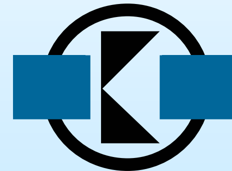
COPPER AND LOW-k: CONSUMABLES OUTLOOK

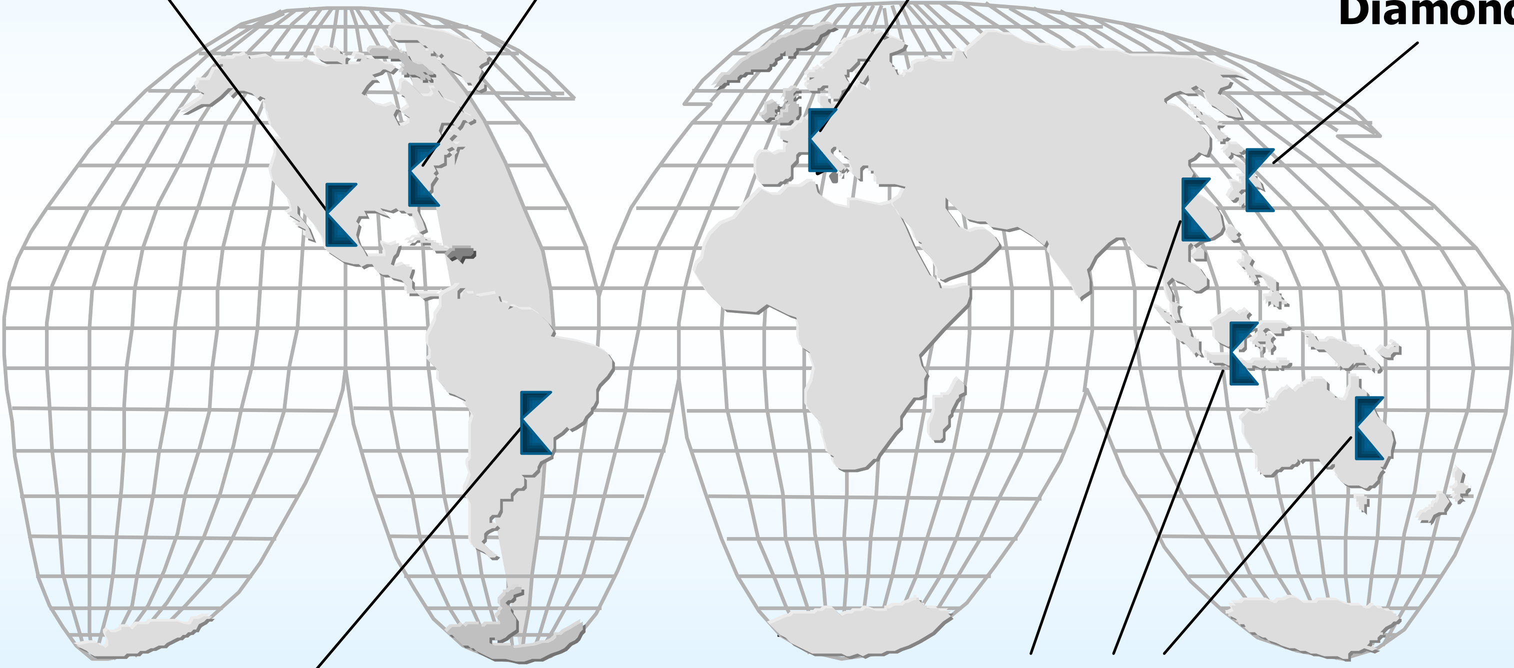
Silicon Valley CMP Users Group

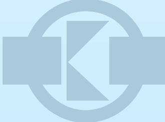
June 5, 2002



For confident decisions in a complex world™

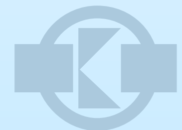
GLOBAL NETWORK



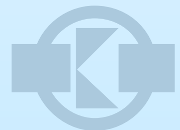


SEMICONDUCTOR EXPERIENCE
(Selected)

- Acids, Etchants and Cleaners
- CMP Consumables
- Dual Damascene Processing
- Gate-stack materials
- Removers
- Dielectrics
- MOCVD Precursors
- Integration schemes
- Cost of ownership
- Metals



Current consumables market



CMP: CURRENT STATE OF INDUSTRY

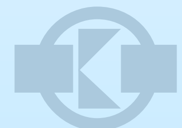
Threat of new entrants
High – Growth Market

Supplier Power
Decreasing with Alternatives

Competitive Intensity of Suppliers
Increasing with new entrants

Buyer Power
High – Fabs have options

Threat of Substitutes
Low for now, but coo?
Slurryless pad and others



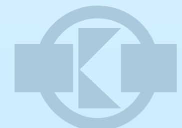
CMP: CURRENT STATE OF INDUSTRY

FABS

Tools	Conditioner	PADS	Slurries	Brushes	Filters	Dispense	Waste Water
Dominated by AMAT	Changing channels	Dominated by Rodel	Dominated by Cabot	Dominated by Rippey	3-4 Suppliers	Opportunities to add value?	

