"Great Recession" Legacy CMP Consumables' New Playing Field

NCCAVS CMPUG Semicon W Meeting

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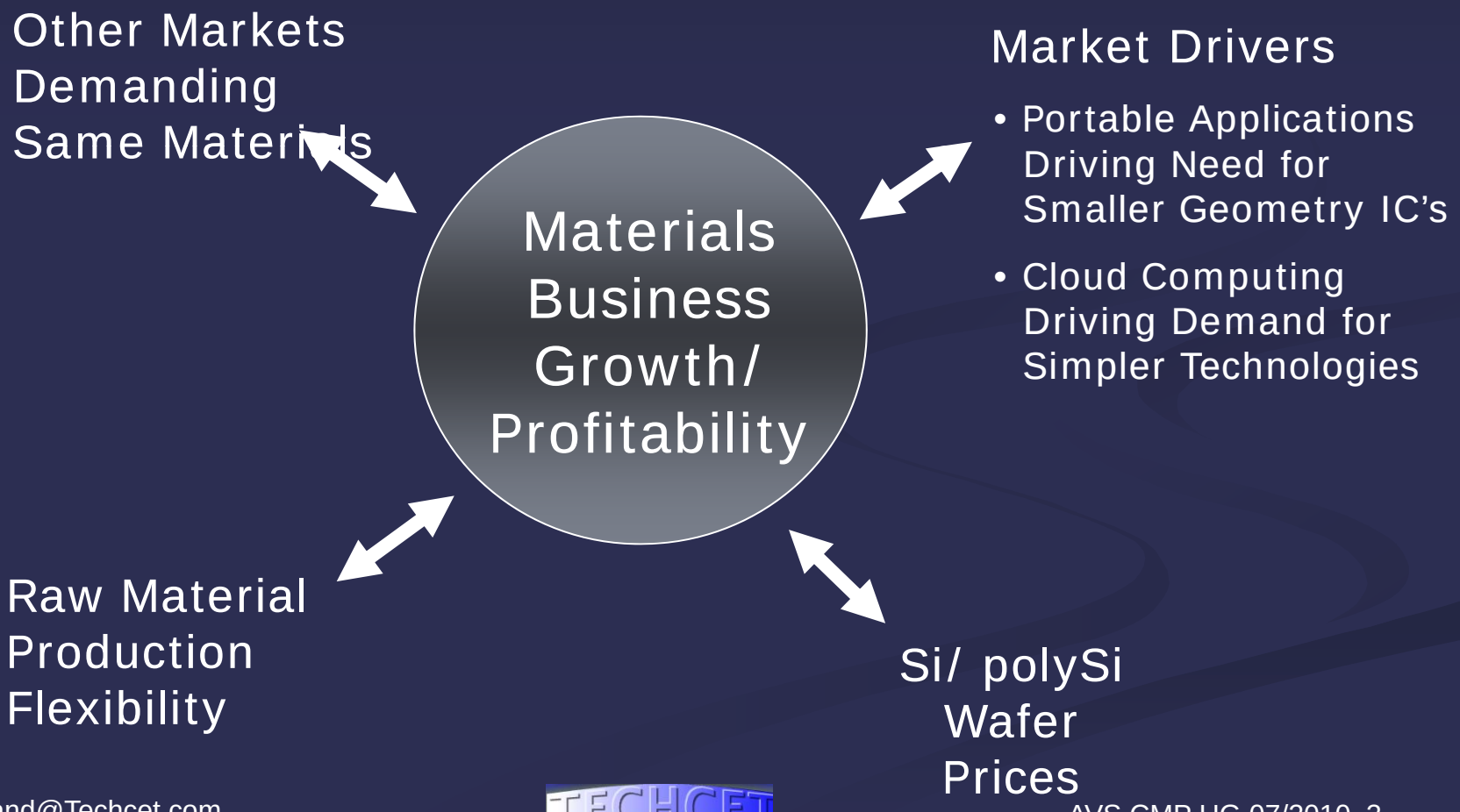
The "Great Recession" Effects

- 2008-09 Very Dark and Scary Years: Materials markets fell as predicted, but no full bounce back in 2010.
- Some Materials less negative: CMP & Bulk Gases
- 2009 was even worse for equipment – the worst of times for Indirect Materials ~ - 40%
- 450 mm becoming a reality despite naysayers
- Cost of "Earth, Wind and Fire" continue to climb

