Equipment & Materials Integration Challenges

American Vacuum Society CMP User Group
December 3, 2003
Sunnyvale, CA

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Outline

- Materials & Equipment Markets
- Emerging Technologies
- Interconnect Integration Challenges
- Summary

The Electronics Ecosystem

	2002	Forecast 2005
Electronic End Equipment	$790B	$1,001B
Semiconductors	$141B	$216B
Semiconductor Equipment	$20B	$35B
Materials	$21B	$27B

SEMI® membership (Semiconductor Equipment, Materials)

Source: SEMI, SIA/WSTS October 2003, Henderson Ventures November 2003

Electronic Materials Cycles

Global Materials Revenue US $B (bar graph)

Annual Growth % (line graph)

$35
$30
$25
$20
$15
$10
$5
$0

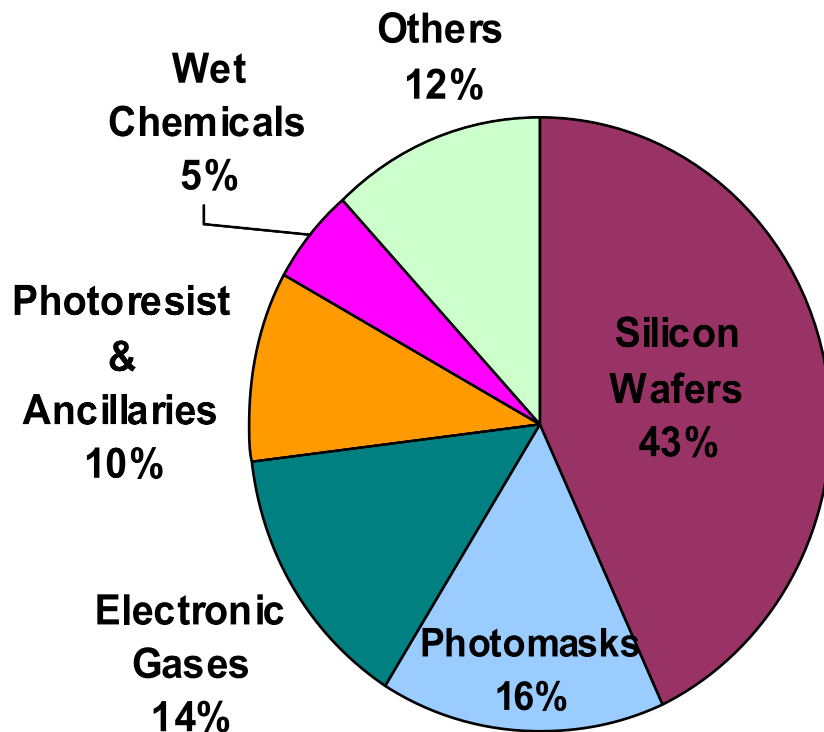
100%
75%
50%
25%
0%
-25%
-50%

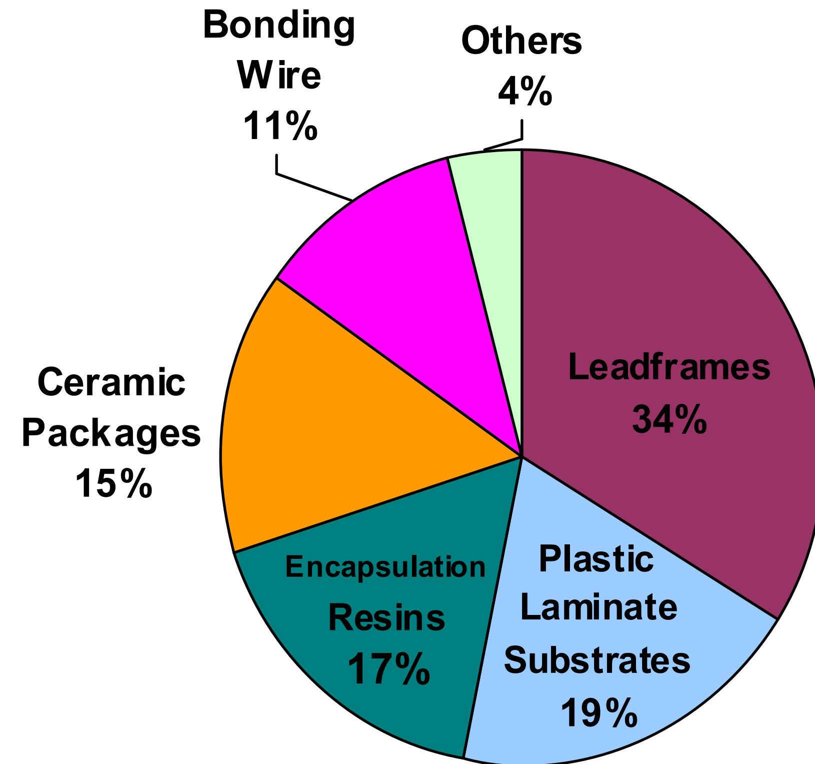
Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003 (E)	2004 (F)	2005 (F)	2006 (F)
Revenue	7	8	9	9	9	10	13	16	19	21	22	20	22	28	20	21	24	27	28	29

