

TEHCET GROUP LLC
PRESENTS

CMP Consumables Update **Suppliers, Markets, Applications**

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UNDER CONTRACT WITH:



TEHCET GROUP LLC

If we could first know where we are and where we are going,
we could then better judge what to do and how to do it.

Abraham Lincoln 1858



The value of the TEHCET Report therefore is in:

Risk Management

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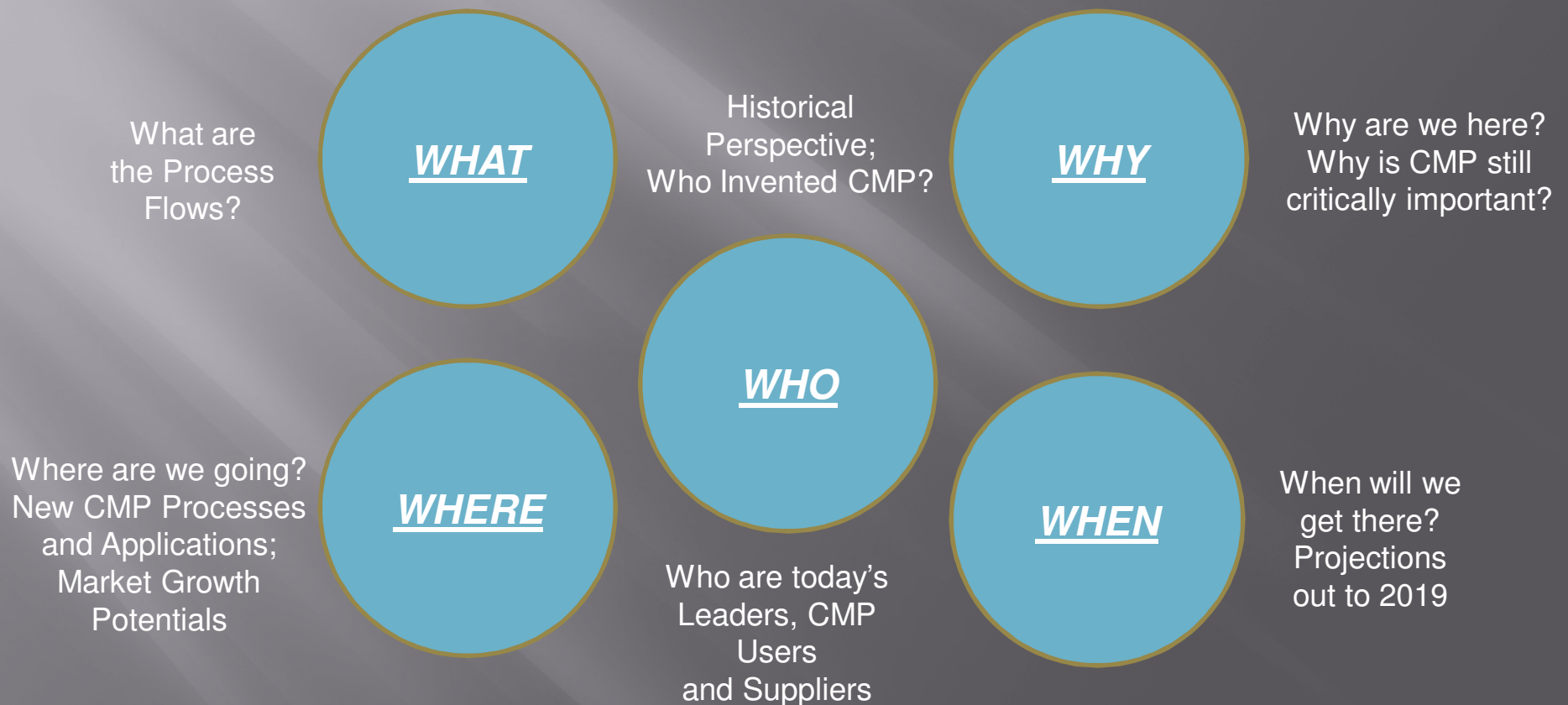
The More you can Learn
From the Best Sources you can Find
The more Capable you will become in:

Risk Management



Techcet CMP Consumables

From the Beginning, we set out to do *Something Different* this year



Techcet CMP Consumables

From the Beginning, we set out to do *Something Different* this year

The report was written to become the definitive resource for:

- The CMP User Community
- CMP Industry Strategists & Technicians
- CMP Supply Chain Managers
- and in addition:
 - Employees new to CMP – it is a Technology Primer
 - New suppliers – it indicates where opportunities are located
 - Investor Community – it highlights market leaders & start-ups

Techcet CMP Consumables

What is in this new report?