Other considerations

- Application – Specific tools and consumables
- Cost of Ownership
- Regional shifting to global business models
- Will tool suppliers get into consumables
- Integration of slurry producers in particles
- No integration plays in pads



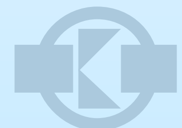
Current state of consumables market . . .

Market-share leaders:

- Cabot down 8-9% from a year ago, and down 18% from the record performance seen in late 2000, BUT…
  - Current quarter-to-quarter sales have flattened
  - Latest quarterly volume up 2.6%, though prices down 1.8%
- Rohm and Haas (Rodel parent) reported Electronics business down 26% as of 1Q02, BUT...
  - Still profitable
  - Includes the photoresist business
  - Slight increases in business noted in 1Q02

The sky isn't falling:

- Volatility in consumables less than half that of equipment
- Technological fundamentals still spell strong growth
- But competition is heavier, especially in oxide slurries



Competing market trends . . .

Price competition in oxide slurries:

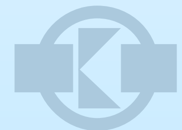
- Oxides becoming commodity-like
- More competitors, especially from Asia
- Price erosion

Focus on technology, not pricing, elsewhere:

- Tough integration challenges remain
- Copper CMP
- Fabs relying on established leaders

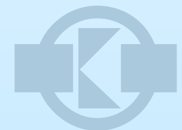
Bottom line: Price is crowding out technology effect:

- 250- and 180-nm nodes still very popular
- Bracing for tungsten-slurry price competition



North American market share declining . . .

- Cabot saw 62% of sales outside U.S. in 2001
- In 2002, the percentage is up to 65%
- Most of the share re-allocation is going to Asia



Pad sector active with new development . . .

Several new entrants:

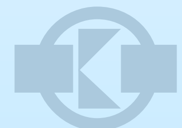
- PPG Industries
- Madison Filter
- Psiloquest
- Others expected

Continuing developments by leaders:

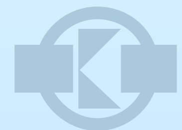
- Rodel photo-patterned thermoplastics pads
- Thomas West "Right Pad"
- Both developments point to more options in hardness v.s. softness in pads

Still a Rodel stronghold, BUT:

