TECHCET Group LLC
presents

CMP CONSUMABLES
2014 MARKET UPDATE

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Electronics Materials Information

TECHCET 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 TECHCET Report is in: *Risk Management*.

From the Beginning, we set out to do Something Different

What are the Process Flows?

WHAT

Historical Perspective; Who Invented CMP?

WHY

Why are we Here? Why is CMP still critically important?

WHO

Who are today's Leaders, CMP Users and Suppliers

Where are we going? New CMP Processes and Applications; Market Growth Potentials

WHERE

WHEN

When will we get there? Projections out to 2019

Techcet CMP Consumables - 2014

- The CMP Industry Climate & Applications Analysis
  - Nine Market Segments +
    - Slurries, Pads, Conditioning Discs, Filters, Brushes, Cleaning Chemistries, Retaining Rings, Equipment Suppliers, Support and Service Suppliers
  - Each of these segments in the new TECHCET Report include:
    - Executive Summary
    - Business Environment Analysis
    - Market Share Information
    - Projections into future years
    - Supplier Company Profiles – extensive, in-depth

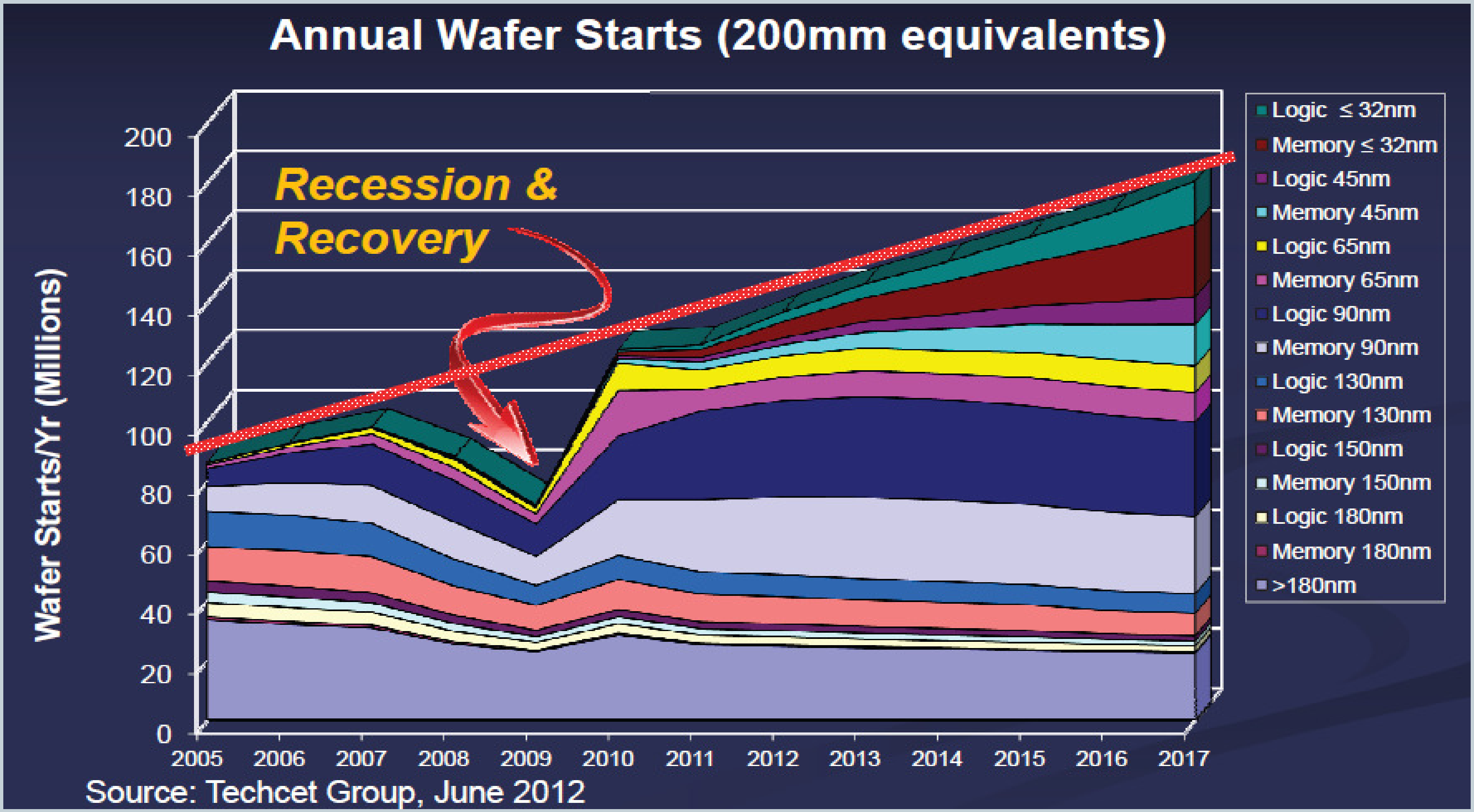
Techcet CMP Consumables - 2014

- 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

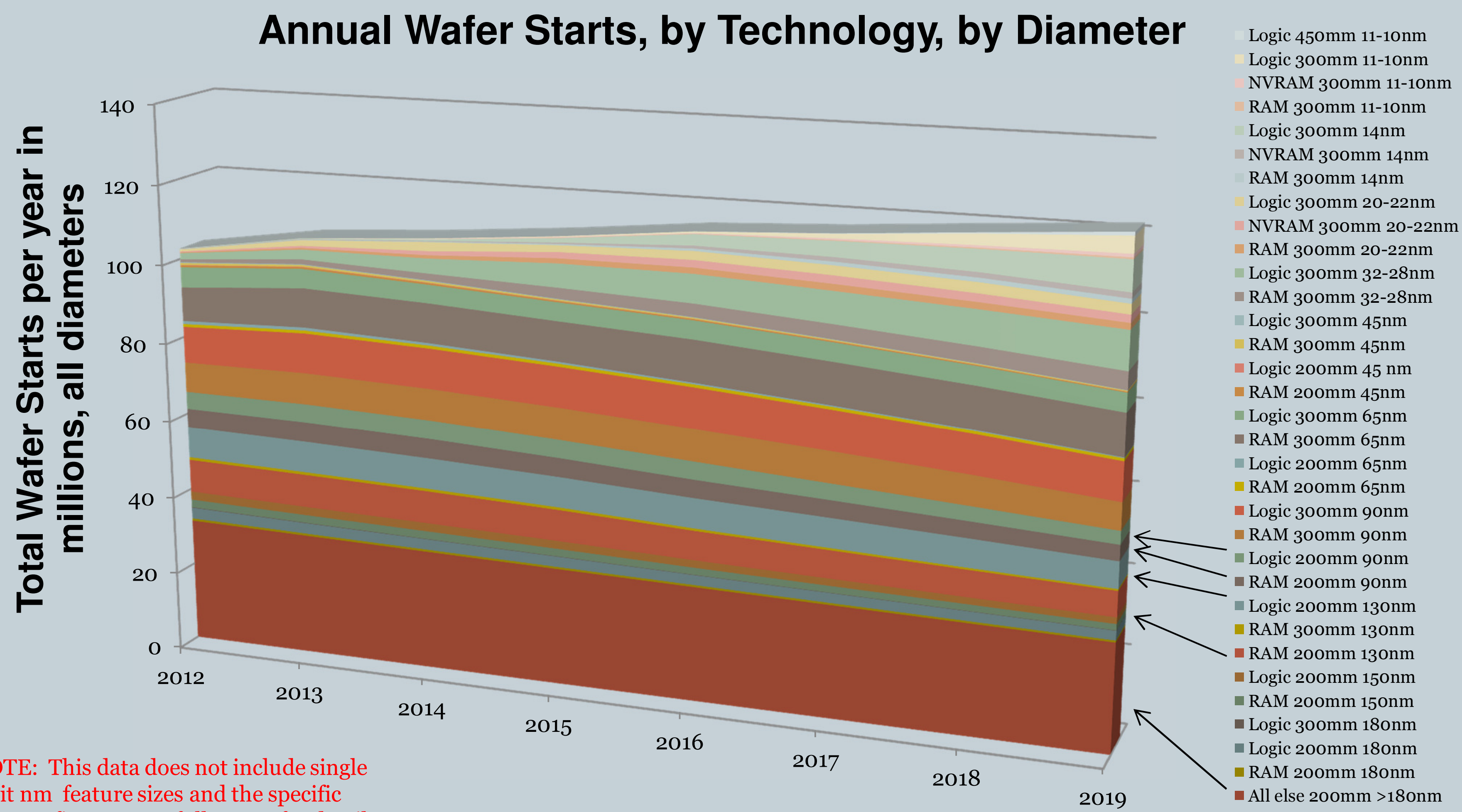
Techcet CMP Consumables - 2014

- 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 – 2012 – Old News

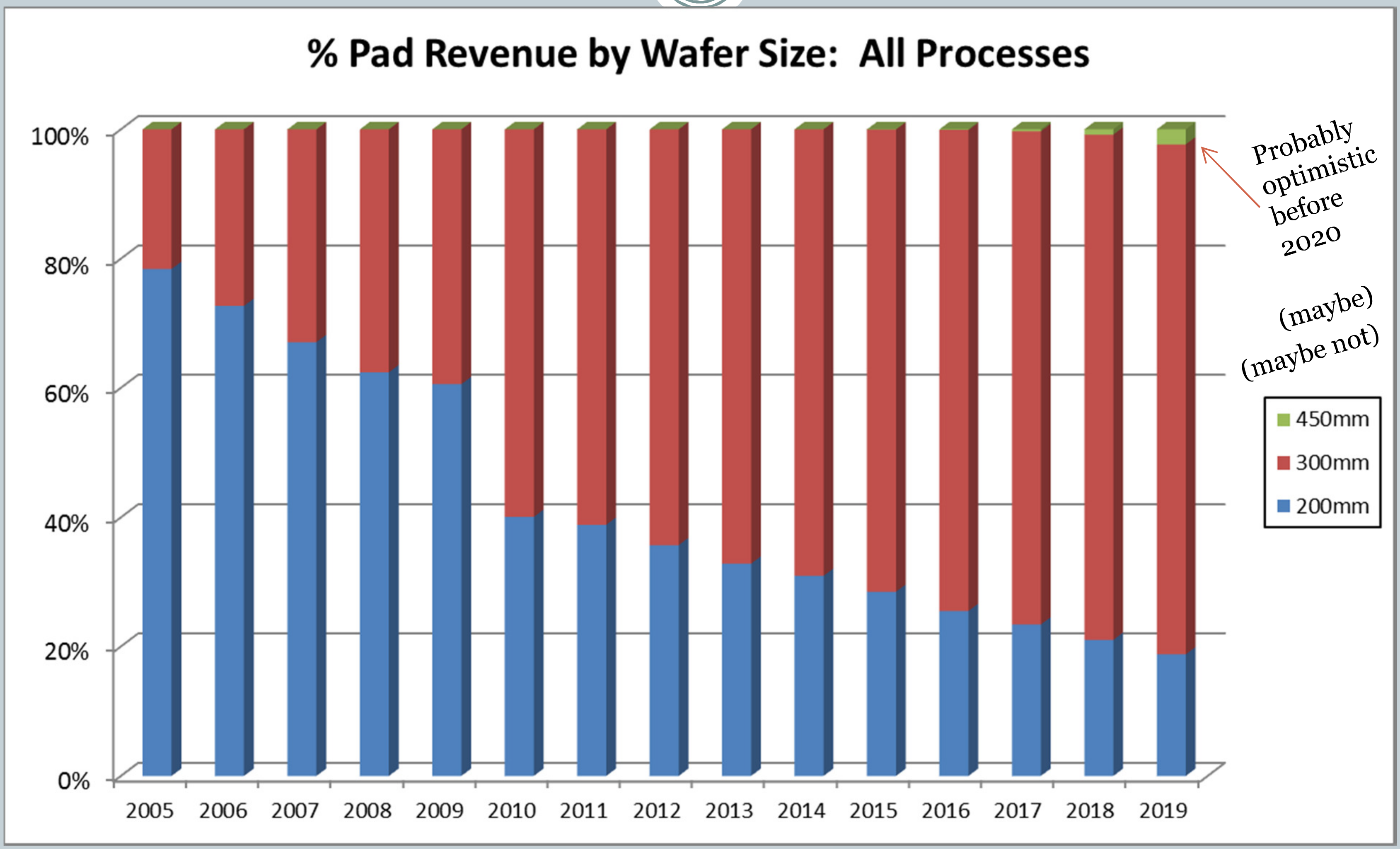


CMP Consumables – 2014 – *New* News