- ▣ The CMP Industry Climate & Applications Analysis
 - Nine Market Segments
 - Slurries
 - Slurry Filters
 - Retaining Rings
 - Pads
 - PVC Brushes
 - Equipment Suppliers
 - Conditioning Disks
 - Cleaning Chemistries
 - Support & Service
 - Each segment in the new TECHCET Report includes:
 - ▣ Executive Summary
 - ▣ Business Environment Analysis
 - ▣ Market Share Information
 - ▣ Projections into future years
 - ▣ Supplier Company Profiles – extensive, in-depth

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What is in this new report?

- ▣ The Supplier Analysis (189) includes:
 - Company name and contact information, date established
 - Parent Company, ownership tree
 - Global locations, manufacturing locations
 - Websites applicable to CMP
 - Company Overview, History, Current involvement in CMP
 - Annual Sales Revenue; Total and CMP related
 - CMP related products and applications
 - Market share position
 - Comments, discussion points, potential changes

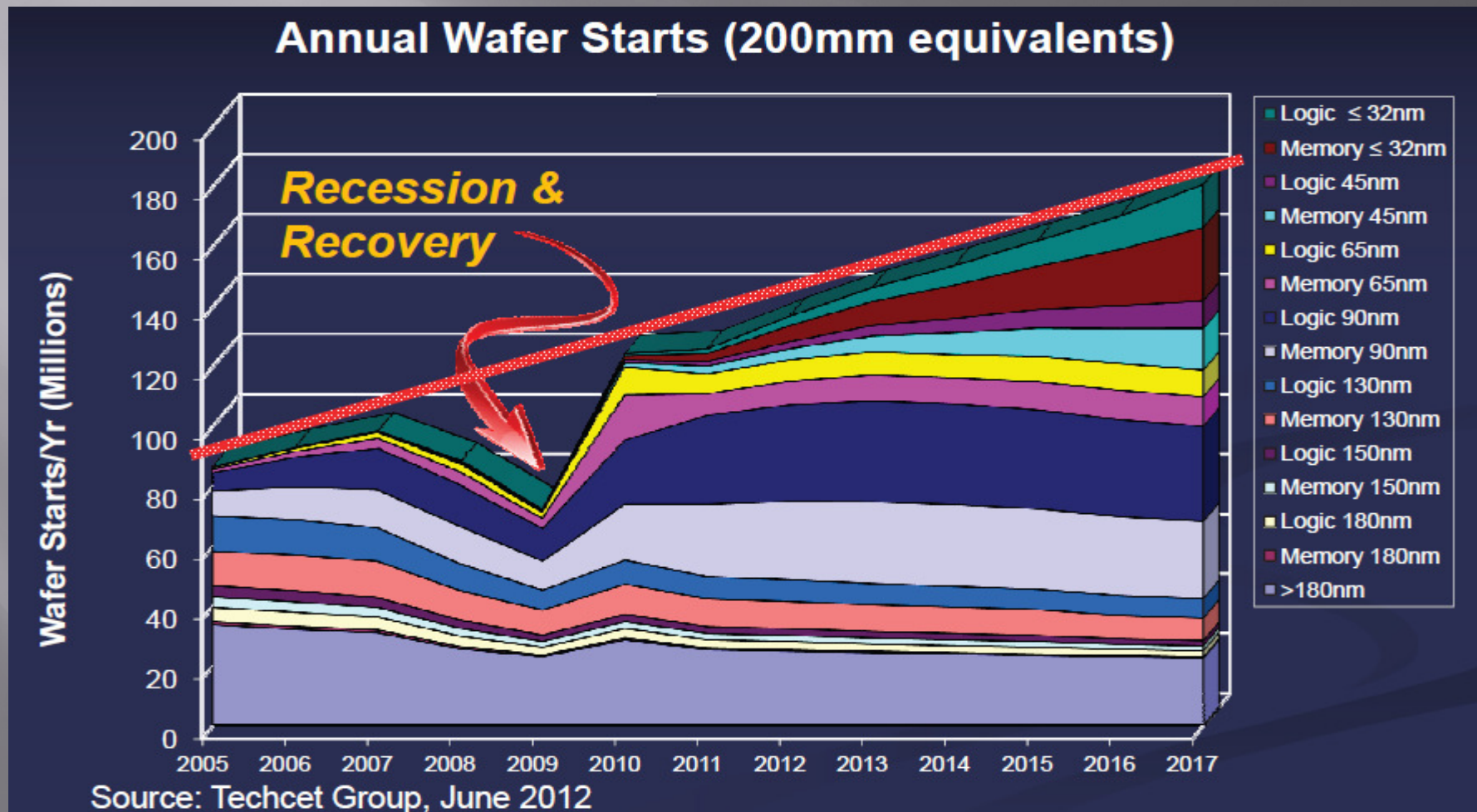
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What is in this new report?