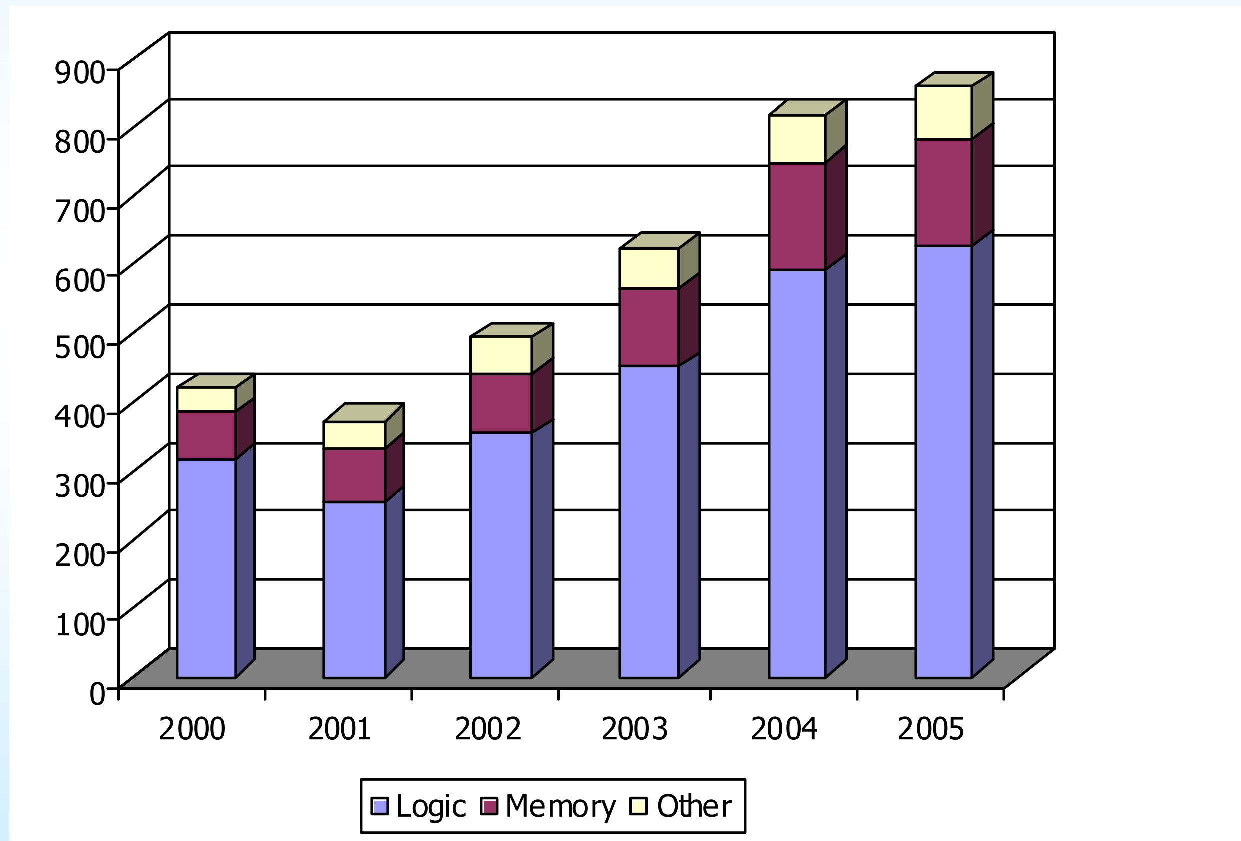
- Pad market appears to be the most active in terms of competitive development