Materials Revenue   Annual Growth

Source: Rose Associates historical reports, SEMI

2002 Global Materials Markets





2002 Global Wafer Fab Materials $12.98B

2002 Global Package Materials $8.41B

Source: SEMI March 2003

Capital Equipment Cycles

Global Capital Equipment Revenue US $B (bar graph)

Annual Growth % (line graph)

Left axis: $0, $10, $20, $30, $40, $50, $60

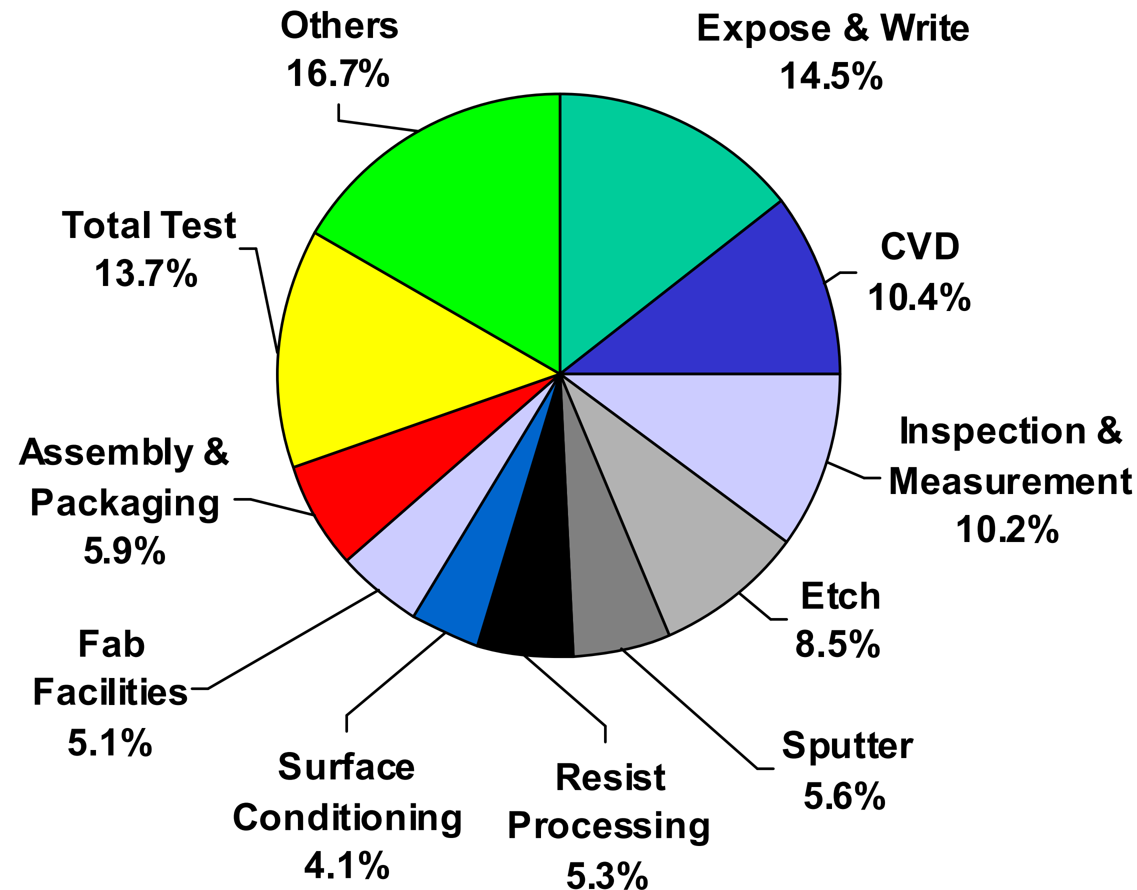
Right axis: -50%, -25%, 0%, 25%, 50%, 75%, 100%

