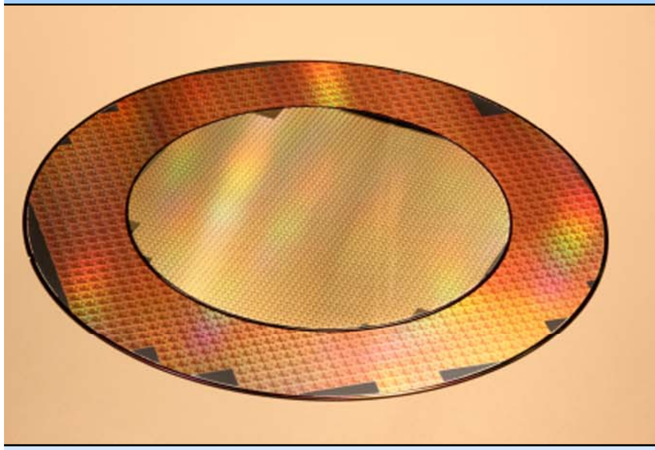

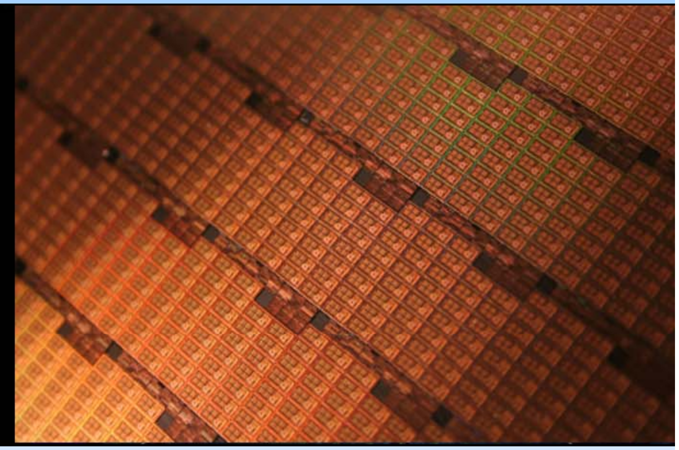

FUTURE CMP PROCESSING REQUIREMENTS

Kyle Flanigan & Michael Corbett
Linx Consulting
July 10, 2013
NCCAVS CMPUG @ Semicon West

LINX-Consulting
see beyond the horizon

SEE BEYOND THE HORIZON

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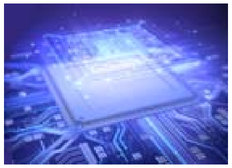
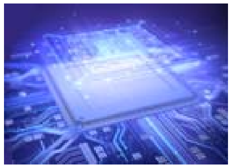


Linx Consulting

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
     - LCD
     - Packaging
     - PV
     - Nano Technology
     - 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