- ▣ The University Research Program Analysis (40) includes:
 - University name and Location information
 - Program Chair or Technology Leader
 - Technology, Product, or Service Focus of this program
 - Website addresses, contact information
 - Overview of their program; direction of their research

CMP Consumables – 2005 to 2012

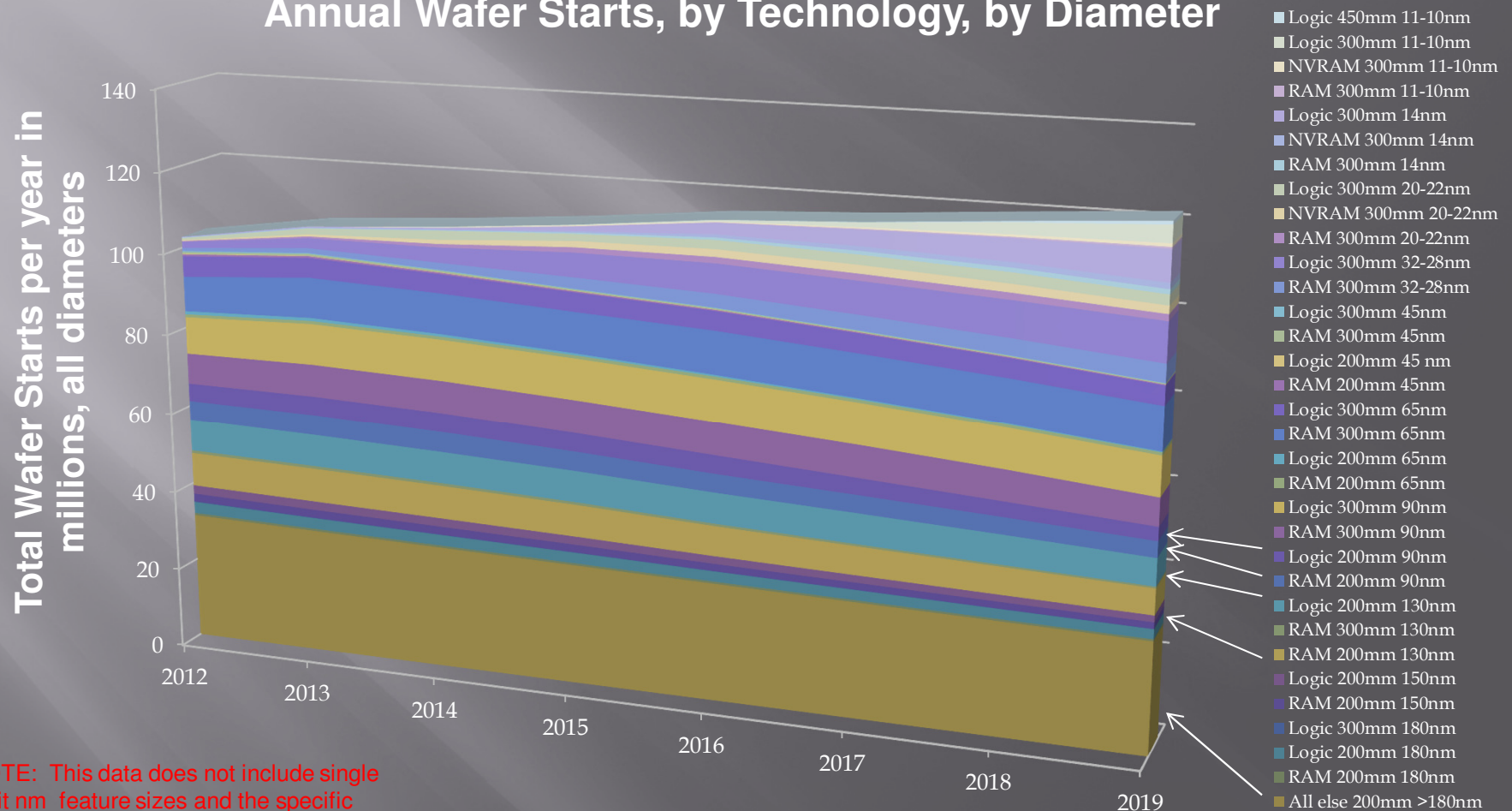
Old News



CMP Consumables – 2014-2019

New News

Annual Wafer Starts, by Technology, by Diameter

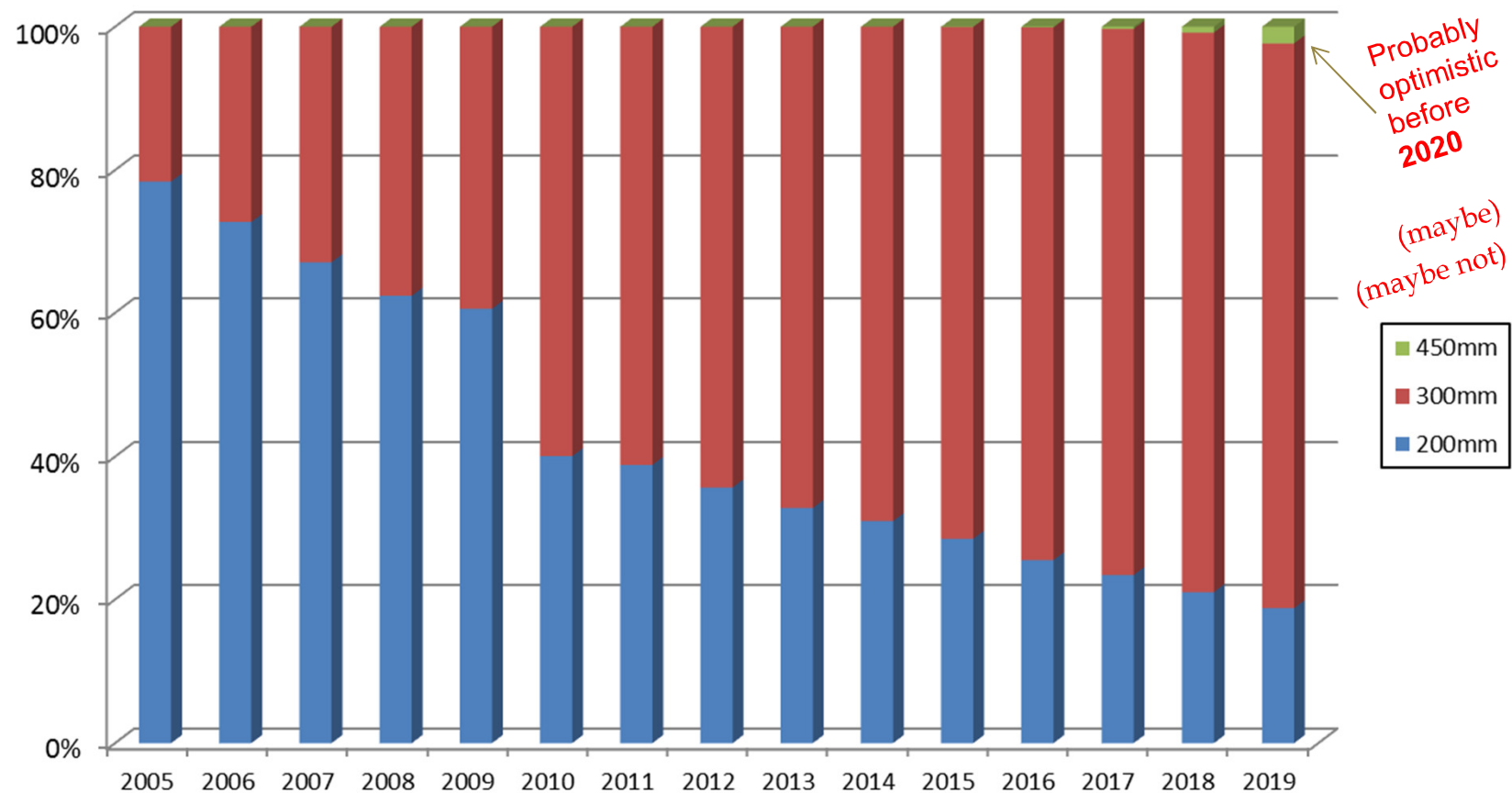


NOTE: This data does not include single digit nm feature sizes and the specific revenue figures: see full report for details