Year	Capital Equipment Revenue
1987	5
1988	8
1989	9
1990	9
1991	9
1992	8
1993	10
1994	15
1995	24
1996	26
1997	28
1998	22
1999	25
2000	48
2001	28
2002	20
2003 (E)	21
2004 (F)	30
2005 (F)	35
2006 (F)	33

Capital Equipment Revenue — Annual Growth

Source: SEMI and SEMI/SEAJ year end historical reports

2002 Global Equipment Markets



Worldwide 2002 Billings = $19.75B

Source: SEMI/SEAJ March 2003

Emerging Technologies Summary

Selected Emerging Technologies Summary	
Substrates	**Silicon on insulator (SOI) & derivatives, strained silicon, strained SOI, 300 mm**
Lithography	**Lower cost photomasks, 2nd generation 193 nm resists and ancillaries, immersion lithography , 157 nm resists and ancillaries, NGL resists and ancillaries**
Interconnects	**Advanced copper electro plating solutions, hybrid low k materials, high k materials, spin on versus CVD, dielectric cleaning solutions, low k compatible CMP slurries**
Package Materials	**Green molding compounds, dielectric materials, overcoat materials, back coat materials, solder stems and balls**

Multiple "winning" solutions for given technology node creates challenge and opportunity

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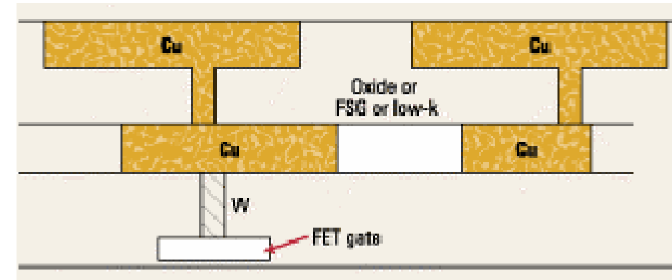
Interconnect Integration Challenges

❑ Copper Interconnects

- "Single batch" ECP tools for 65 nm
- Electroplating chemistries becoming more complex



❑ Dielectrics

- Hybrid low k approach for inter metal dielectric
- Spin on versus chemical vapor deposition
- Hafnium based high k materials for gate insulator
- Metal gates

❑ Chemical Mechanical Planarization

- Low k compatible slurries
- Nanotechnology for slurries
- Post CMP Cleaning solutions

Source: Semiconductor International (image)