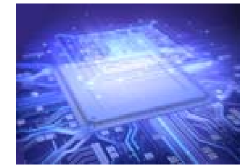
7. Advanced Patterning Forecasting

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

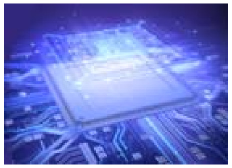
MARKETING & SALES

Market Analysis/Monitoring

Market Forecasting and Modeling

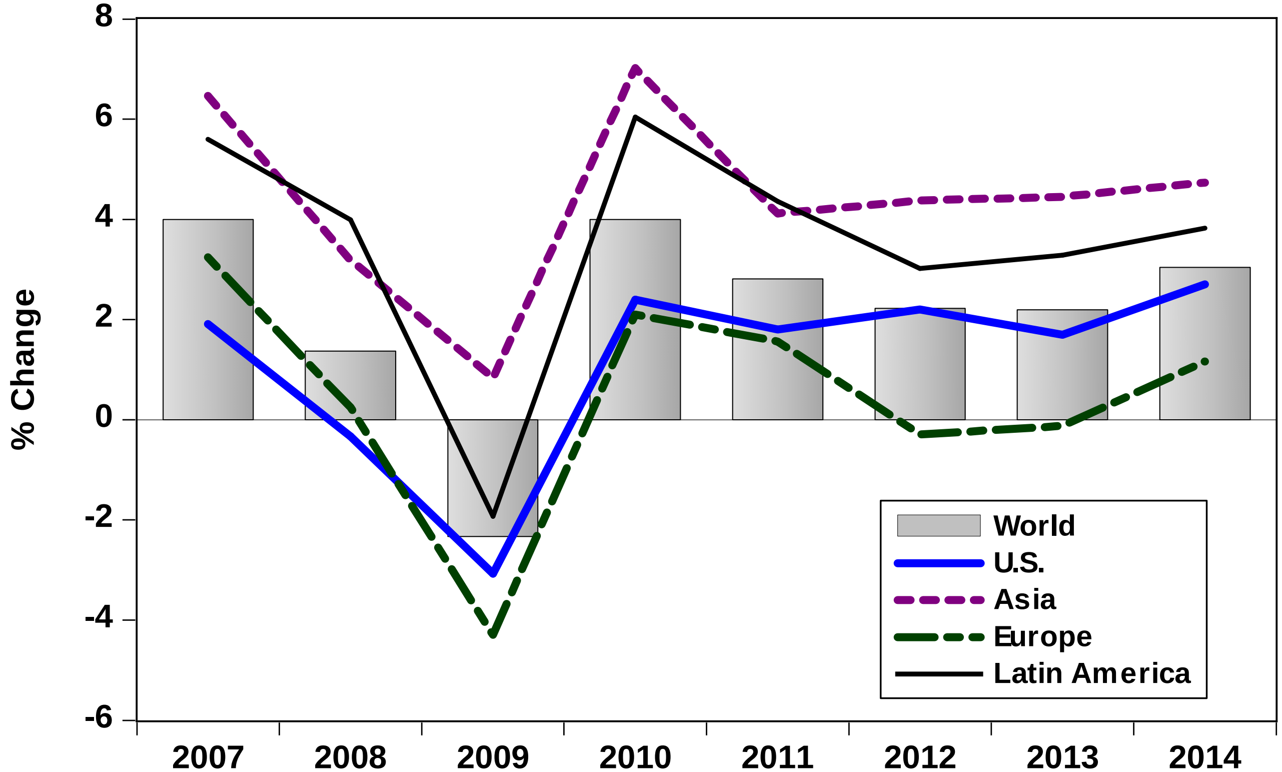
Competitive Intelligence

Customer Perceptions



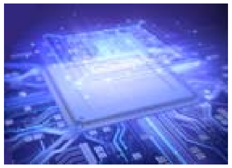
SHORT TERM VISIBILITY

Global Real GDP Growth: By Region

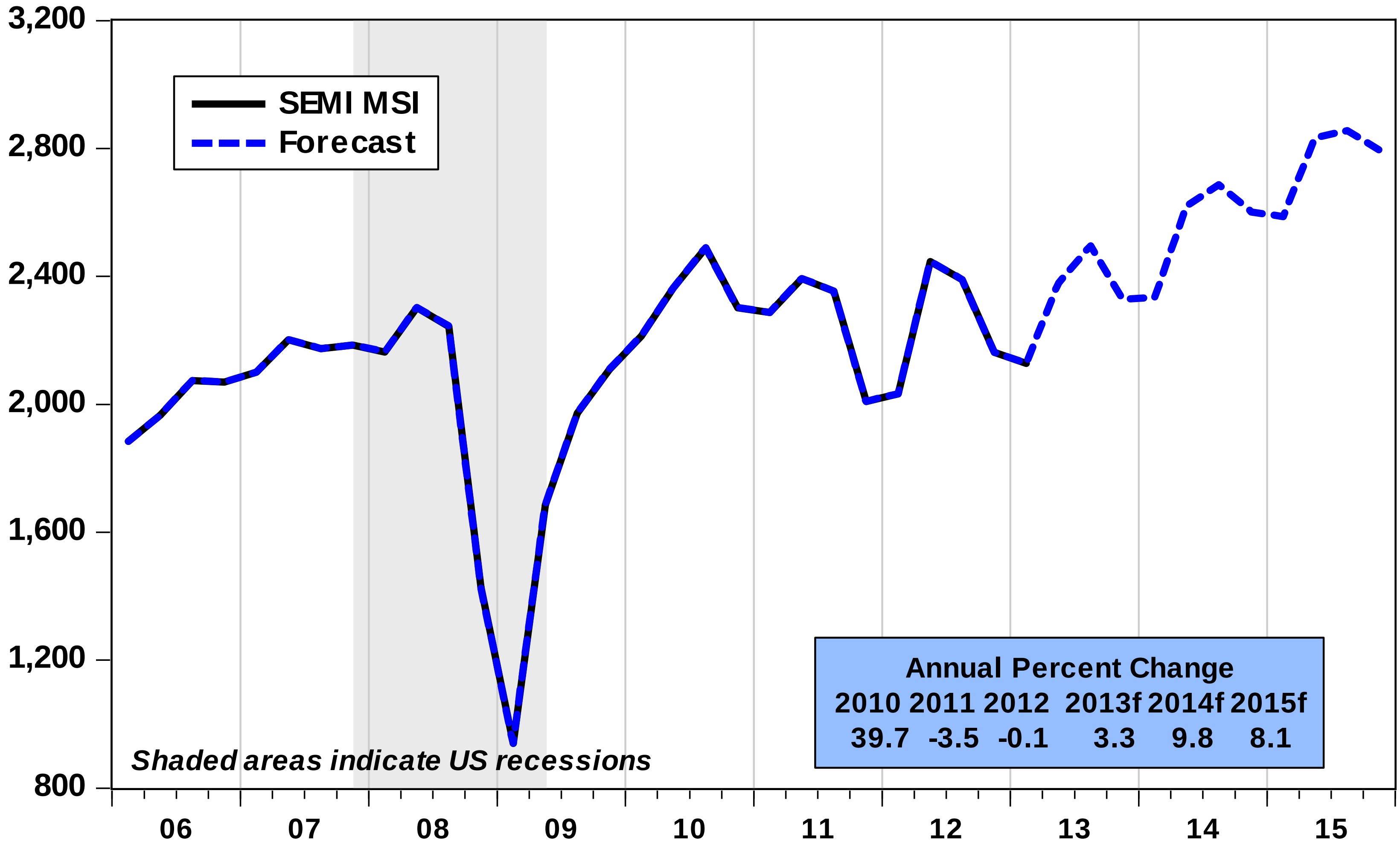


- US: below trend in 2013 and slips below total world growth
- Asia growth the highest, but region growth estimate has been shaved a little since Q1 2013 forecast
  - Japan a little stronger on new policies
  - China weaker after weak report for Q1 real GDP growth
- Eurozone recession continues through 2013, Europe overall flat