Supply Constraints/ Drivers

(IC Materials, not CMP Specific)



Cost Reduction Focus 2008-09

- All IC Materials Are Affected
- Cheaper Materials
  - Sputter Target Purity versus Price
  - CVD/ALD Precursors (Hf-organo versus $HfCl_4$)
- Do More with Less
  - Previously Undiluted Slurries Diluted
  - Self-Mix of Post-CMP versus Specialty Chemical
- Cost Pressure Throughout the Supply Chain
- New Entrants Focus on Cost of Ownership

Despite Recession: New Technologies and Growth Opportunities

Pre-1985

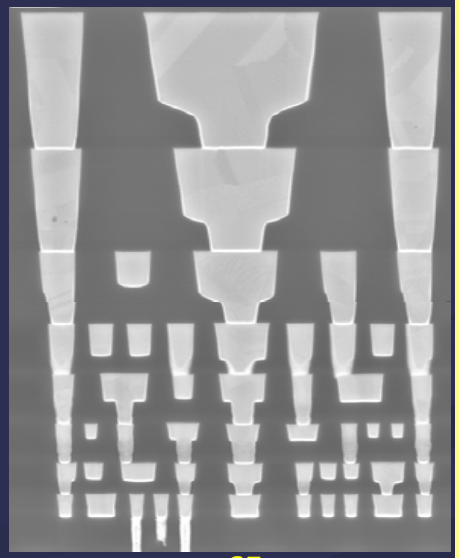
1000 nm
Two Al Metal layers, BPSG & TEOS

Mid-1990's

250 nm
Five Al metal layers, W Plugs, SiOF

130 nm
one W & Six Cu Layer

Mid-2000's



65 nm
Eight Cu Layer

2010's

- SOG STI and pre-M1 Dielectric
- Hi K Dielectric & Metal Electrode Gates
- Hi K Memory Capacitors
- >8 layers of Cu Wire, 45nm
- AirGap @ ≤32nm

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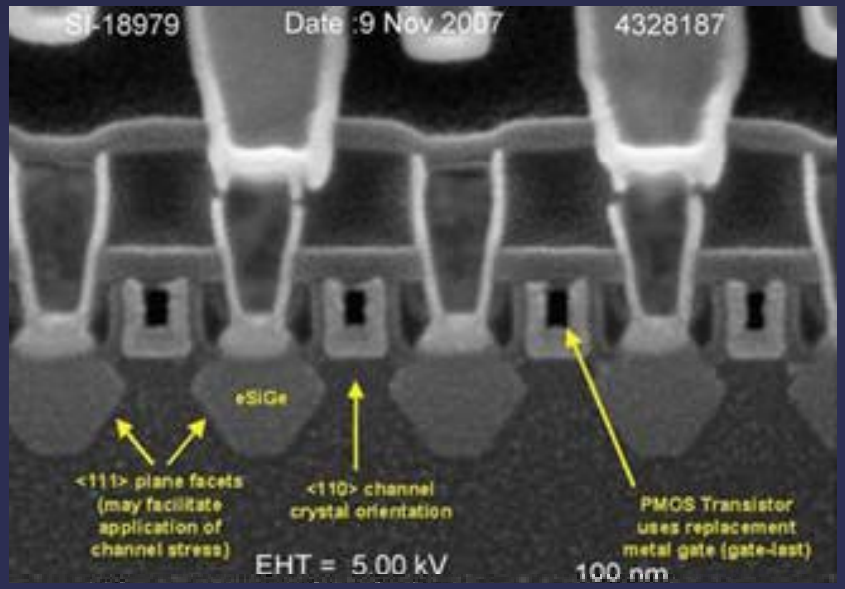
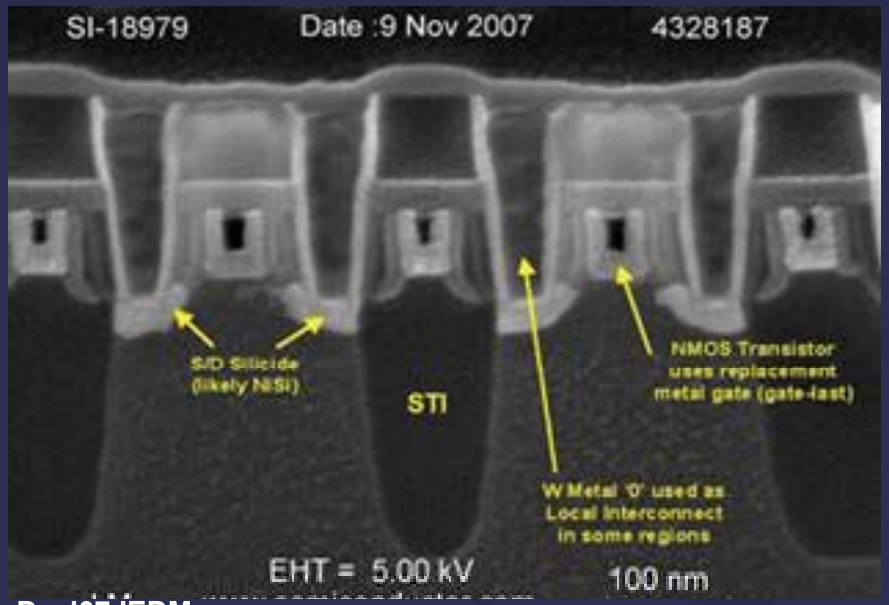
New High K – Metal Gate