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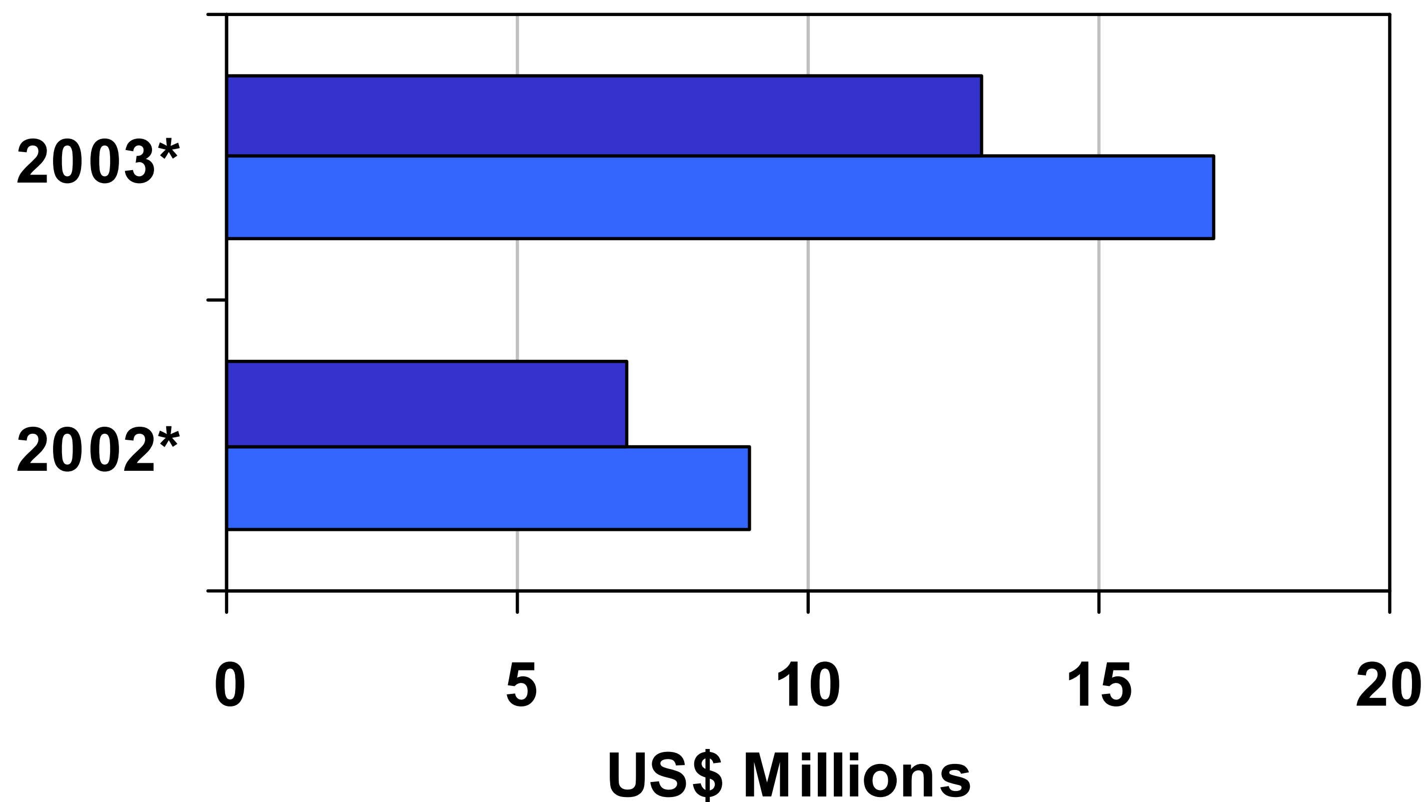