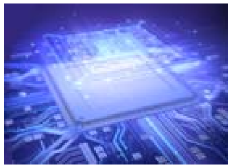
Q2 2013 Semiconductor Forecast



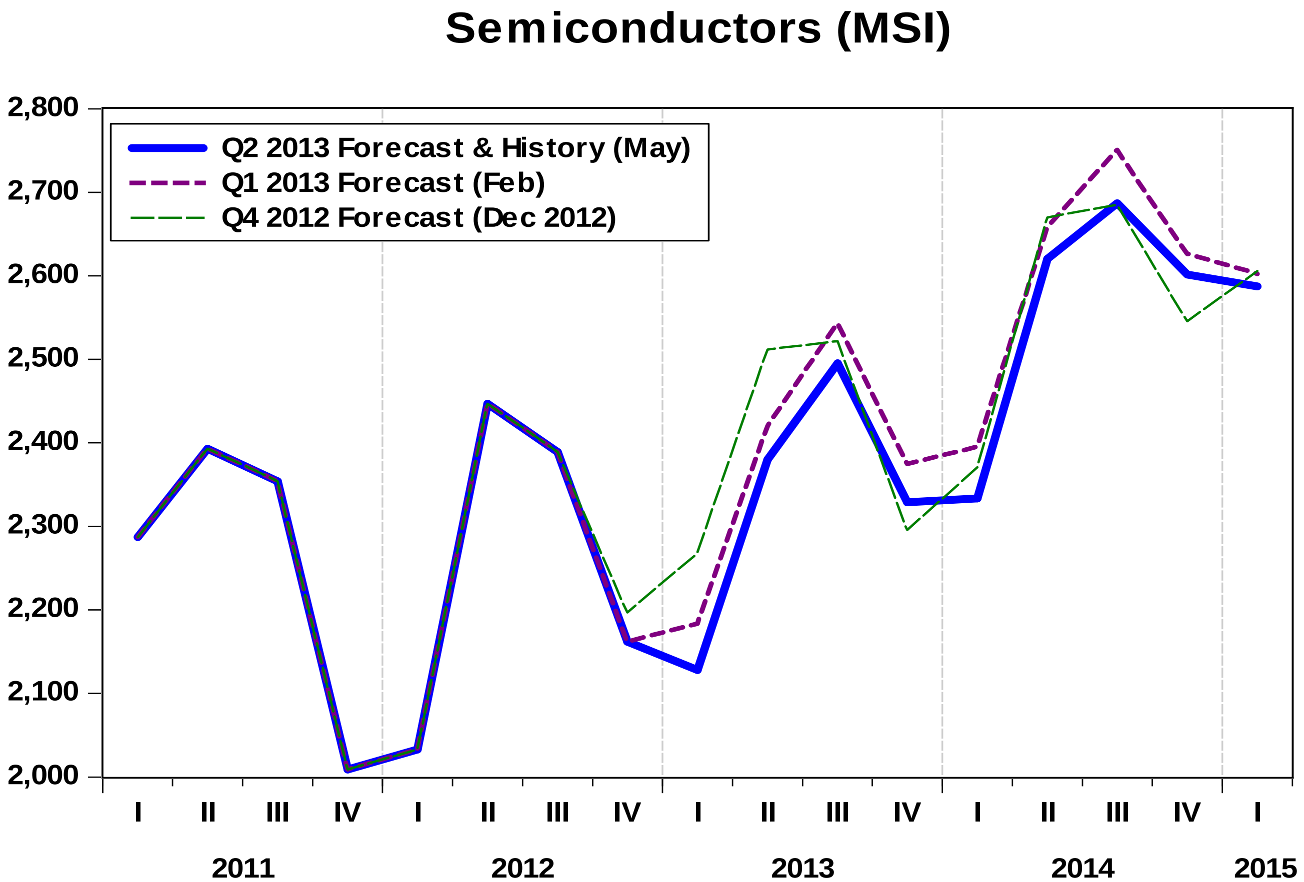
MSI grows roughly 50% faster than Global Real GDP in 2013, better than past two years, with acceleration in 2014