CMP Consumables – 2014-2019

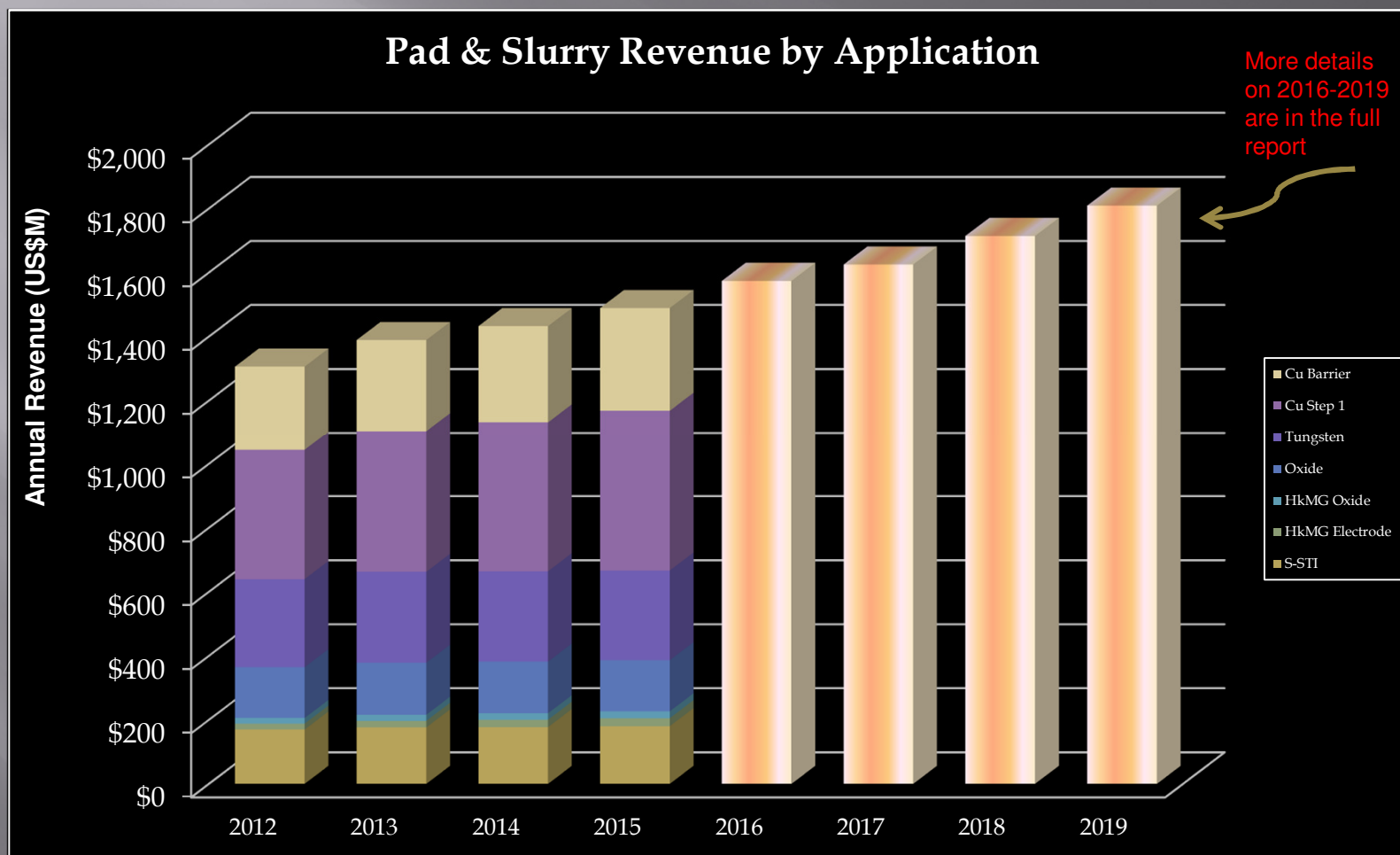
New News

% Pad Revenue by Wafer Size: All Processes



CMP Consumables – 2014

New News



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- ▣ The Business of CMP – in a nutshell
 - Older technologies – their dominance is weakening
 - ▣ 200mm and smaller
 - ▣ 90nm (and larger) Logic and Ram
 - ▣ Tungsten and some ILD CMP processes
 - Newer technologies – their presence is growing
 - ▣ 300mm - definitely
 - ▣ 450mm - still some degree of speculation on timing
 - Expected to be the most expensive per-fab retooling the semiconductor industry has ever seen
 - ~ \$6B to \$10B US\$ for each fab!
 - ▣ 22nm and smaller (14nm going into production; 7nm, 5nm on the horizon)
 - ▣ Copper and Copper Barrier CMP processes
 - ▣ Some Selective STI growth continues
 - ▣ Discussions are ongoing about single digit nm feature sizes!

