for eDRAM / Replacement for SRAM
  - Hybrid Memory Cube (HMC)
- NAND in servers







Source: HMCC

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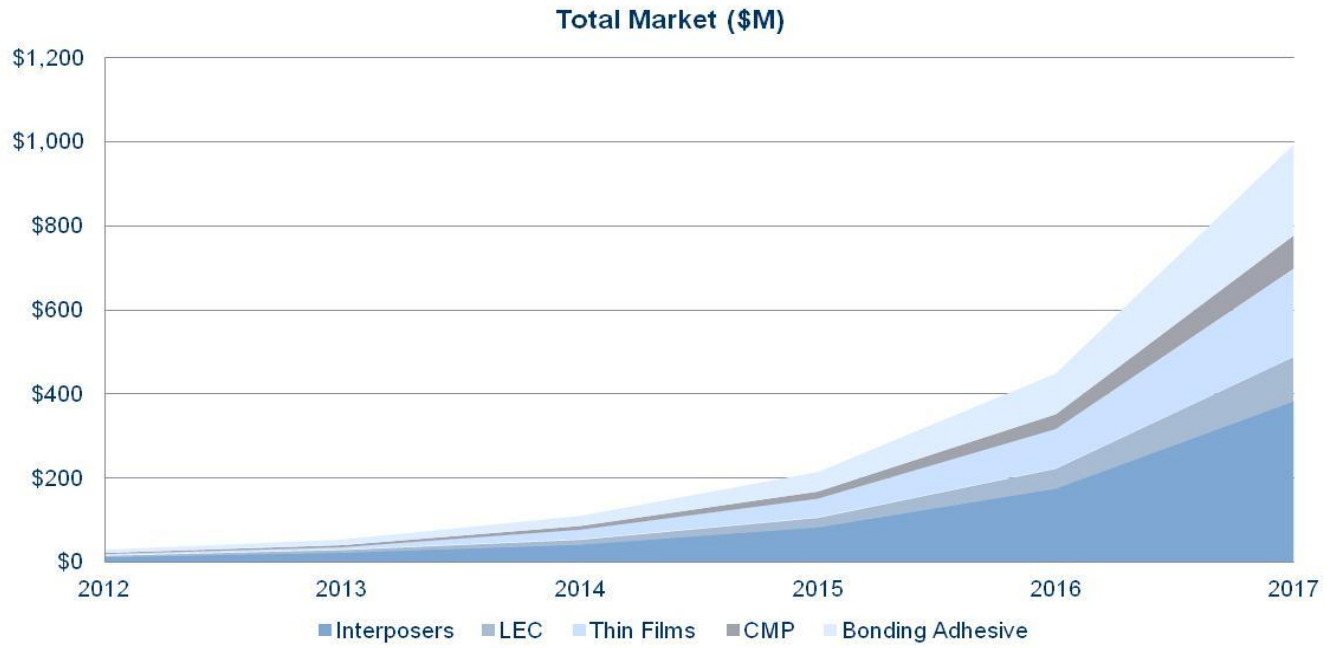
TSV Consumables

Category	2010 - 2015	2016 - 2020	2021 - 2025
DRAM			
LOGIC			
NAND			



Future Quality Requirements

- Quality Improvement
  - Increasing number of metals and elements in CofA
    - 8 to 24
  - Increased Sensitivity
    - ppm -> ppb -> ppt
    - Inorganic chemicals regularly specified at ppt levels
  - Function specifications becoming more specific
    - Resolution, DOF EL, line collapse, profile, adhesion, footing, toploss, LER, LWR
    - Selective etch rates
    - Polish rates, defectivity, dishing

- Service Improvement
  - Beyond SPC
  - Ship to stock qualification

- Sub-Supplier Monitoring
  - Materials component supply analysis
  - Materials fingerprinting

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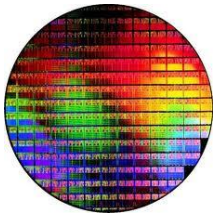
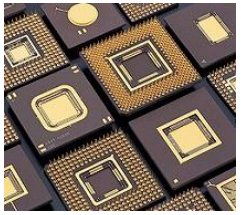
Impact of Excursions

Detection location




IMPACT to:	Raws	Qualified Product	On Wafer	Packed Chips	Consumer Product
Business					
Operating capitol	💰	💰💰	💰💰💰	💰💰💰💰	💰💰💰💰
Good Will	💰	💰	💰💰	💰💰💰💰	1/∞
Technical					
ID Root Cause	💰	💰	💰💰	💰💰💰	💰💰💰💰
Recurrence of Issue	💰	💰	💰💰	💰💰💰	💰💰💰💰