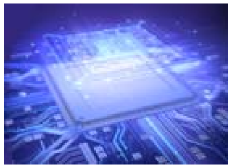
SEE BEYOND THE HORIZON



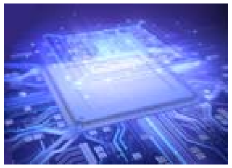
Semiconductor Area Forecast



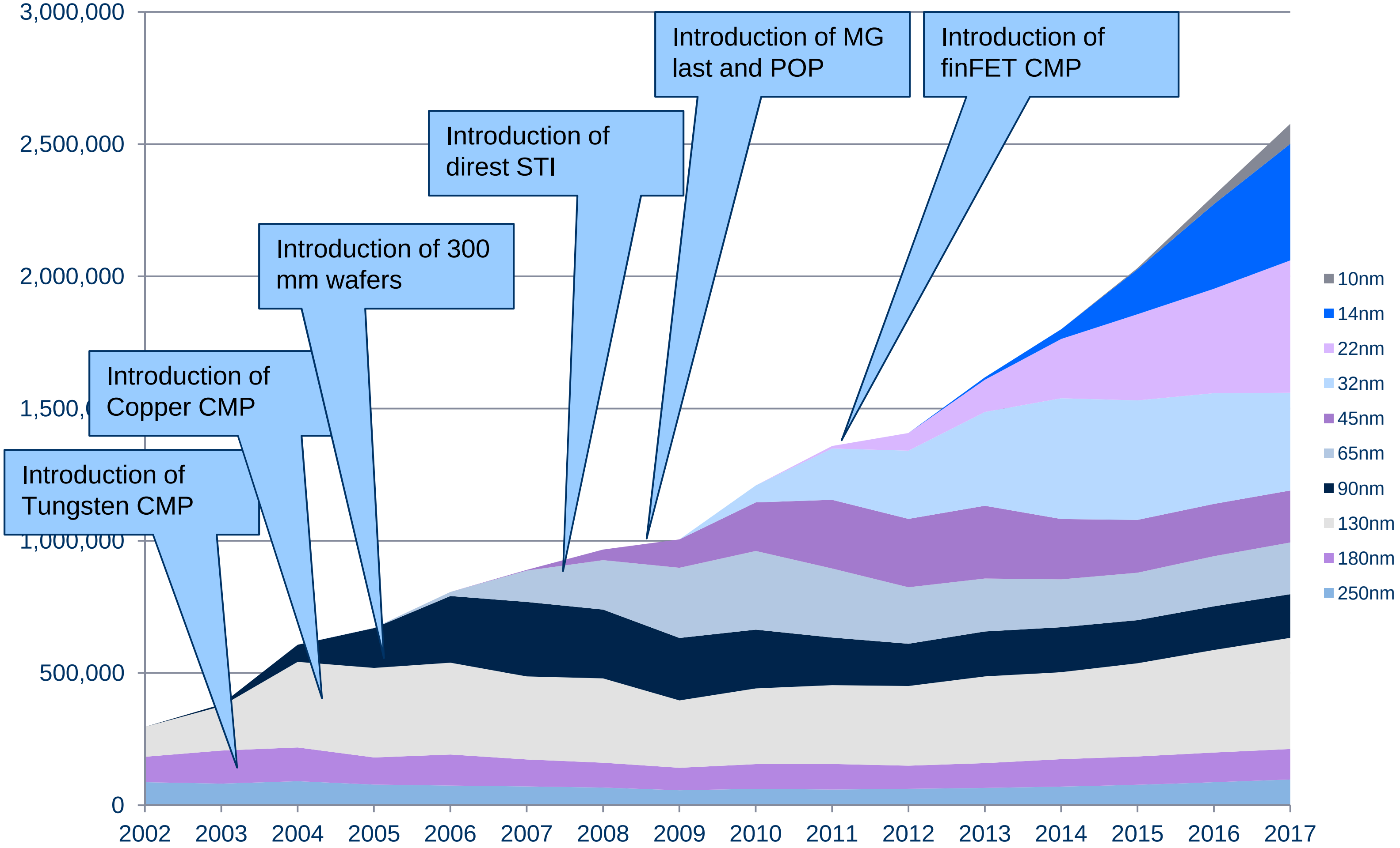
Q2 2013 Forecast (May 2013)	2013Q1	**2013Q2F**	**2013Q3F**	**2013Q4F**	**2014Q1F**
MSI	2128	**2380**	**2495**	**2329**	**2334**
%Change	-1.6%	**11.8%**	**4.8%**	**-6.7%**	**0.2%**