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- ▣ The Business of CMP – in a nutshell (continued)
 - Growth in consumables revenue – now comfortably above \$2B US\$
 - Growth in Copper, Copper Barrier, some Selective STI applications
 - 5-year CMP slurries and pads CAGR: 3.87% (driven by slurries)
- ▣ IC Customer base is changing: Consolidation, Retraction
 - Fewer customers, larger customers, a few are very large
 - ▣ (and demanding!)
 - Supplier companies face ASP challenges
 - ▣ Due to competition and customer “muscle”
- ▣ Diversification of 200mm fabs
 - MEMS – growth rate outpacing overall IC market growth rate
 - ▣ Expected to be a \$20B US market by 2017
 - Specialized market and product niche

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- ▣ Who are the Slurry Suppliers? (listed by revenue estimates)
 - Major supplier: Cabot Microelectronics Corporation (~ 36%)
 - Then: Hitachi, FujiFilm, DA Nanomaterials, Fujimi, DOW
 - Tungsten slurry not growing much; Copper slurry is surging
- ▣ Manufacturing in multiple country sites
 - Or forming collaborative or JV arrangements with Asian-based manufacturers
- ▣ Stand-alone Competitors in the Asian Region
 - China, Taiwan, South Korea
 - IP and patent infringements are not uncommon
 - Some are supported by major device fabs

Techcet CMP Consumables

- ▣ Who are the Polishing Pad Suppliers? (listed by revenue estimates)
 - 20 suppliers share the global TAM ~ \$720M US\$
 - Major supplier: DOW Electronic Materials (but market share receding)
 - Then: Cabot Microelectronics Corp.
 - And: innoPad, Thomas West, NexPlanar, Fujibo
 - Others: 3M, JSR, IV-Tech, KPX
- ▣ Manufacturing in multiple country sites
 - In order to get closer to the customer base
 - To mitigate risk of natural disasters
 - Establishment of secondary or tertiary manufacturing sites
- ▣ Stand-alone Competitors in the Asian Region
 - IP infringements are not uncommon

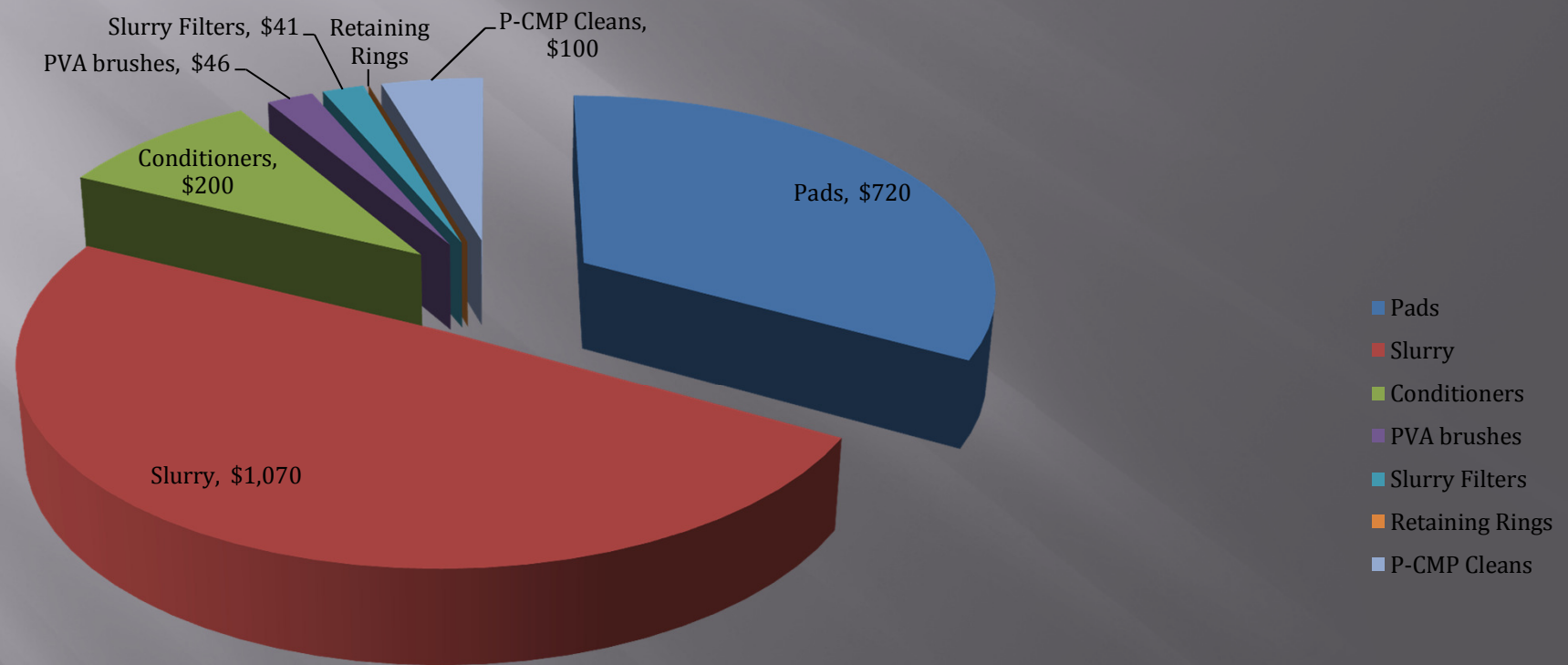
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- ▣ Who are the other CMP suppliers?
 - Pad Conditioners
 - ▣ Market Size: ~ \$200M US\$
 - Leaders: 3M, Saesol, Kinik combined market share of 86%
 - P-CMP Cleaning Chemistries
 - ▣ Market Size: ~ \$80M to \$120M US\$
 - Leaders: Air Products, ATMI (Entegris), combined share of 67%
 - PVA Brushes
 - ▣ Market Size: ~ \$46M US\$
 - Leaders: ITW Rippey, Aion, Entegris, combined share of 91%
 - Slurry Filters
 - ▣ Market Size: ~ \$41M US\$
 - Leaders: Pall, Entegris, combined market share of 87%