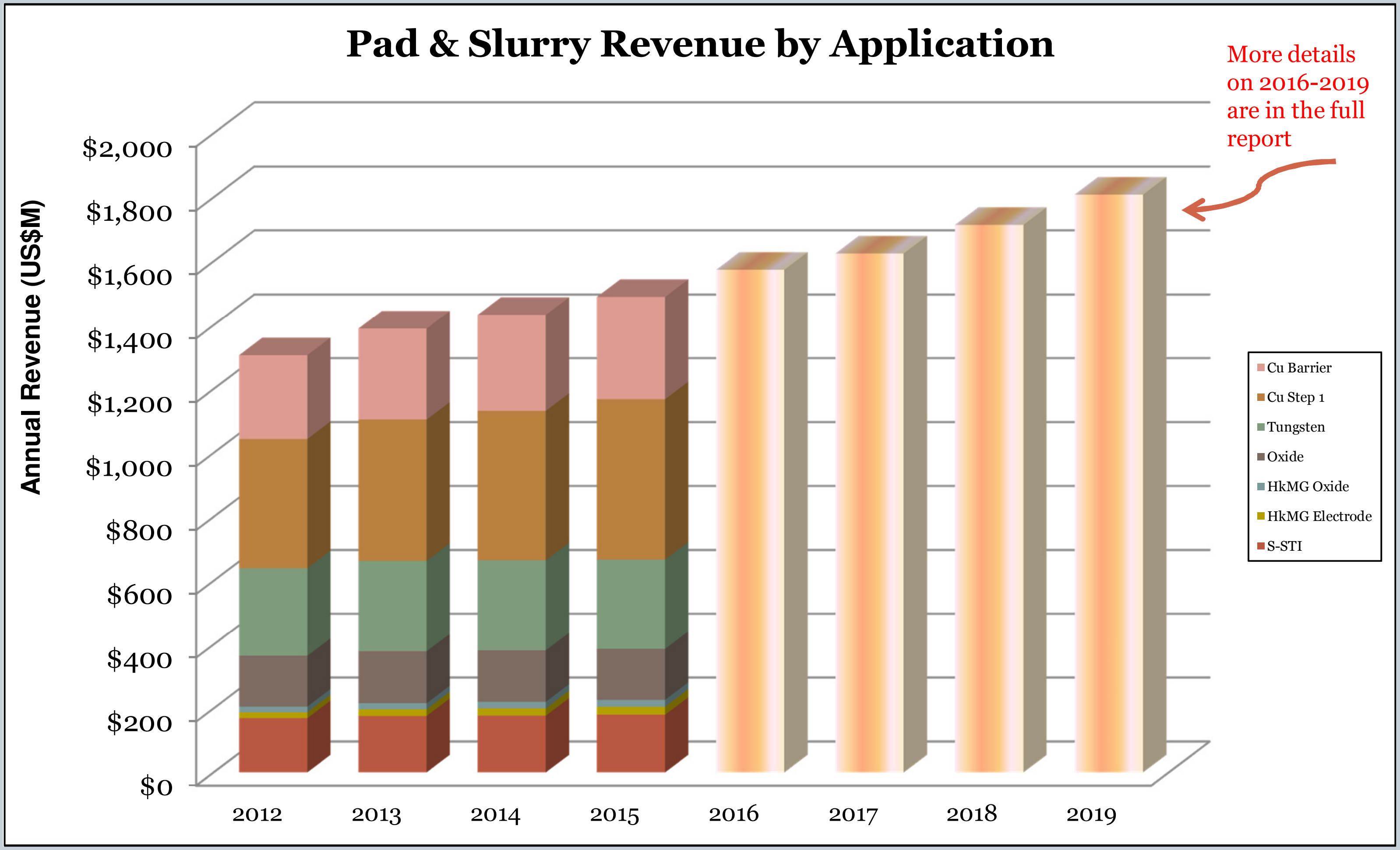


NOTE: This data does not include single digit nm feature sizes and the specific revenue figures: see full report for details

CMP Consumables – 2014 – *New* News



CMP Consumables – 2014 – *New* News



Techcet CMP Consumables - 2014

- 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; ~ $10B US$ each
    - 45nm and smaller
    - Copper and Copper Barrier CMP processes
    - Some Selective STI growth continues
  - Discussions are ongoing about *single digit* nm feature sizes!