TRENDS IN CMP SLURRIES AND PADS FOR NEW DEVICES AND WAFERS



Major Developments in CMP to Date



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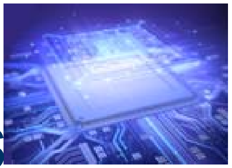
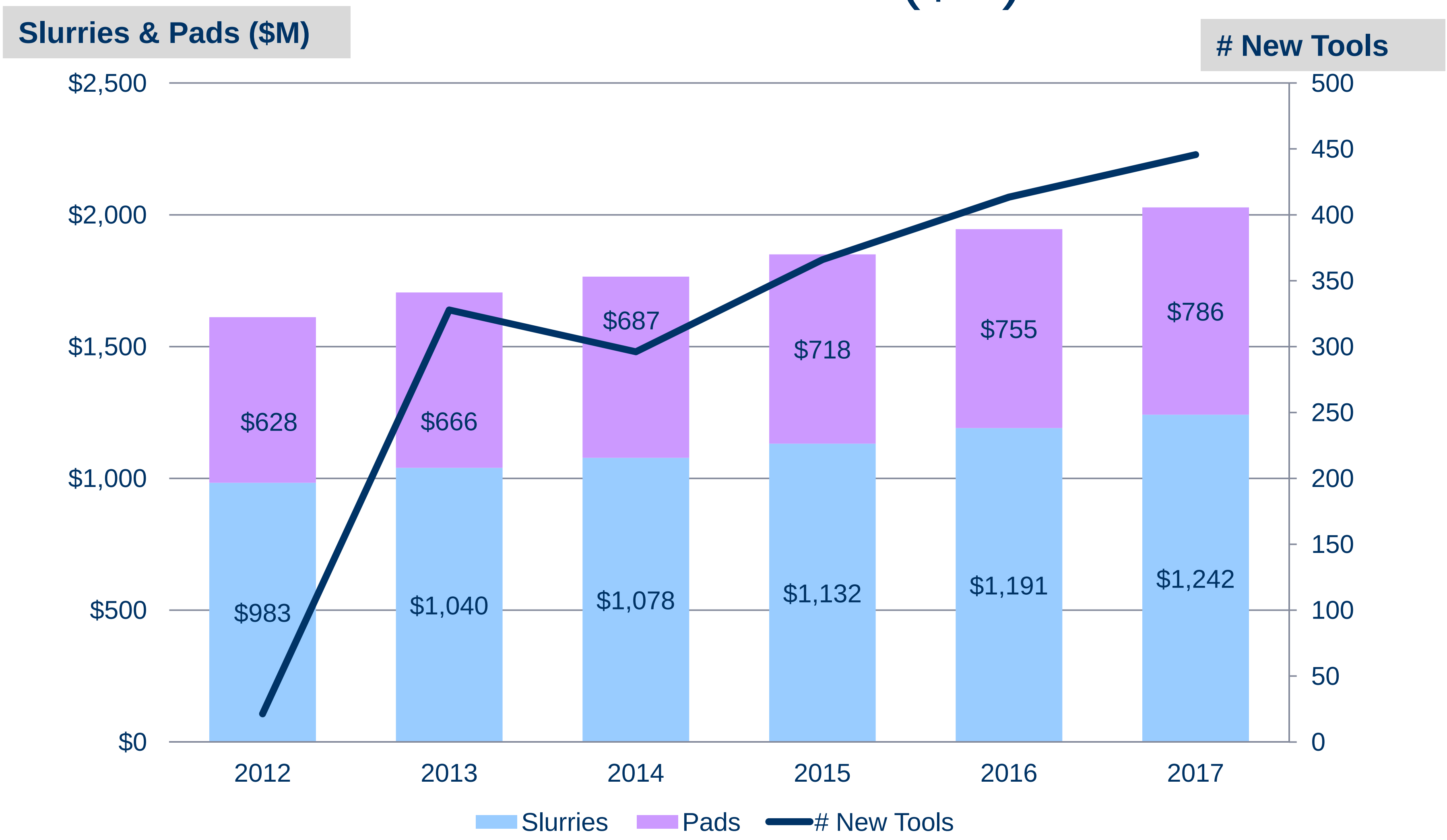
Growth in CMP Consumables ($M) & # Tools





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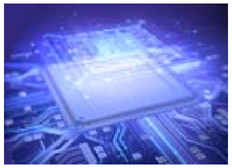
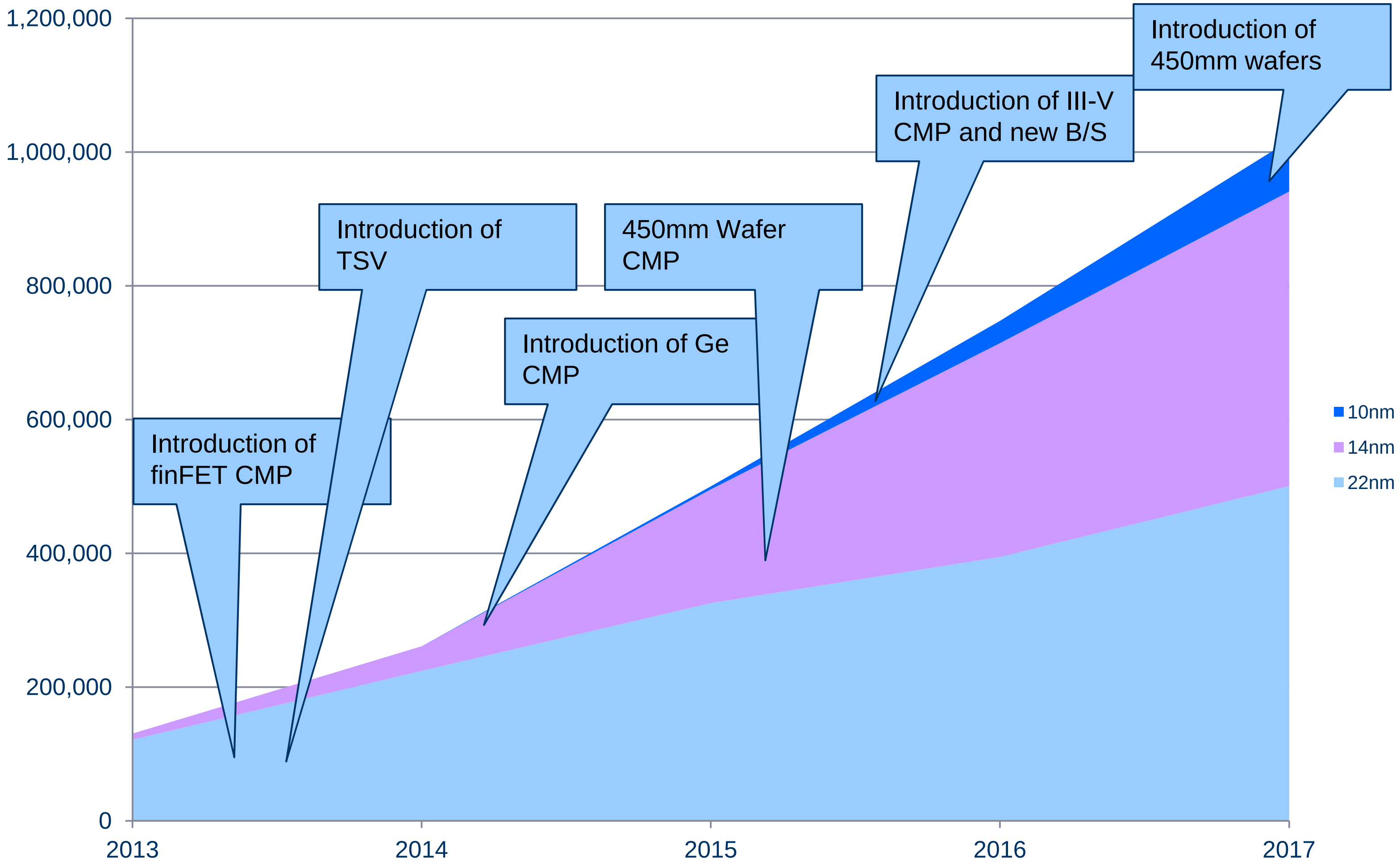
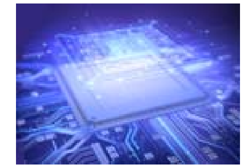
Major Developments in CMP Going Forward





