

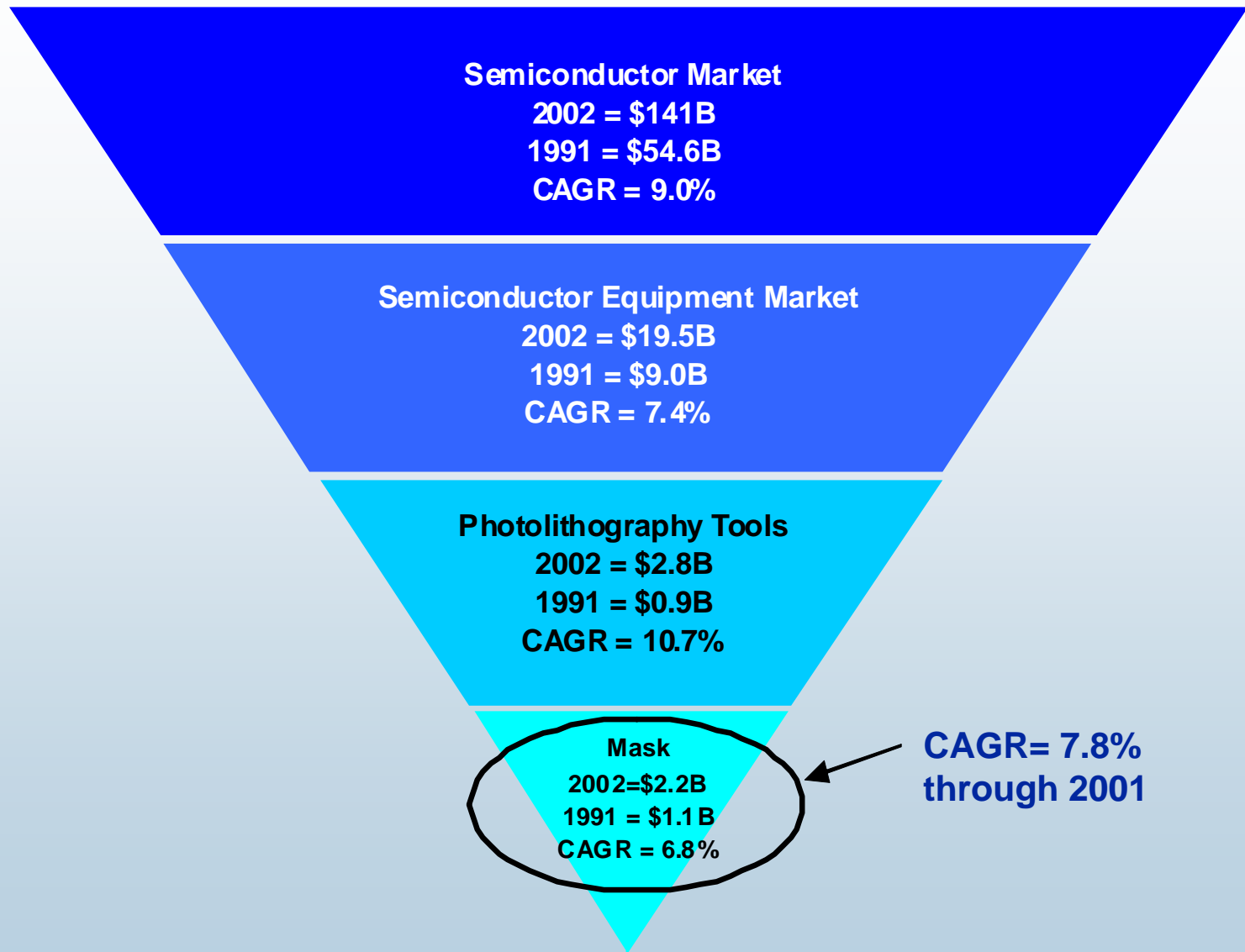
SPIE Symposium on Photomask Technology

Mask Industry Assessment 2003