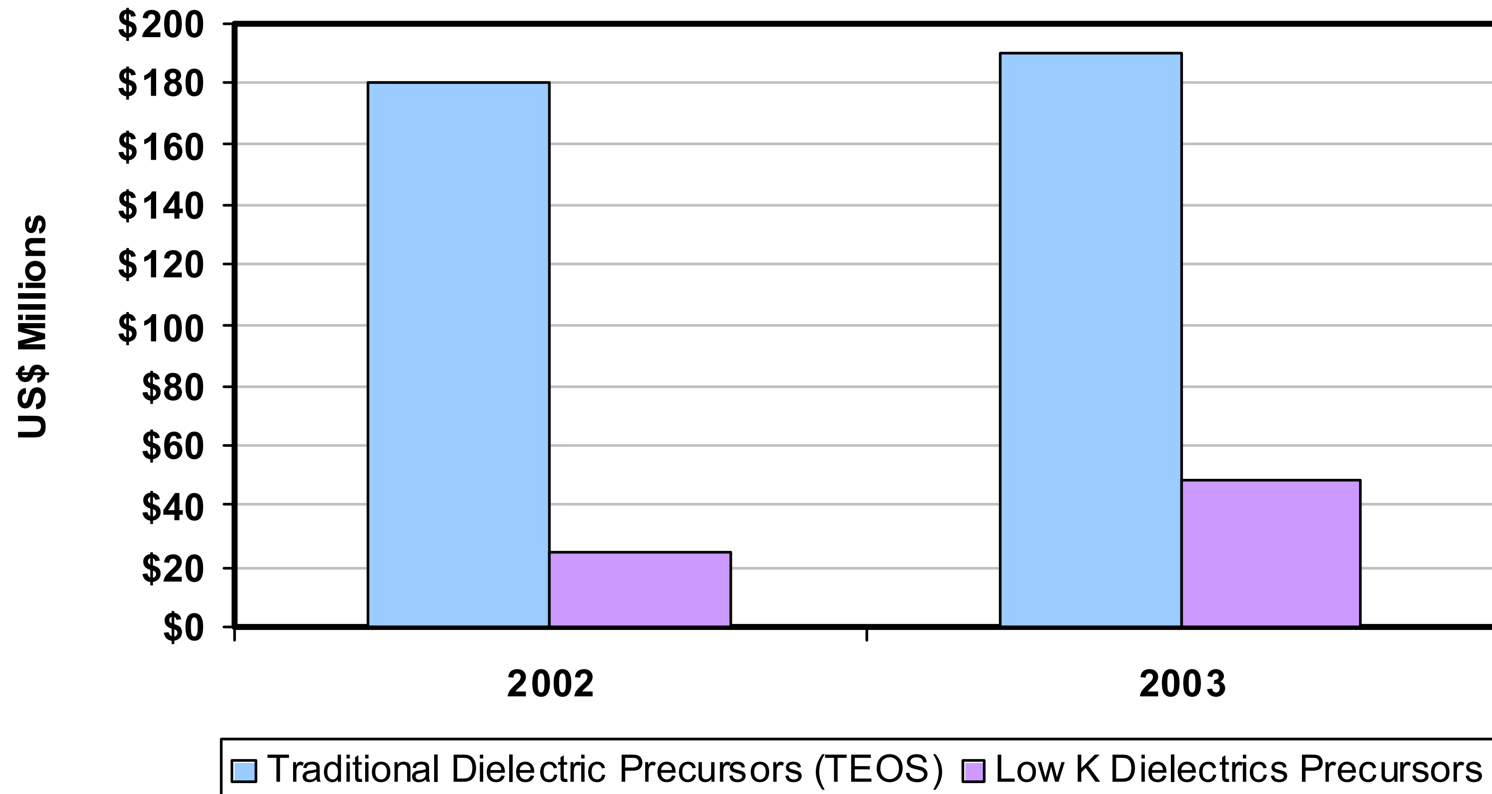
Electroplating Chemicals