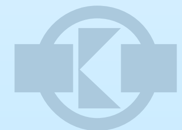


Consumables outlook

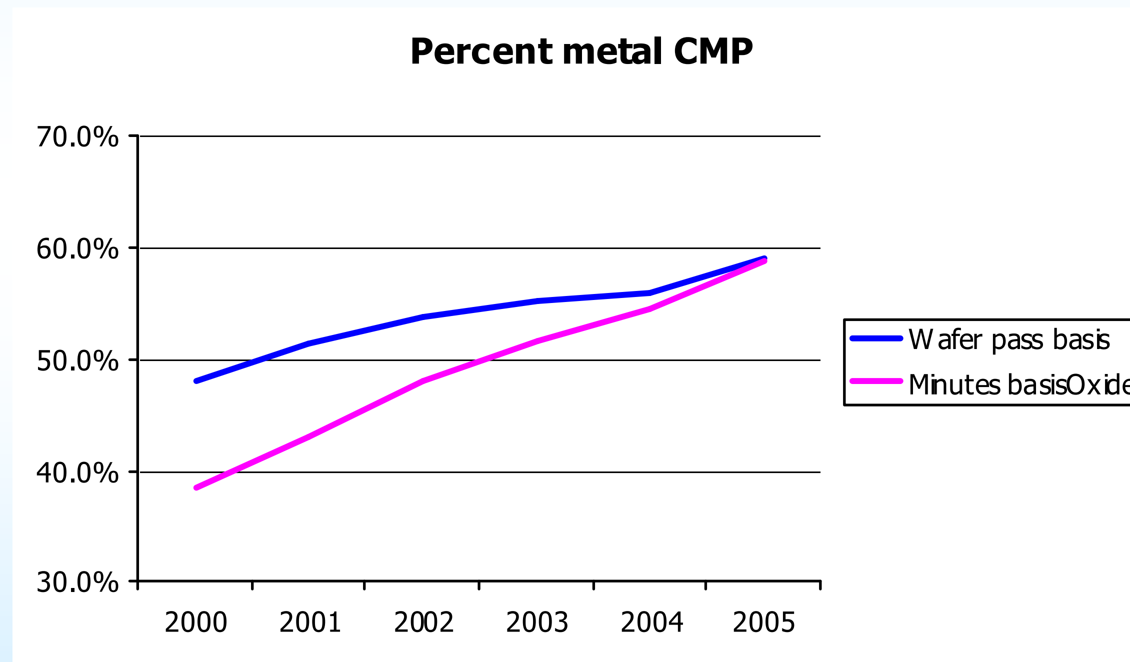


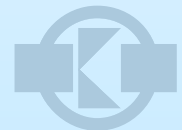
GLOBAL GROWTH IN CMP OPERATIONS BY DEVICE CATEGORY, 2000 - 2005



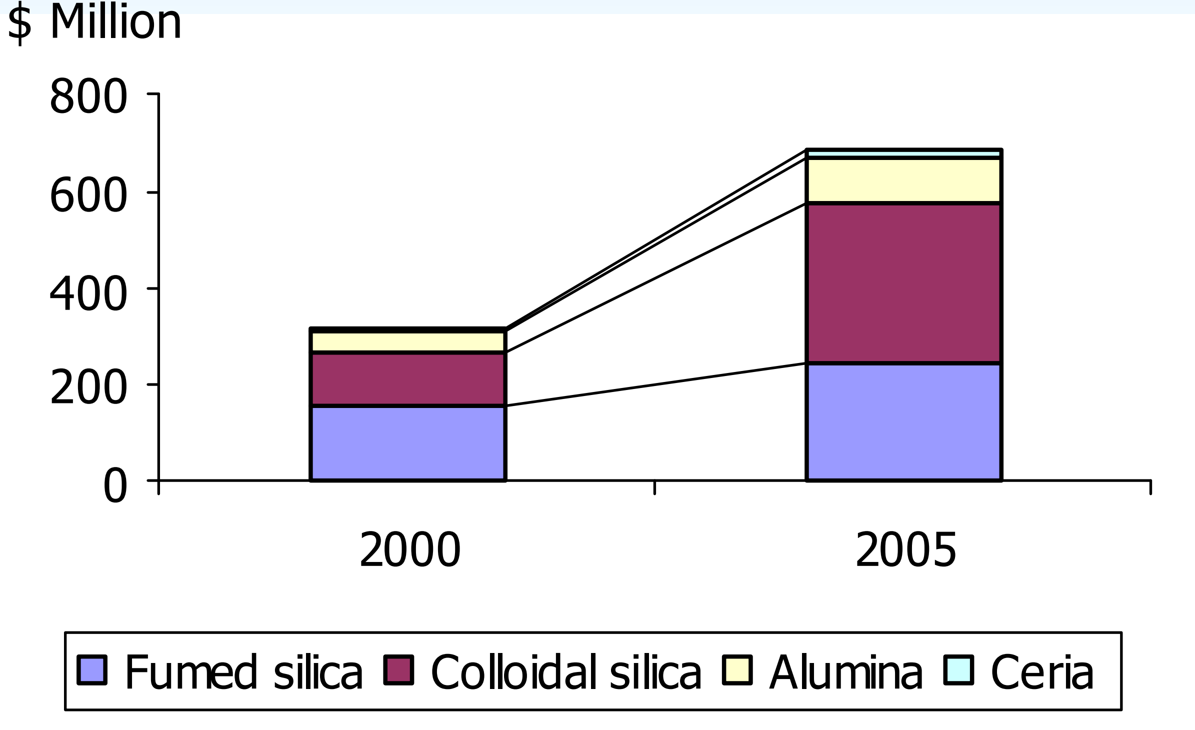


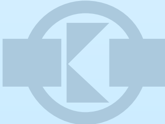
As CMP matures the number and types of planarizations will shift from oxide to metal . . .