Replacement Metal Gate Process

PMOS



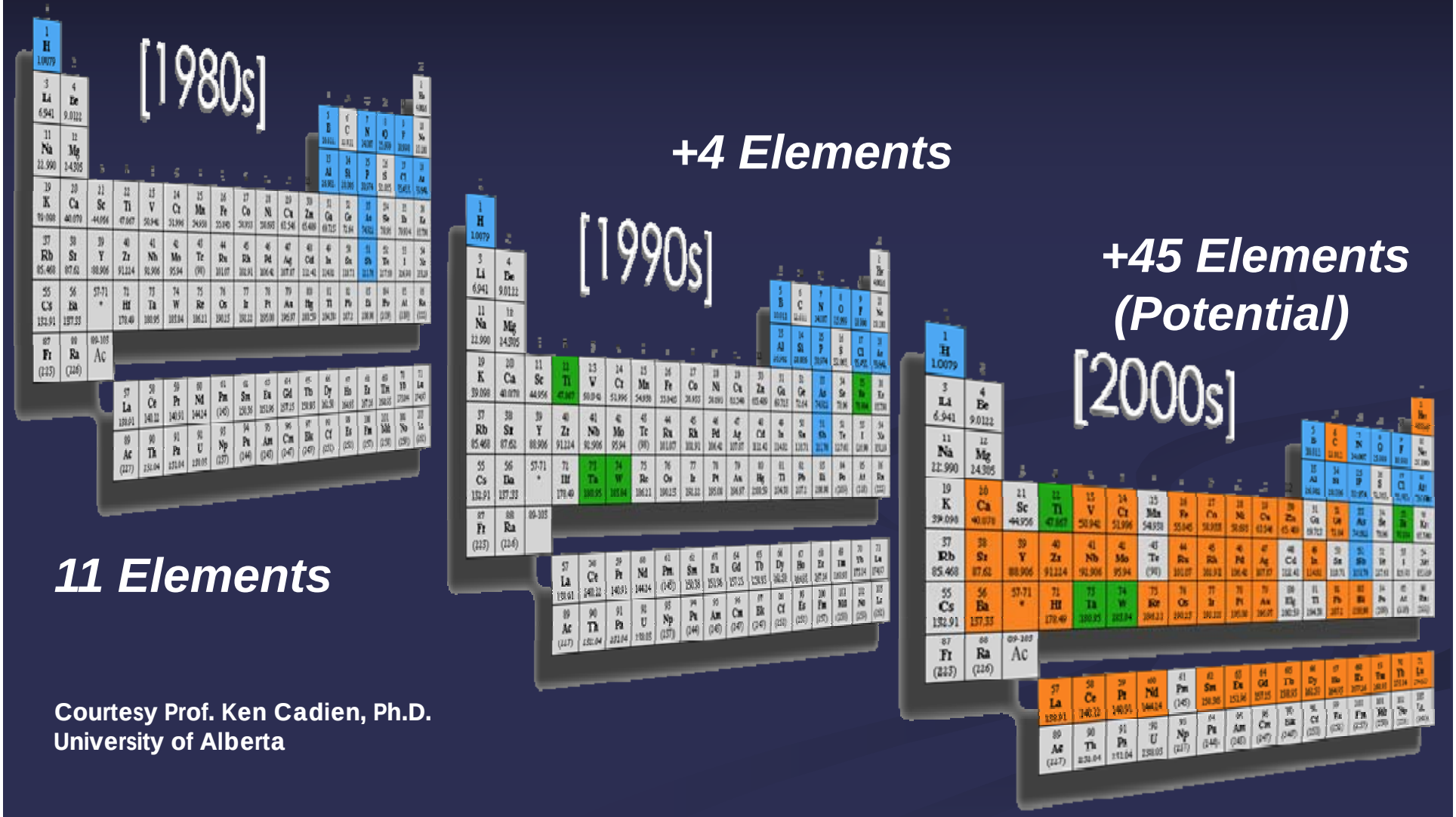
NMOS



Pictures from Dec'07 IEDM

- Significant growth expected for Precursors, for 2015 Market