* High and low estimates due to significant volume of custom chemicals at some large customers

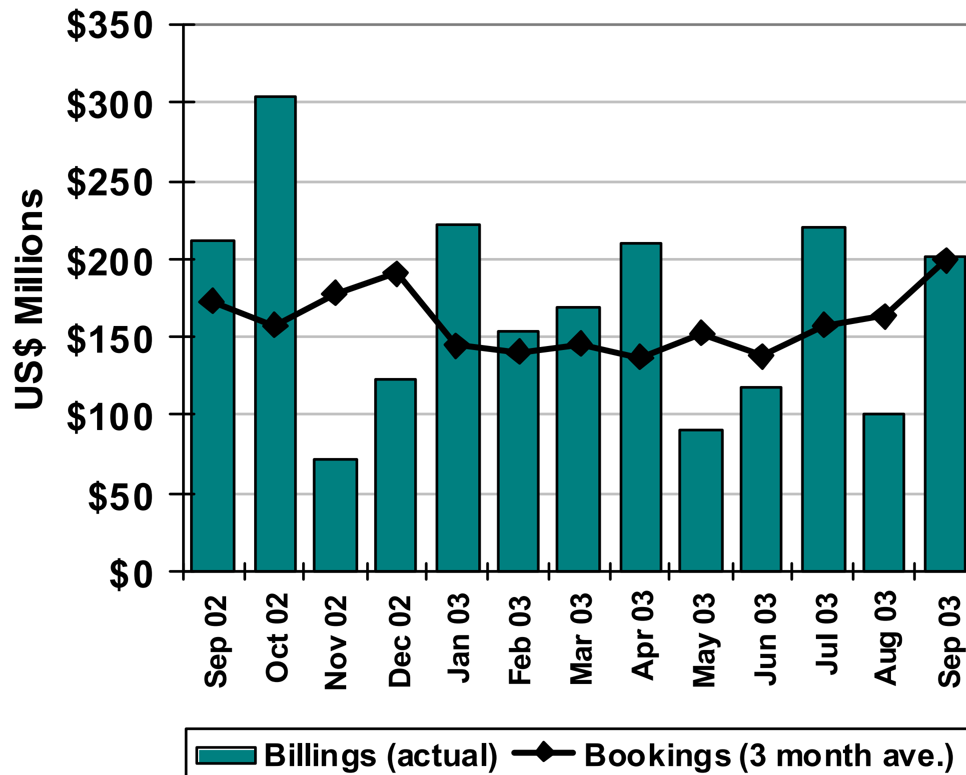
Source: Techcet Group March 2003

Dielectric Materials



Source: Techcet Group May 2003, Kline & Company 2002

Chemical Vapor Deposition Trends

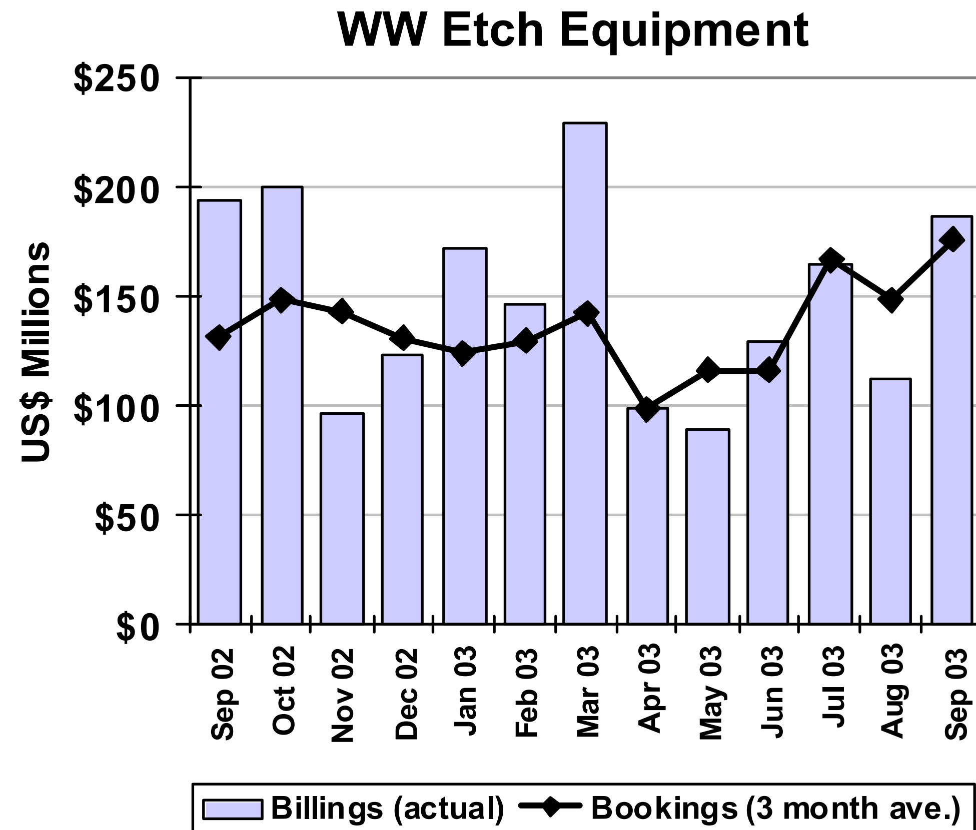


- September bookings grew 22% over August
- Low & high k films, dielectric anti-reflective coatings (DARC) and 300 mm offer growth opportunities
- Atomic layer deposition required for certain applications at 90 nm node
- Reduced pressure epitaxial reactors for heterostructures