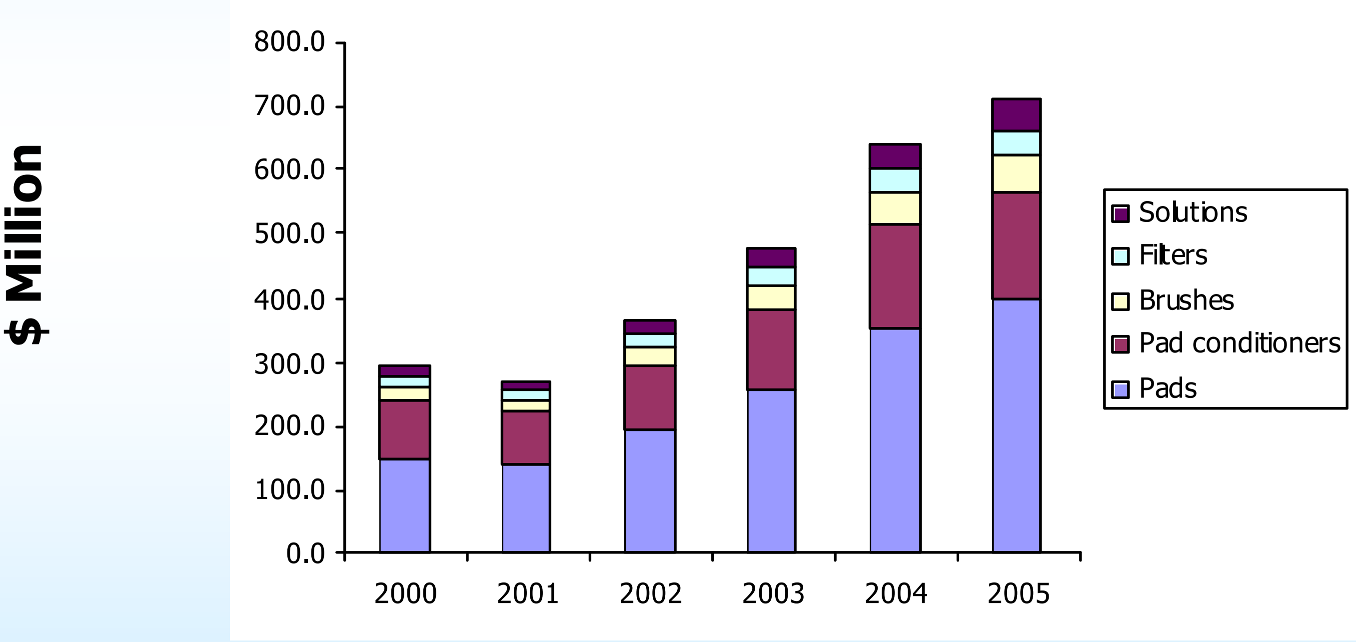


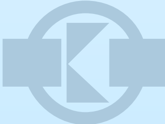
Fumed silica dispersions will continue to grow rapidly but will lose share to other types of CMP slurries over the next five years . . .





Other major consumables in CMP are pads, brushes and filters. Together they account for approximately one-half of the total consumables market . . .

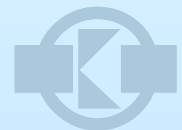




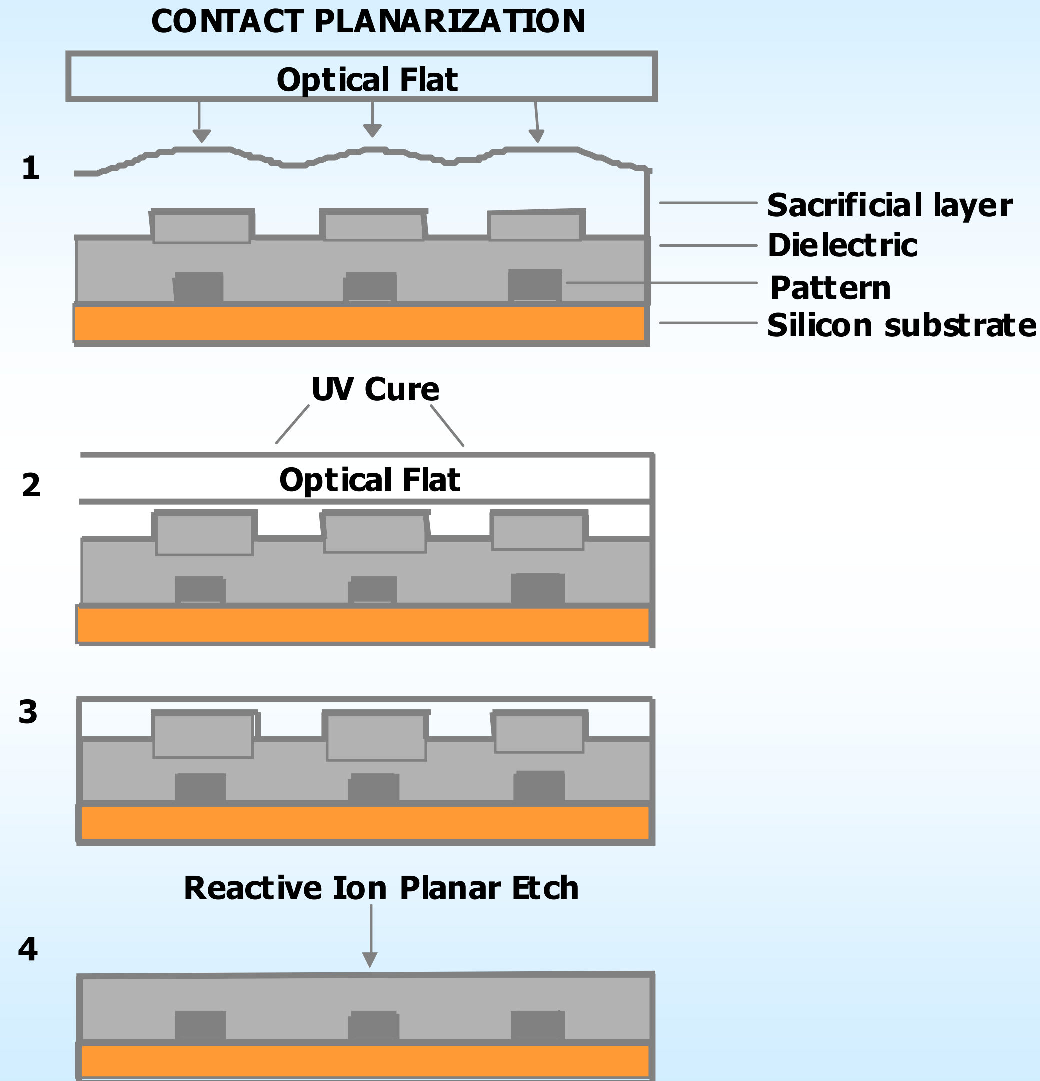
CMP has been a process standard since the 250-nm design rule was passed, over five years ago, but its continued use “as we know it” is by no means certain