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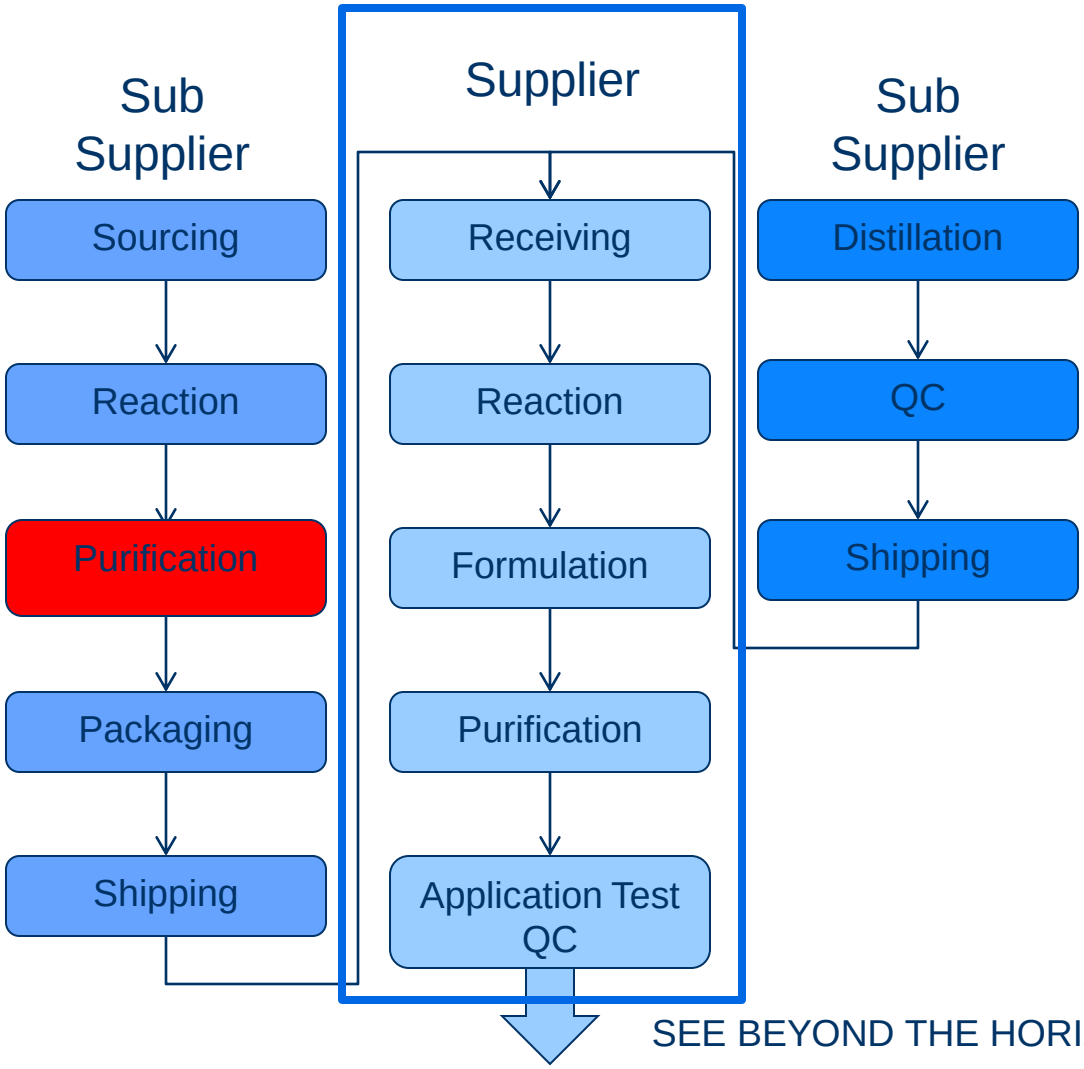
Advanced Materials Learning/Characterization



- Well controlled manufacturing at the supplier leads to product qualification
- Changed process at the sub-supplier changes end product performance
- Process audit located the change, and was rectified at cost of time and product
- Sub-supplier process mapping during product development
- Beyond CofA material fingerprinting
- Understand and Control variation

SEE BEYOND THE HORIZON

Summary

- Continued strong organic industry growth for balance of 300mm ramp out
- Many new CMP applications including:
  - 450mm wafers
  - TSV
  - FEOL – Ge and III-V
  - New barrier and seed
- Multiple new device types – MRAM and RRAM on the horizon to replace NAND and DRAM mean for new opportunities
- Winner for the remainder of 300mm will likely be same companies to participate in 450mm
- Impact of excursions grows with time
  - Quality and supply chain sources of deviation most be better understood