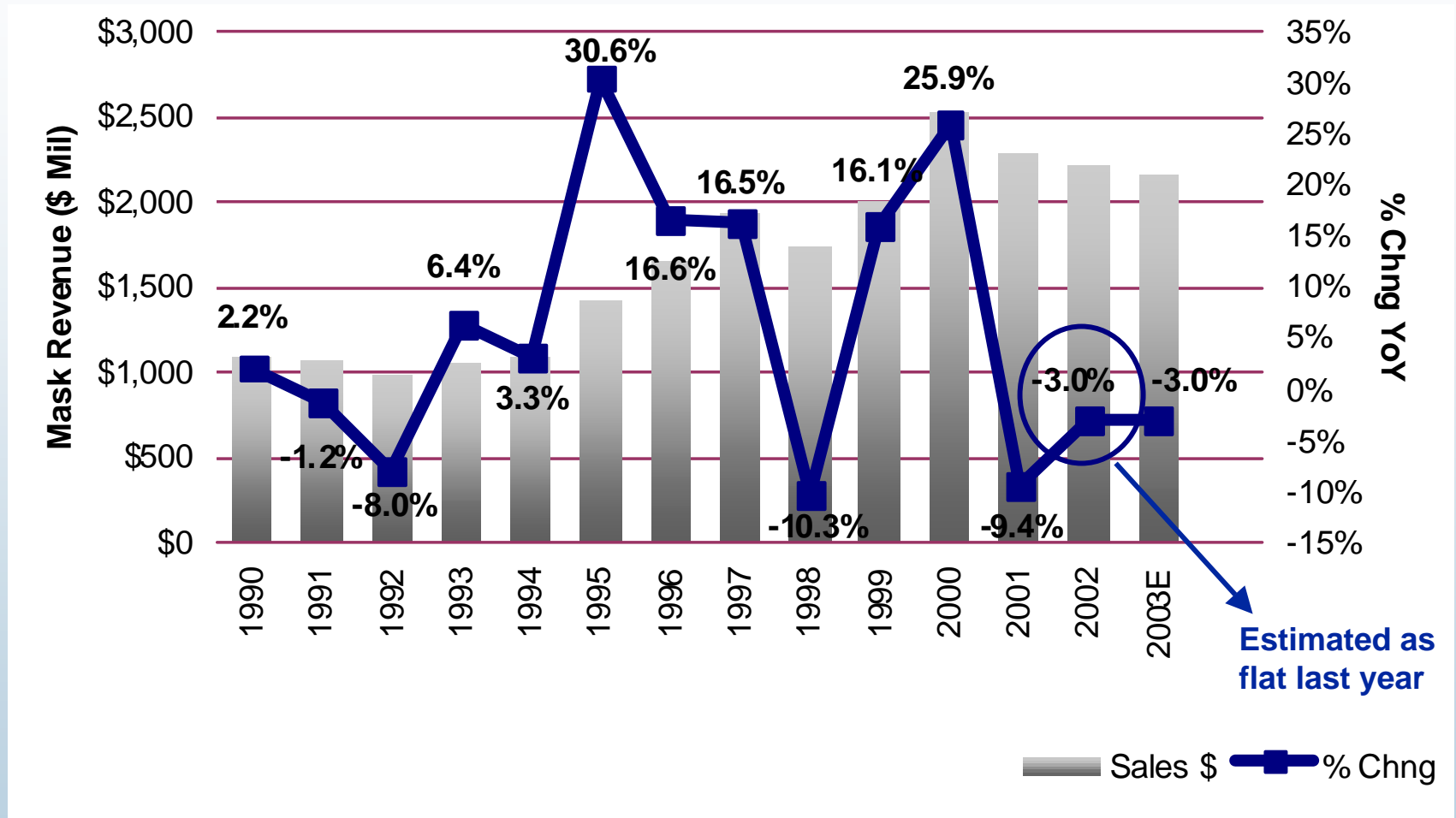
Kurt R. Kimmel
Mask Strategy Program Manager