Size in Expected to be <$100M
- Oh boy, more CMP (Al)

ICs Materials Diversity



11 Elements

+4 Elements

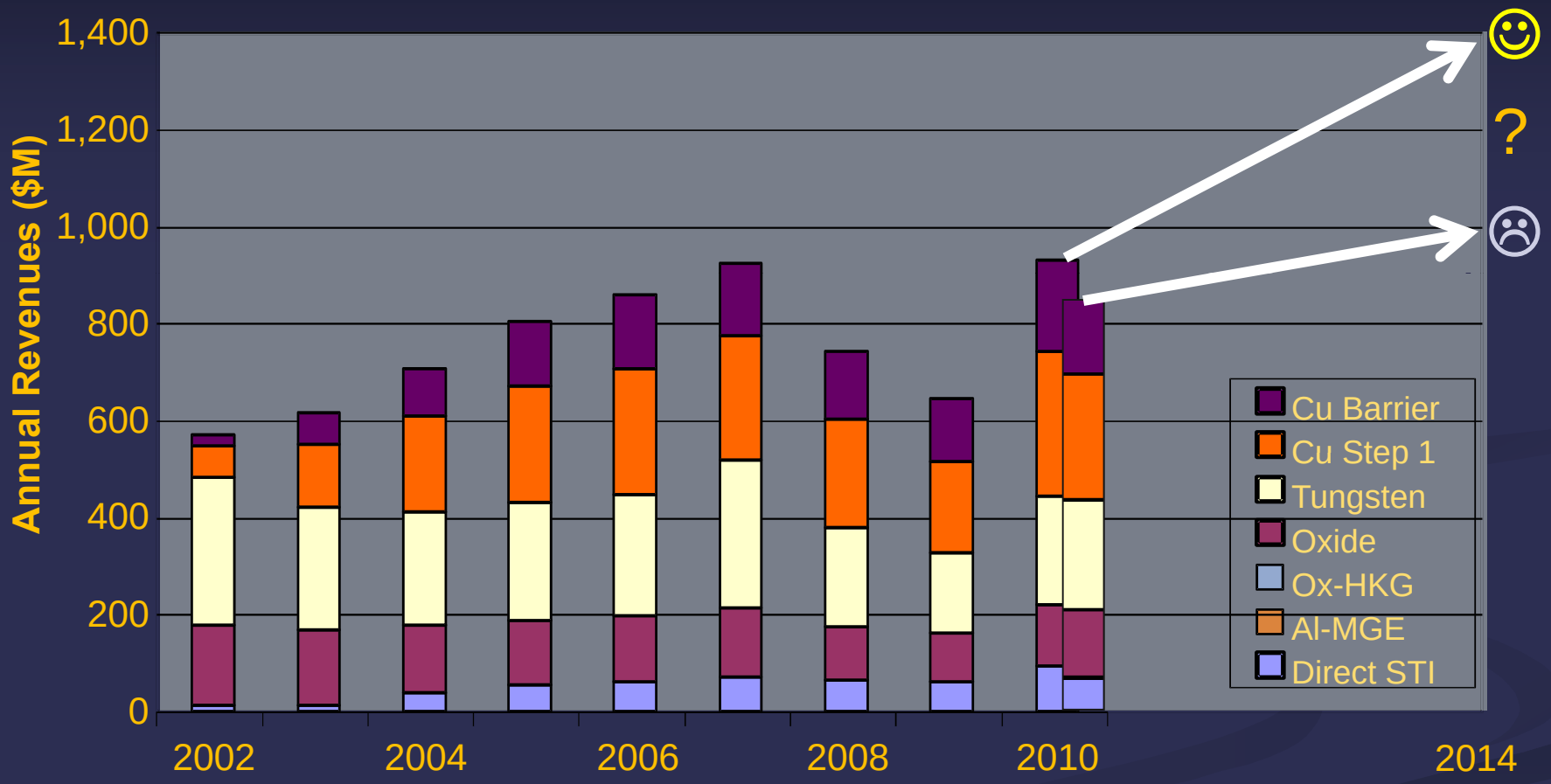
+45 Elements (Potential)