Defectivity Requirements – Tools & Process



Control of the Tool

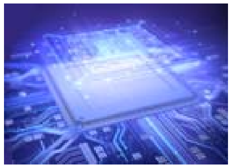
- The trend is towards extremely low downforce in the polishing process
- 1 to 2 psi is common at 14nm for oxide, nitride and poly (POP process) using ceria slurry
- Silicon FinFET processing also uses low downforce CMP

- RPMs on both the platen and head have to be optimized
  - Higher RPM increases the removal rate but leads to more abrasion on the surface
  - Therefore lower RPMs are required

Control of the Pad

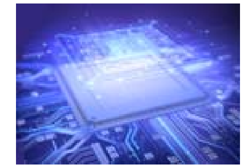
- Pads
  - Grooves should be free from debris due to groove cutting
  - Pads should not have sharp edges
- Conditioning
  - Optimum conditioning of the pad is of paramount importance. Grit size of conditioners play an important role in defectivity control

Defectivity Requirements – Consumables



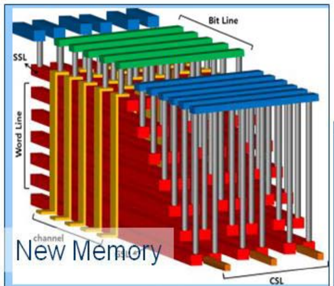
Control of the Slurries

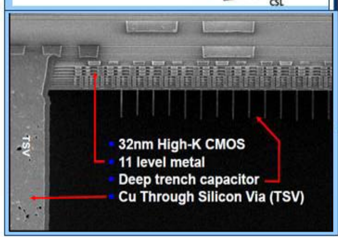
- For 22nm and 14nm, the industry needs to have extremely tight control on the slurries and pad quality
- In advanced slurries, morphology of the slurry particles will be critical
  - No agglomerations and angular particles
  - Need mostly spherical particles and to minimize the number of edges
- Trend to low abrasives or abrasive free – 0.5% or lower solids content as the slurry formulation trend is to greater chemo effect than mechanical effect
- Selectivity requirements will prove challenging to slurries as selectivity is increased tuned as a key point of the overall process control
- Galvanic corrosion needs to be controlled in-situ – this is controlled by using the correct ingredients/formulations
- Advanced slurry formulations may utilize 10 to 15 distinct ingredients

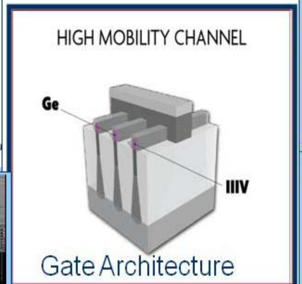


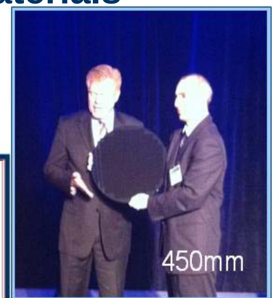
New Materials are Increasing Rapidly

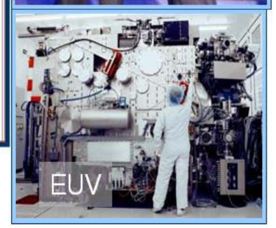
New Opportunities for Materials



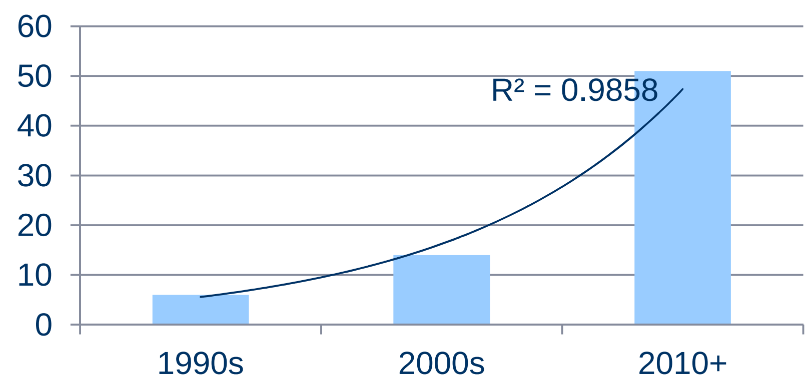






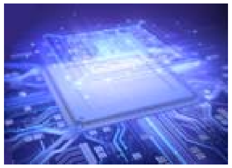


New Materials Required

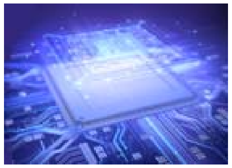


The Quality Dilemma

1. New Materials are often found in / required for the most critical applications
2. New materials lead to new value chains
3. New value chains lead to new sources
4. New sources are usually unqualified