Alternatives include:

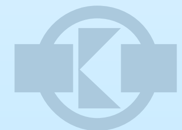
- CMP without abrasive slurry
  - Abrasive-free polishing solutions
  - Electropolishing
- Fixed-abrasive pads
- Non-CMP planarization
  - Contact planarization
  - Planar etch
  - Press & Peel dielectrics



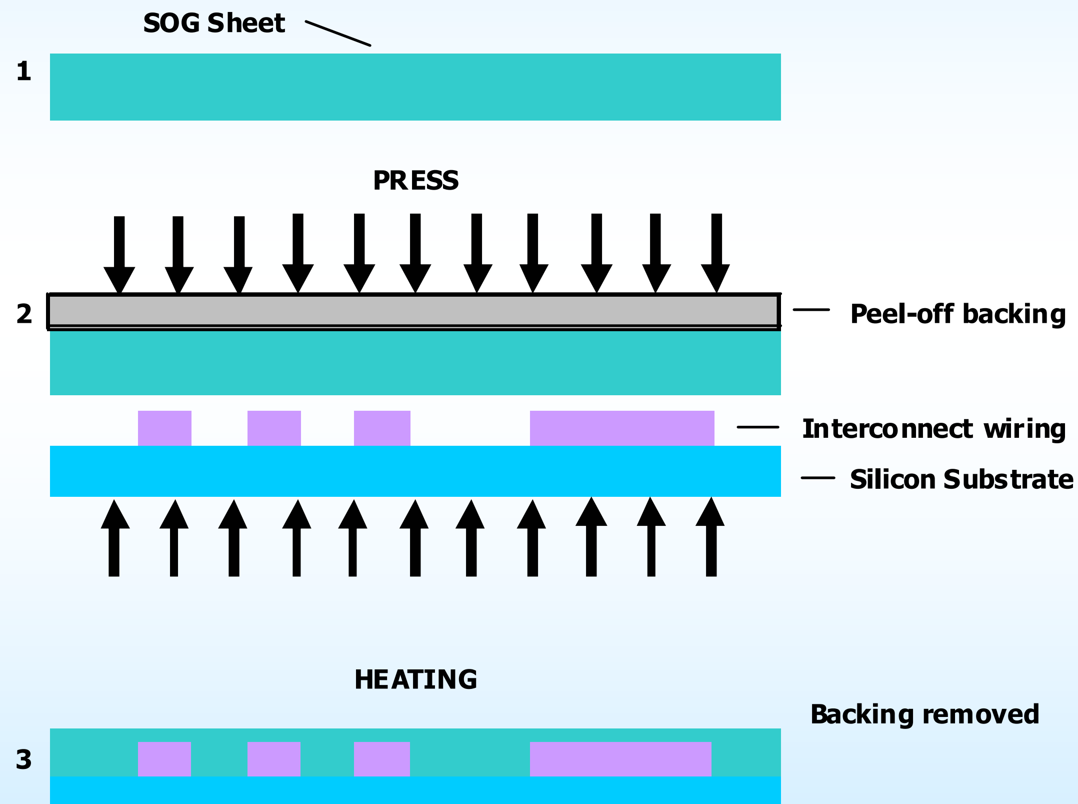
Contact planarization, involves the use of a lens blank to flatten a sacrificial layer, which is cured with UV and then etched away . . .