Source: SEMI/SEAJ November 2003

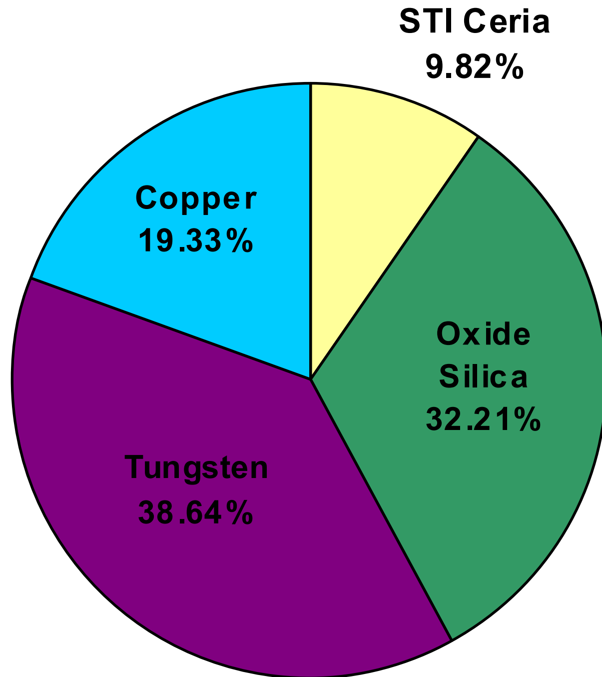
Etch Equipment Trends

- September bookings grew 19% over August bookings
- Japan is largest market, closely followed by U.S. and Korea, respectively, through September 2003
- Dielectric etch tools represent largest market segment, followed by polysilicon and metal etch
- Technology and productivity improvements driving growth in dielectric etch tools