Courtesy Prof. Ken Cadien, Ph.D.
University of Alberta

CMP Materials – Still Accepting New Entrants

- A First? CMP Slurry Revenues Down 20% & 13% in 2008 & 2009
- Post-Recession, CMP Slurry Revenues Recover, Hoping to Match 2007 (2010 >1.20 x 2009)
- Numerous Slurry Suppliers Bring Price Competition, esp. Cu & Barrier and now Direct STI Slurries
  - Cu and Barrier not “one size fits all”
  - Direct STI (Ceria) growing, only one pass per wafer start … new competitor takes signif share
- PCMP: Cu still a growth market, W niches below 45nm, Direct STI opportunities abound
- PVA brushes & Retaining rings – new suppliers, new designs, new materials

IC CMP Slurry Revenues



Slurry Abrasive Suppliers Abound

Company	Product Focus
Adcon Lab, Inc.	abrasives
Anji Microelectronics, Inc.	slurry
Asahi Glass Company	slurry & abrasives
AZ Electronic Materials	slurry & abrasives
Baikowski	abrasives
BASF	slurry
Bayer	slurry & abrasives
Cabot Corporation	abrasives
Cabot Microelectronics Corp.	Slurry
CCIC	Abrasives
Cheil Industries Inc.	Slurry
Chemical Products Corp.	Slurry
DuPont-Air Products NanoMaterials	Slurry
Dongjin SemiChem	Slurry
Dow Chemical	slurry
Eka Chemical	slurry
Elkem	abrasives
Eminess	slurry
Epoch Material Company, Ltd.	slurry
Evonik/Degussa	abrasives
Ferro	slurry
FujiFilm, part owner Planar Solutions	N/A
Fujimi	slurry
Fuso Chemical	abrasives
Grace	abrasives

Company	Product Focus
Hitachi Chemical	slurry
Innovative Organics	slurry & abrasives
Intersurface Dynamics	slurry
JSR Microelectronics	slurry
Kemesys	slurry
Mallinckrodt Baker	slurry
Mitsui Mining	abrasives
Nalco	slurry & abrasives
NanoPhase	abrasives
Nissan Chemical	slurry
Nitta-Haas	slurry
Planar Solutions	slurry
Praxair	slurry
Precision Colloids, LLC (CPC division)	abrasives
Rhodia	abrasives
Rohm and Haas Electronic Materials	slurry
Showa Denko	slurry
Silco International, LLC (Now Evonik)	slurry & abrasives
St. Gobain (Norton)	abrasives
UK Abrasives	abrasives
Umicore	abrasives
Universal Photonics	slurry
UWiZ	slurry
Wacker	abrasives