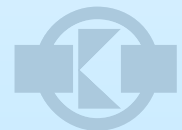


Source: J.A. Prybala, Lucent Technologies, AVS 2nd Intl Conf., Feb, 2000



Press and Peel technology from ASET. Together with DSN, can deposit dielectrics without any need for planarization





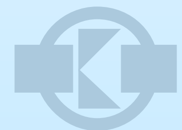
CMP without abrasive slurry…

Abrasive-free polishing (AFP)

- Hitachi HS-C, with H_2O_2, for copper bulk only
- Rodel Reactive Liquid, also for copper bulk
- AMAT claims solutions for copper bulk and finishing

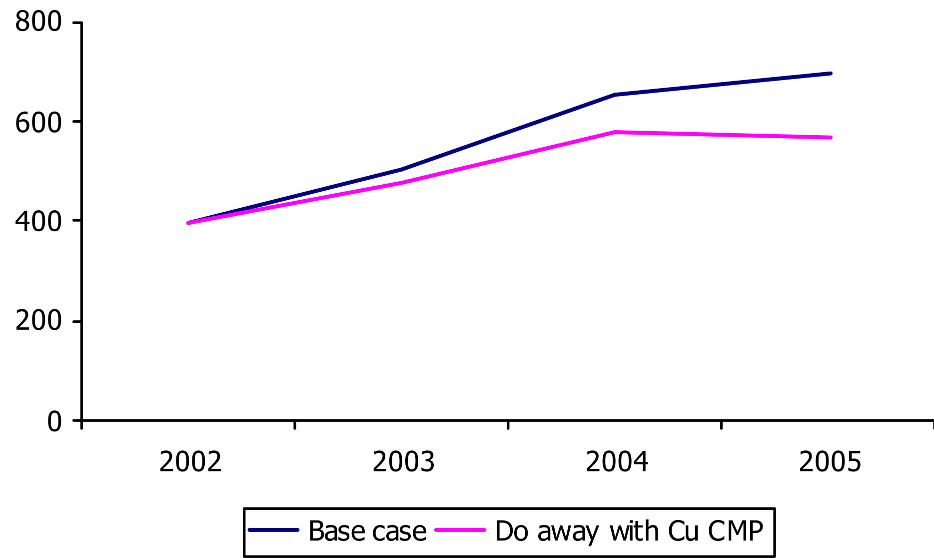
Electropolishing

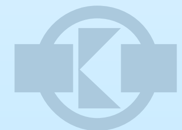
- NuTool combines electrodeposition with pad polishing, with or without slurry
- ACM Ultra SFP (Stress-Free Polishing)
  - No pads or slurry
  - Aimed at low-k integration



What if planar deposition wins big?...

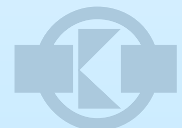
- Base case projects token planar deposition in 2003-2005
  - Penetration limited to MPUs, SoCs, DSPs
- If (a BIG IF) just those categories go all to planar deposition, slurry market drops 18%
  - It couldn't happen this fast!!!





Integration challenges ahead…

- **Not just metal CMP will occur**
  - Expect dishing, hence an oxide buff
  - Expect low-k exposure to slurry
- **Pay attention to platen pressure**
  - Too much might destroy a low-k film
  - Can be used to advantage in "smart" slurries
  - Pressure profile across the head needs control and understanding
- **Implementing low-k while <u>reducing</u> cost-of-ownership**



More Integration Challenges to CMP . . .

300-mm wafers could lead to a reduction in the volume of consumables

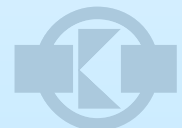
- By one estimate, average slurry usage rises from 560 ml/wafer to only 650 ml/wafer -- only a 20% increase for a >200% increase in polishing area

Low-k dielectrics require special care

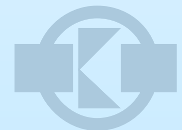
- Dense versions are now commercial
- Porous versions will go commercial 2006-2008