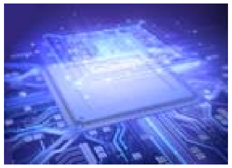


SUPPLY CHAIN AND QUALITY



Supply-Chain Optimization Background

- Market trend is to push supplier quality into the supply chain
- End customers (End-user) are pushing suppliers to avoid costly firefighting by pre-emptively qualifying the supply chain
- Some companies are developing collaborative programmes which are firewalled and confidential
- Others are demanding more information with an expectation of supplier transparency for the whole supply chain.
- Suppliers need to set up effective audit trails for all sub suppliers
- This may lie within the capability of large suppliers, but small and medium size suppliers may not have the expertise to develop acceptable supply change qualification systems

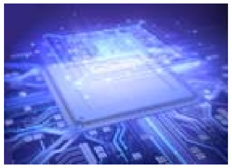


Future Quality Requirements

- Quality Improvement
  - Increasing number of metals and elements in CofA
    - 8 to 24 or full spectrum
  - 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

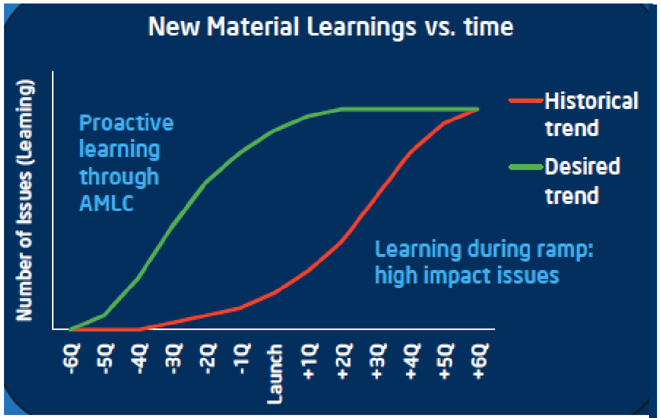
- Service Improvement
  - Beyond SPC
  - Ship to stock qualification

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



Incumbent Supplier Base is being Challenged

Hendry ISS 2013

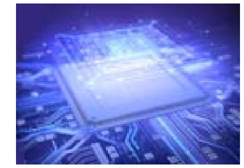


Hendry ISS 2013

New material formulations being introduced
New suppliers bring innovation
Mature formulations used for new applications

Technology cycles are being compressed
New suppliers have a steep learning curve
End-users have limited process characterization resources

The Entire Value Chain is Being Challenged



End-Users

Need to have materials qualified

Need to track more of the supply chain

Need to control overheads

Handling many more materials

Sub-Suppliers

Original contracts did not call for stringent quality processes

Do not sell directly to end-user – it is not our problem

Do not know how to implement systems

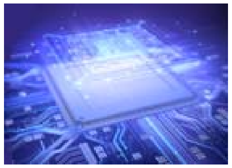
Need to understand appropriate levels of spending and scale to these operations

Prime Suppliers

Being held accountable for sub-supplier systems

Do not have capabilities to track activities at sub-suppliers

Need to understand appropriate levels of spending and scale to these operations



Supply Chain Optimization Challenge

- Companies at all levels in the value chain need to increase the levels of resourcing required to support the semiconductor industry.
  - Prime & sub-suppliers have multiple Tier 1 end users in the industry
  - End users have unique audit or pre-audit template required
  - Customer pre-audits and audits require significant resources to complete
  - Each process increases the depth and breadth of questions
  - Advanced process nodes require complete re-evaluation of established C of A
- Suppliers at all levels are struggling to meet expectations
  - New suppliers to the industry do not have the resources available
  - Older products have may have significant supply gaps but these will not be identified or closed to meet ramp cycles
  - Suppliers at all levels need to make new investments in quality systems and need guidance from a strategic materials supply chain organization.

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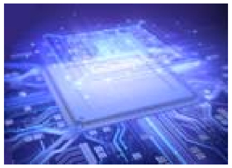


What is Happening Today?

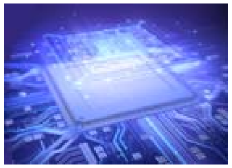
IC Manufacturers are making changes

- Focusing on formulation sub-suppliers
- Are evaluating strategic supplier readiness
- Imposed significant fines for quality manual violations
- Actively eliminating under performing suppliers

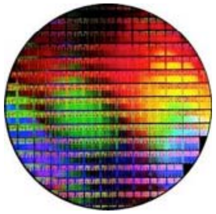
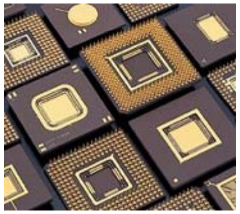
Suppliers need assistance to overcome barriers:

- Executive Sponsorship
  - Assignment of talent and resources for change
  - Commitment to attainment of quality goals
- Education
  - Understanding WHAT and WHY and HOW MUCH
- Involvement
  - All aspects of sales and operations are stakeholders for quality metrics
- Price
  - End users need to pay for the appropriate level of testing and production capabilities