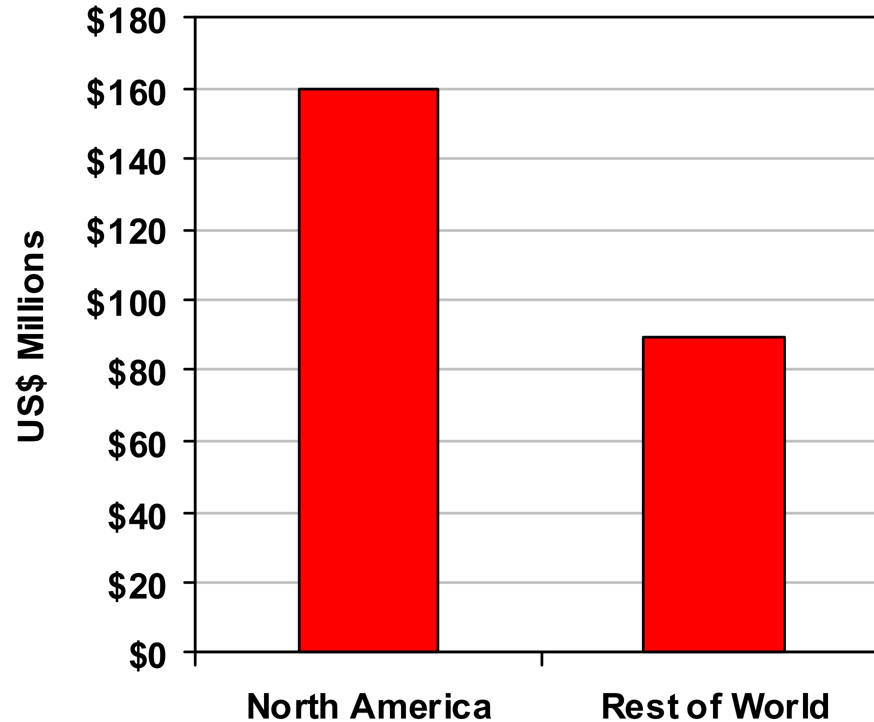


Source: SEMI/SEAJ November 2003

CMP Consumables



2003 WW CMP Slurry
Market Estimate ~$350M

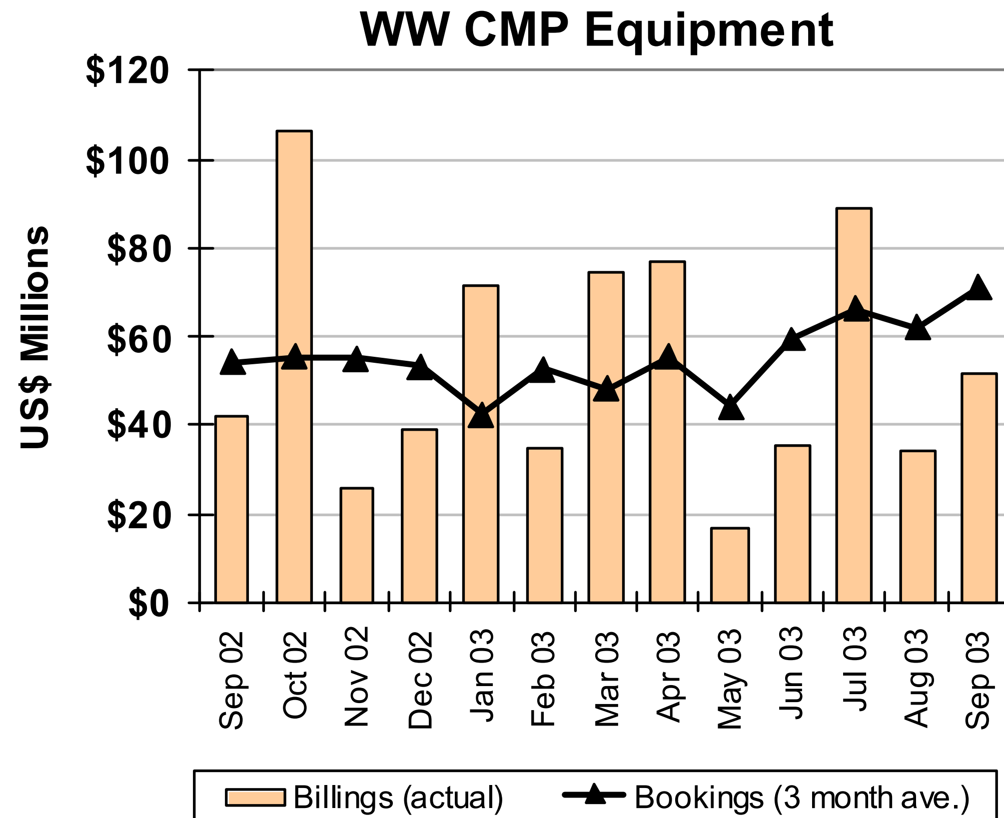


2003 WW CMP Pad
Market Estimate ~$250M

Source: Techcet Group May 2003

CMP Equipment Trends

- September bookings up 15% over August bookings
- Taiwan demand for CMP tools only 11% of market in 2003, down from 25% in 2002
- Applied Materials, Ebara and Novellus Systems and Lam Research account for ~90% market



Source: SEMI/SEAJ November 2003

Changing Industry Dynamics

❑ Proliferation of Joint Development Agreements

- Integration mandating closer cooperation
- Equipment suppliers moving into materials arena?
- Consortium for Advanced Semiconductor Materials & Related Technologies

❑ New Entrants in Emerging Materials Segments

- CMP slurries and pads
- Dielectrics

❑ Consolidation of Players

- Expanding product portfolios
- Powerhouses emerging

Summary

- **Numerous challenges and opportunities in materials and equipment markets**
  - Adoption of technologies at different nodes leads to slower market penetration for emerging materials and technologies
  - Integration requires increased collaboration and increased R&D

- **Materials markets less cyclical than equipment markets**
  - Large investments required for infrastructure and R&D
  - Variety of supply changes anticipated