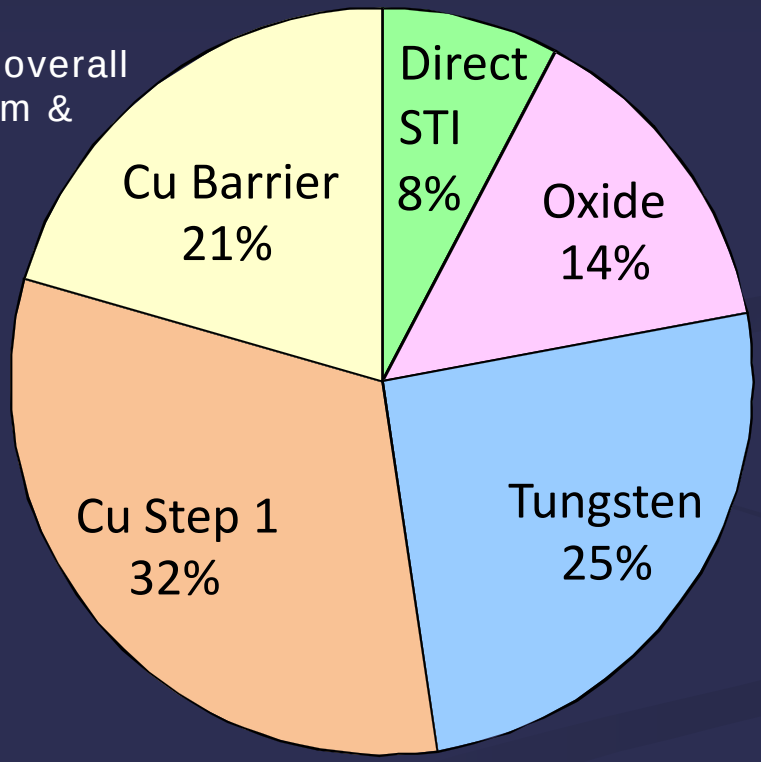
Major Slurry Suppliers

- Cabot CMP still largest revenue market share
  - Tungsten, ILD, Al, some STI
  - Eternal Acquisition good for Cu
  - CMP Pads making progress (see Mike's presentation)
- Five Suppliers ~ 10% each:
  - Dow Chemical, no longer with Eternal
  - Fujimi, Strong is Si Wafer, Share of Cu & ILD
  - DA Nanomaterials … more barrier and Cu
  - Hitachi, Direct STI strong … New competitor
  - Planar Solutions … less barrier and more Cu

What's New?

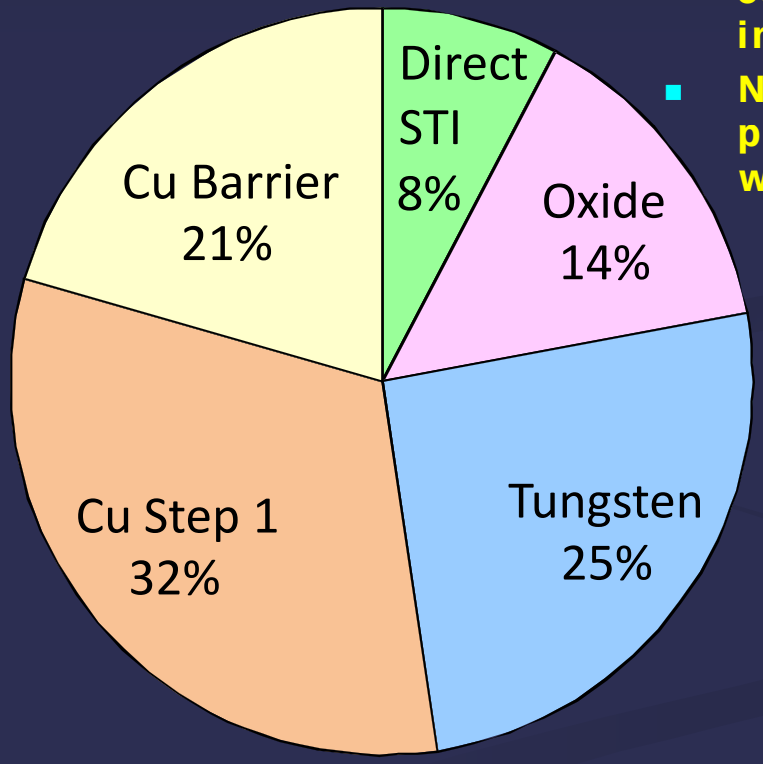
Metal Gate Electrode

- **Finally Al CMP is back**
- Small % of overall CMP at 45nm & 32nm



% 2009 Revenues

What's New?