Copper

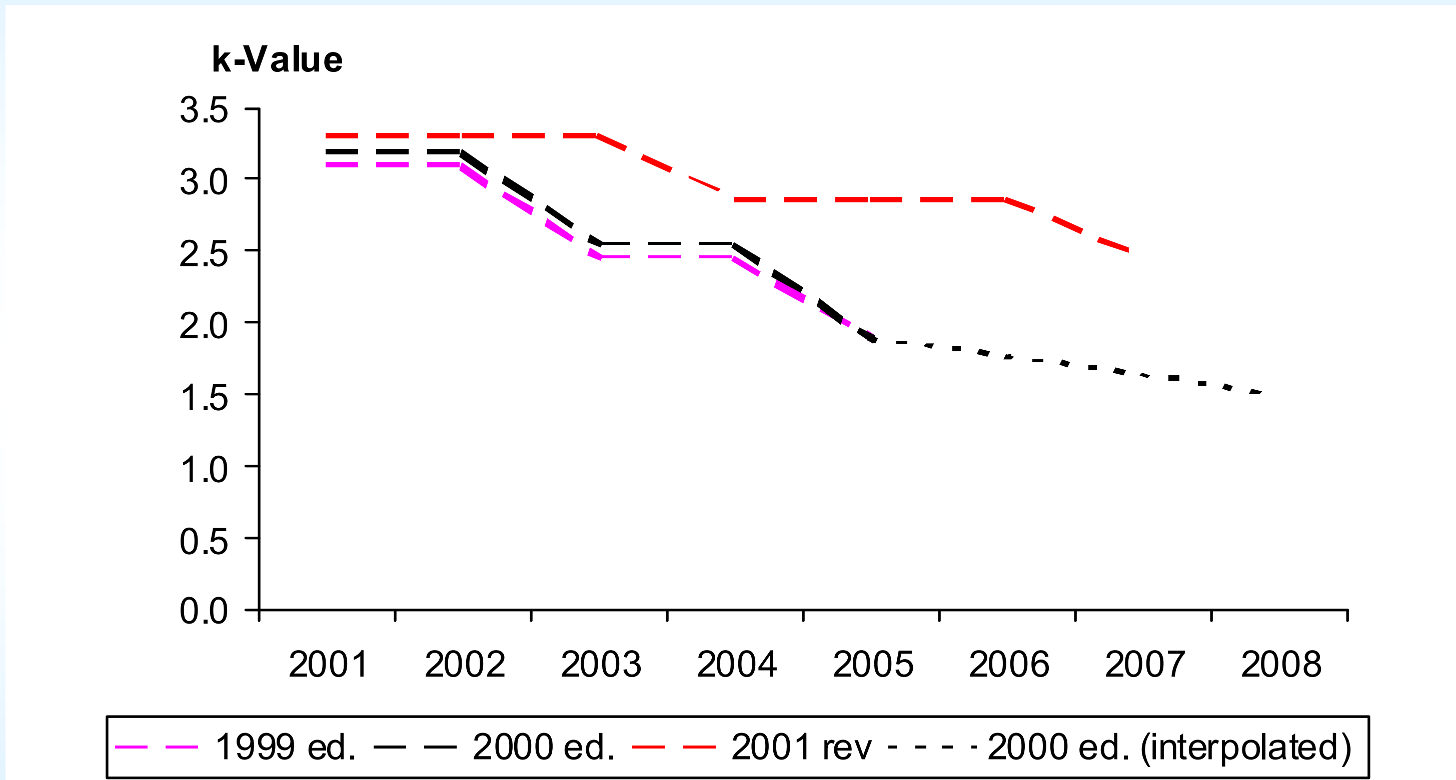
- Numerous grades with custom selectivities

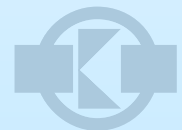


Low-k dielectrics

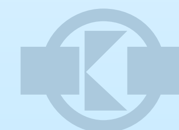


Low-k Roadmap delay...





CLASSIFICATIONS OF DIELECTRICS AND ANCILLARY MATERIALS			
		Materials	
Function	Material class	**CVD**	**Spin-on**
Premetal	**Inorganics**	BPSG	
Interlayer dielectric (ILD)	**Inorganics**	SiO_2, FSG	
	Organics	PTFE, FLAC	Polyphenylene, polyarylene, PTFE, others
	Silico-organics	SiOC	HSQ, SOG, silsesquioxanes, siloxanes, others
Cap/hard mask/ etch stop layers	**Inorganics**	SiN_x, others	
	Organics		
	Silico-organics	SiC	Proprietary polymers



CVD v.s. spin-on, continuing debate…