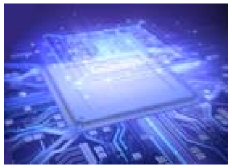
Impact of Excursions



Detection location

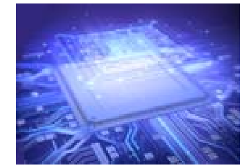
IMPACT to:	Raws	Qualified Product	On Wafer	Packed Chips	Consumer Product
Business					
Operating capital					
Good Will					
Technical					
ID Root Cause					
Recurrence of Issue					



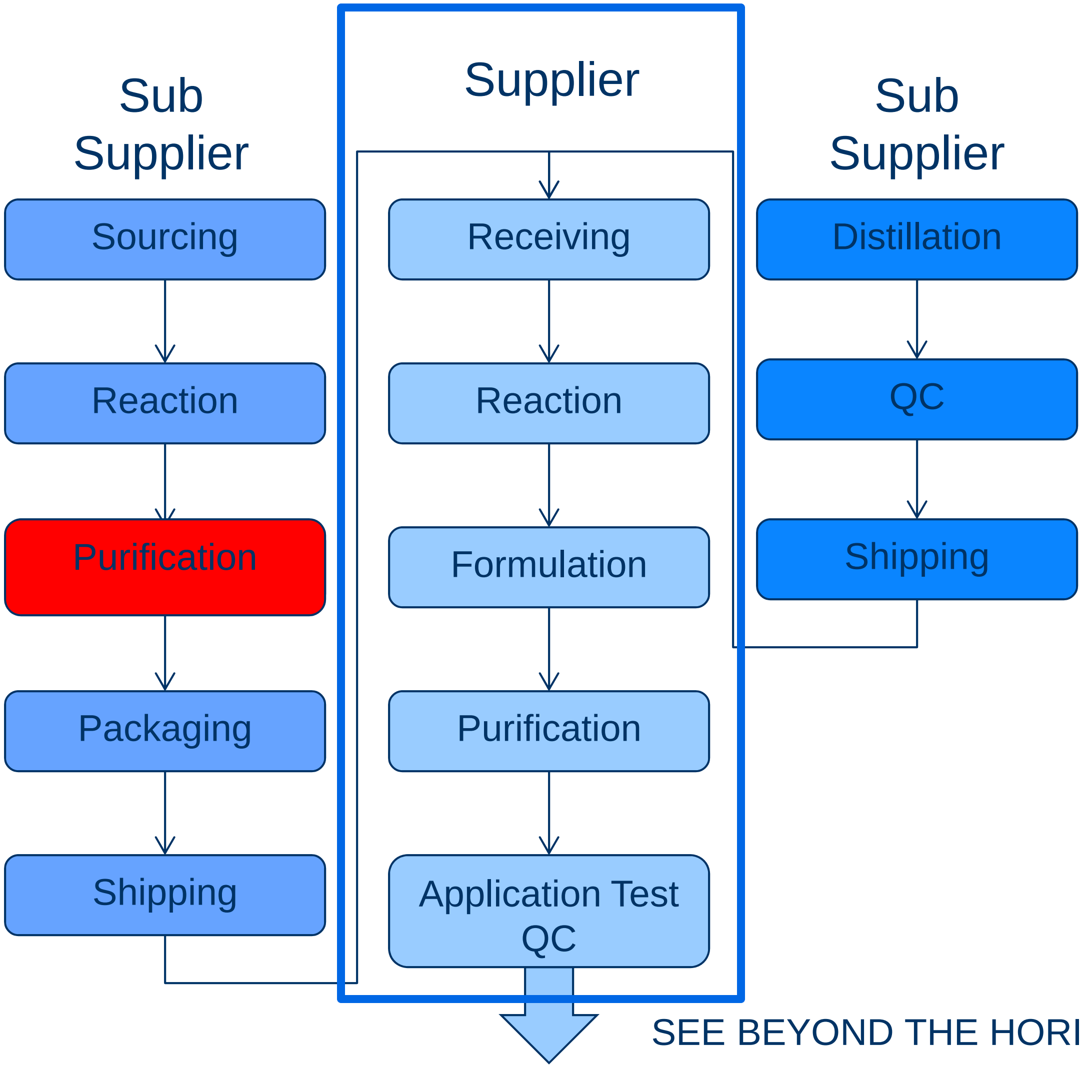
Why Linx?

The advanced materials and tooling market is again evolving. New platform development is costly and risky. End-users are identifying new strategic partners and suppliers who they can rely on to help meet their business goals. Supply chain risk has been identified as a significant vulnerability. In response to this, FABs are rethinking strategic partnerships to focus on suppliers who have consistently met project deliverables and not slipped on manufacturing ramp schedules. We can help throughout this evolution.

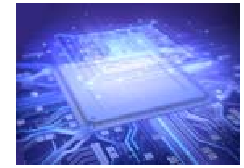
http://csduk.learningpool.com/course/view.php?id=438



Advanced Materials Learning/Characterization



- Well controlled manufacturing at the prime supplier leads to product qualification
- Changed process at the sub-supplier changes end product performance
- Process audits identify areas of interest to be investigated during an excursion
- Sub-supplier process mapping is now expected during product development
- CofA are not sufficient for adv. materials
- GOAL: Eliminate Variation



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

- Supply Chain Management is key differentiator. The Impact of excursions grows with time
  - Quality and supply chain sources of deviation most be better understood
  - Companies with strong supply chain management are the most likely to expand at or better than the industry growth rate.