% 2009 Revenues

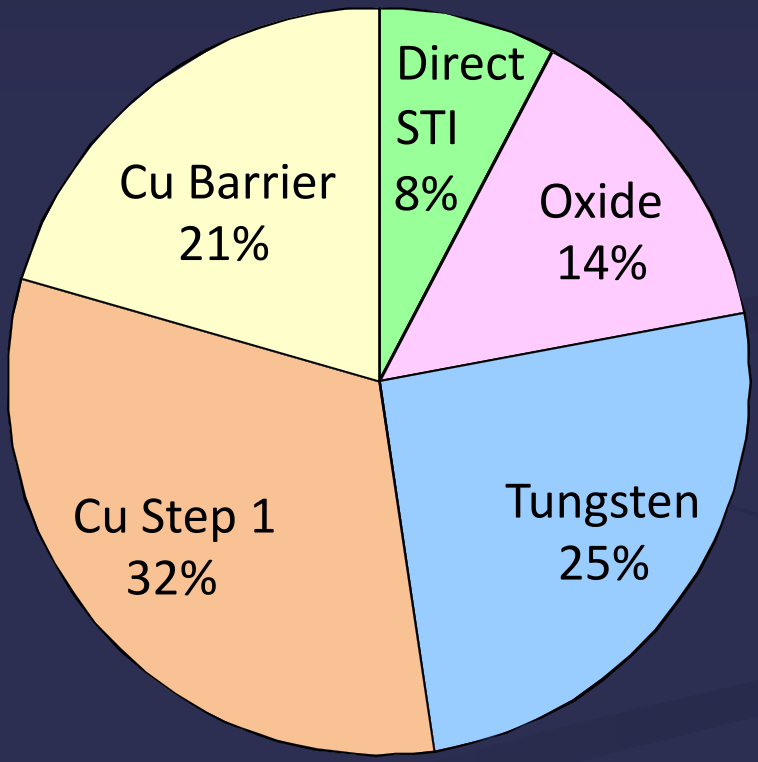
Direct STI (Ce)

- **Expensive abrasive, reduced abrasive content has large impact**
- **New Entrant made progress when Fabs were most $ conscious**

What's New?

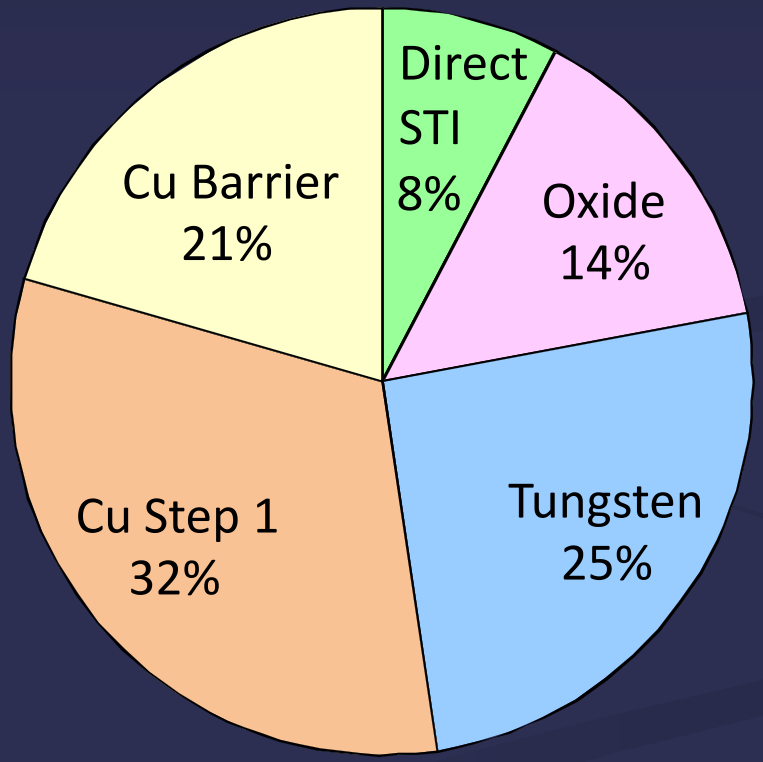
Copper & Barrier

- **Reduced abrasive content reduces cost / wafer pass**
- Highly fragmented and competitive market
- Will "Rule of Three" ever materialize?



% 2009 Revenues

What's New?