Techcet CMP Consumables - 2014

- 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

Techcet CMP Consumables - 2014

- 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 - 2014

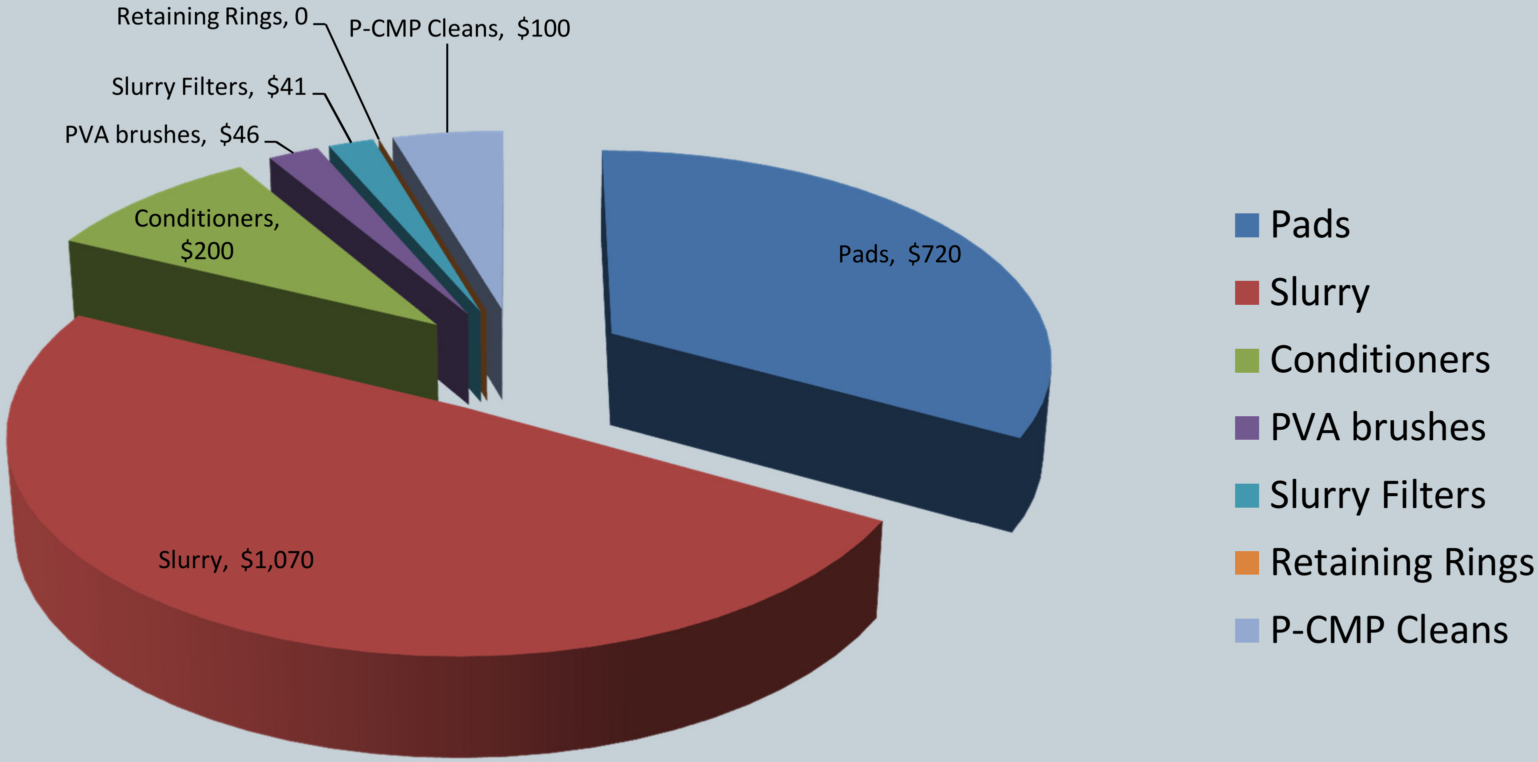
- Polishing Pad Suppliers – listed by revenue estimates
  - 20 suppliers share the global TAM ~ $720M US$
  - Major supplier: DOW Electronic Materials (but market share receding)
  - Then: Cabot Microelectronics Corp.
  - And: innoPad, Thomas West, NexPlanar, Fujibo
  - Others: 3M, JSR, IV-Tech, KPX
- 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

Techcet CMP Consumables - 2014

- 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 - 2014

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



Techcet CMP Consumables - 2014

- 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?

Techcet CMP Consumables – 2014 – (WWTWK)

- 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.
- Significant Growth Moves/Changes of Consumables Manufacturers
  - Entegris takes over ATMI
  - 3M - strong moves in filters and pad conditioners
  - Some smaller, innovative pad and slurry manufacturers gaining foothold (copper)

- New, Expanding Applications for CMP
  - TSV in FEOL, MEOL, BEOL applications
  - MEMS
  - 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?)

Techcet CMP Consumables – 2014

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

- 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.
  - 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.

Techcet CMP Consumables – 2014

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

- Techcet Group LLC
  - Techcet Partners
    - Karey Holland, PhD
    - Steve Holland, PhD
    - Lita Shon-Roy
  - Technology & Market Analysts
    - Michael Fury, PhD, Director, Senior Technology Analyst
    - Chris Michaluk, Director, Senior Technology Analyst
    - Jiro Hanaue, Director, Senior Technology Analyst
    - Bob Roberts
    - Gary Ray, PhD
    - Gerald Elder, PhD
    - Yu Bibby, PhD

(Hard & soft copies available)

Techcet CMP Consumables – 2014

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 and University CMP related programs

Special thanks to:

- Dr. Karey Holland
- Dr. Michael Fury
- Lita Shon-Roy
- Paul Feeney

  - **To order, contact: Lita Shon-Roy**
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Thank You