Techcet CMP Consumables

Market Sizes in Millions of US\$

□ Total CMP Consumables (less retaining rings) = \$2.177B US\$



Techcet CMP Consumables

▣ Looking for the New Normal

- From **Solid State Technology**, (March 12, 2014) – “The Semiconductor Industry Association (SIA) today announced that worldwide sales of semiconductors reached \$26.28 billion for the month of January 2014, an increase of 8.8 percent from January 2013 when sales were \$24.15 billion, marking the industry's highest-ever January sales total and the largest year-to-year increase in nearly three years... sales in the Americas increased by 17.3 percent compared to last January.
- From **Alix Partners** (March 12, 2014) – “Companies throughout the industry continue to grapple with several challenges, including soft macroeconomic market environments in key geographies, intense competition, pricing pressure, and short and costly product life cycles. Combined Sales, General, and Admin expenses (SG&A) and R&D spending increased 35% the past three years.”
- From **PWC Global**, (March 12, 2014) – “Current (semiconductor) market conditions and outlooks are mixed for the next few years, largely because of the fragile global economic outlook.”

▣ Which one is the New Normal?

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Update: 3rd Quarter 2014 (2nd quarter numbers)

- ▣ Actual performance numbers from the supplier community are limited to the public and not typically shared
- ▣ Data from publically traded user companies is available
 - We can examine this information and draw conclusions on the health of the consumable supplier community
 - ▣ based upon quarter-to-quarter performance
 - Intel, Samsung, Qualcomm, SK Hynix, Texas Instruments, Renesas, Infineon, NXP, Freescale, all reported 2nd quarter revenue up at least 4% over 1st quarter (some as high at 8% to 10%)
 - Toshiba, and Micron are the only companies reporting negative growth in 2nd quarter results versus their 1st quarter results.
 - ▣ However, that negativity was less than they expected.
- ▣ Many predictions for 2015 growth performance are similar to the performance being seen in 2014.

Research sources: Gartner, SI Stats, WSTS, IMF

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(What We Think We Know)

- ▣ Ceria, Cerium Oxide
 - Continues adaptations in STI and ILD applications
 - It is price sensitive, source sensitive, supply sensitive, defectivity sensitive
- ▣ 450mm

"Intel, ASML, AMAT slow down their migration to 450mm wafers." from Seeking Alpha, March 14, 2014

 - Indications are that projecting out 5 years... *(or more!)*
 - ▣ 24% of total wafer starts will still be 200mm (or smaller)
 - ▣ 75% of total wafer starts will be 300mm
 - ▣ Probably 1% (or less) will be at 450mm
- ▣ Copper and Copper Barrier continue to grow
 - Offering opportunities for innovative suppliers
- ▣ At 22nm and below:
 - all suppliers in all CMP segments must devote time, effort, research, and manufacturing improvements to reach the defectivity requirements or risk extinction.

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(What We Think We Know)

- ▣ At 22nm and below (continued):
 - “Gate Last” for high performance logic followed possibly by other logic, perhaps flash, and then other memory going this direction
 - Metal of choice at 22nm and below
 - ▣ Aluminum? What about polishing issues? (smears, humps, comet trails)
 - ▣ Tungsten? Will it play a significant role? (alternative to aluminum?)
 - ▣ How does either one affect CMP slurries and pads?
- ▣ Significant Growth Moves/Changes at Consumables Manufacturers
 - Entegris takes over ATMI
 - 3M - strong moves in filters and pad conditioners
 - Some smaller, innovative pad and slurry manufacturers gaining foothold (copper)

Techcet CMP Consumables – Beyond

(What We Need To Know)

- ▣ Alternative Technologies
 - Nanowires
 - Carbon nanotubes
 - Graphene
 - Vacuum Transistors
 - “POET” or Planar Opto-Electronic Technology
- ▣ How do these technologies affect the implementation of CMP principles and practices?
- ▣ What changes will be needed in CMP consumables?
- ▣ When will they have an effect on a manufacturing scale?
- ▣ Who will be the technology leaders?