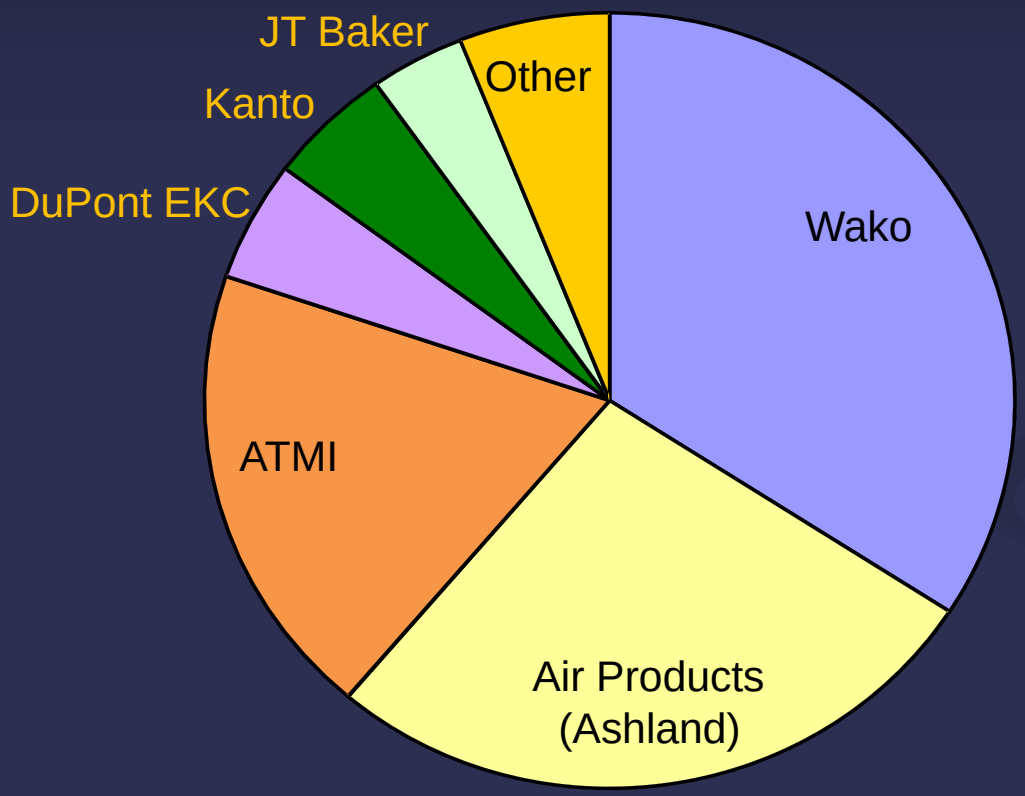


% 2009 Revenues

Tungsten

- **Effect of recent court battle TBD**
- W not large growth market
- Slurry dilution & competition erode margins

Post CMP Cleans



% 2009 Revenues

- Post Copper CMP is still largest segment
- Post Direct STI is becoming more and more important
- Post Al Gate Electrode CMP could become next critical clean

Slurry Disposal

- Lower tech applications abound
- Recycle for CMP?
- Reclaim and re-use of spent CMP slurries
  - Concentrate used slurry
  - Reduce heavy metal contamination
- Road filler or ??
- Does it pay to be green?

Future is Looking Bright

- CMP Slurry
  - Pricing pressure with numerous players and dilutions
  - But IC developers find us new applications
- Post CMP Clean
  - Pricing pressure as some Fabs mix their own
  - But IC yield pressures find us new customers
- Korea and China
  - They are buying lots of products that use Ics
  - Local materials suppliers are making headway, in many IC materials.

Techcet Group

- Business Development and Strategic Planning Consulting – Specialized in Electronic Materials Supply Chain Business & Technical Trends
- Techcet Critical Material Reports* :

- High K & Metal ALD/CVD Precursors
- Interconnect Materials Beyond 65nm
- Solar Cell Process Materials
- Solar Cell Equipment Consumables
- Polysilicon Market and Supply Chain
- Ceramics
- Ion Implant Sources
- Liquid Dopants
- Low Temperature Dielectric Precursors
- CMP Consumables
- Gases
- Graphite
- Masks and Reticles
- Photoresists and Photoresist Ancillaries
- Quartz
- Silicon Carbide
- Sputter Targets
- Wet Chemicals

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