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The Resource for: The CMP User Community, CMP Industry Strategists & Technicians, CMP Supply Chain Managers

- ▣ New, Expanding Applications for CMP
 - TSV in FEOL, MEOL, BEOL applications
 - MEMS – incredible number of applications
 - LED – GaN on silicon substrates
 - Nanotechnology
 - MicroMachining
- ▣ Consolidations - Changes
 - Applied Materials and TEL
 - Entegris and ATMI
 - More supplier consolidations can be expected
 - ▣ Seemingly inevitable when:
 - the customer count shrinks
 - ASP pressures increase
 - Technology growth begins to soften (Tungsten, and some ILD applications)
 - IBM may remove itself from device manufacturing or partner (GF?)

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□ Summary

- CMP related technologies in general, when examined as a Technology Sector of the overall semiconductor industry look to be relatively strong for the next five year period – driven by copper.
 - 2014 Mid-Year reports show solid year-over-year growth in IC shipments (25+%) and manufacturing equipment bookings (25+%)
- Closer investigation clearly indicates a weakening trend in Tungsten and some ILD applications, and a diminishing volume of 200mm wafer starts.
- The variety of applications of CMP technologies is growing in MEMS, MOEMS, TSV, and other nanotechnologies.
- At 22nm and below, defectivity needs to be the primary concern of everyone in the CMP Consumables Market sector (users and suppliers).
- Investments into 450mm technology are being made but pausing.
 - The schedules for wholesale introduction and respectable ROI are still vague; with impacts upon pads more than slurry at this point.
- Supplier consolidations are expected to continue.

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The Resource for: The CMP User Community, CMP Industry Strategists & Technicians, CMP Supply Chain Managers

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- ▣ Lita Shon-Roy, President/CEO
- ▣ Karey Holland, PhD, Chief Technologist and Future Technologies Analyst
- ▣ Mike Fury, PhD, Senior Technology Analyst – CMP Consumables
- ▣ Chris Michaluk, Director of Business Development and Senior Technology Analyst – Metals

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- ▣ Paul Feeney, Director of Process Development

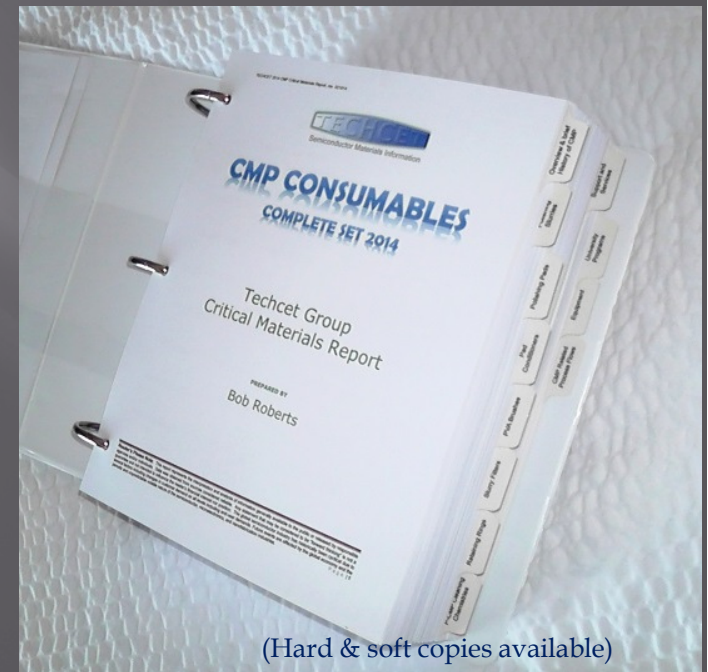


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The Resource for: The CMP User Community, CMP Industry Strategists & Technicians, CMP Supply Chain Managers

▣ The Techcet Group, LLC

- The 2014 Techcet Report on CMP Consumables & Market Analysis
 - ▣ 12 Sections, over 600 pages
 - ▣ Overviews and Analyses of:
 - 9 CMP Market Segments
 - 189 CMP Consumable Suppliers
 - 13 CMP Equipment Suppliers
 - 40 College/University CMP programs
- **To order, contact: Chris Michaluk**
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