September 10, 2003

Photomask Business Position

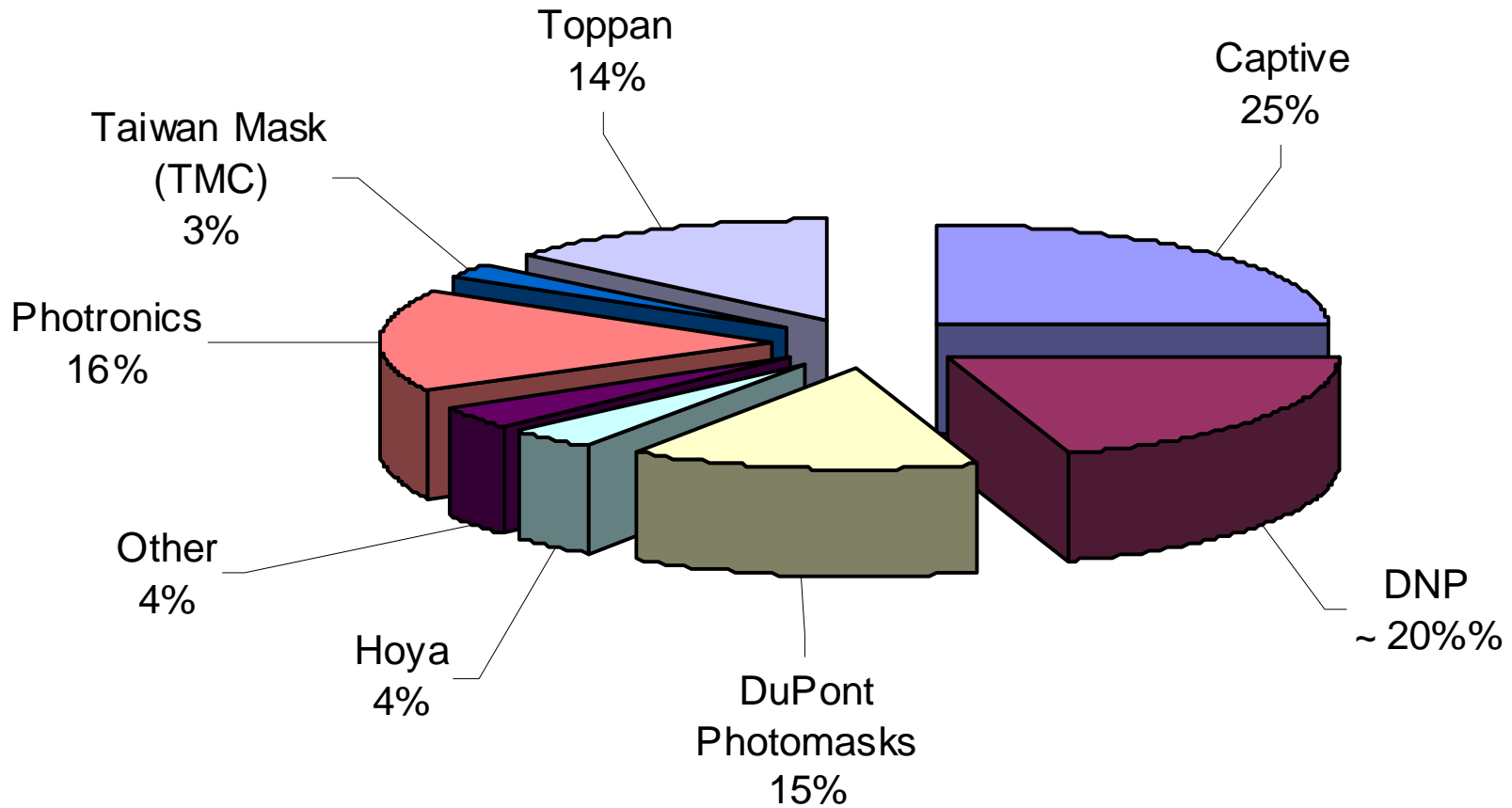


WW Mask Industry Revenue



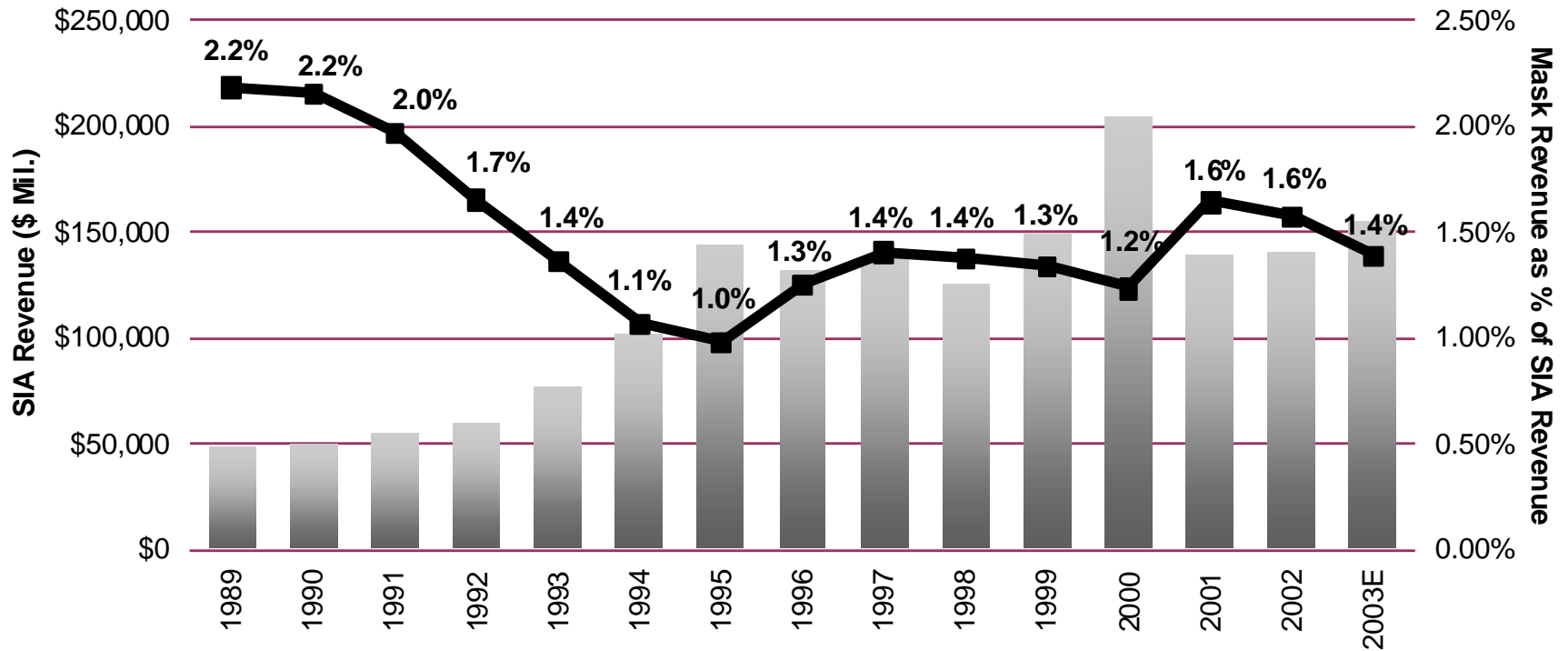
Source: VLSI Research, Lehman Brothers estimates

WW Mask Industry Revenue Leaders



Source: Lehman Brothers

WW Mask vs. Semicon Industry Revenue

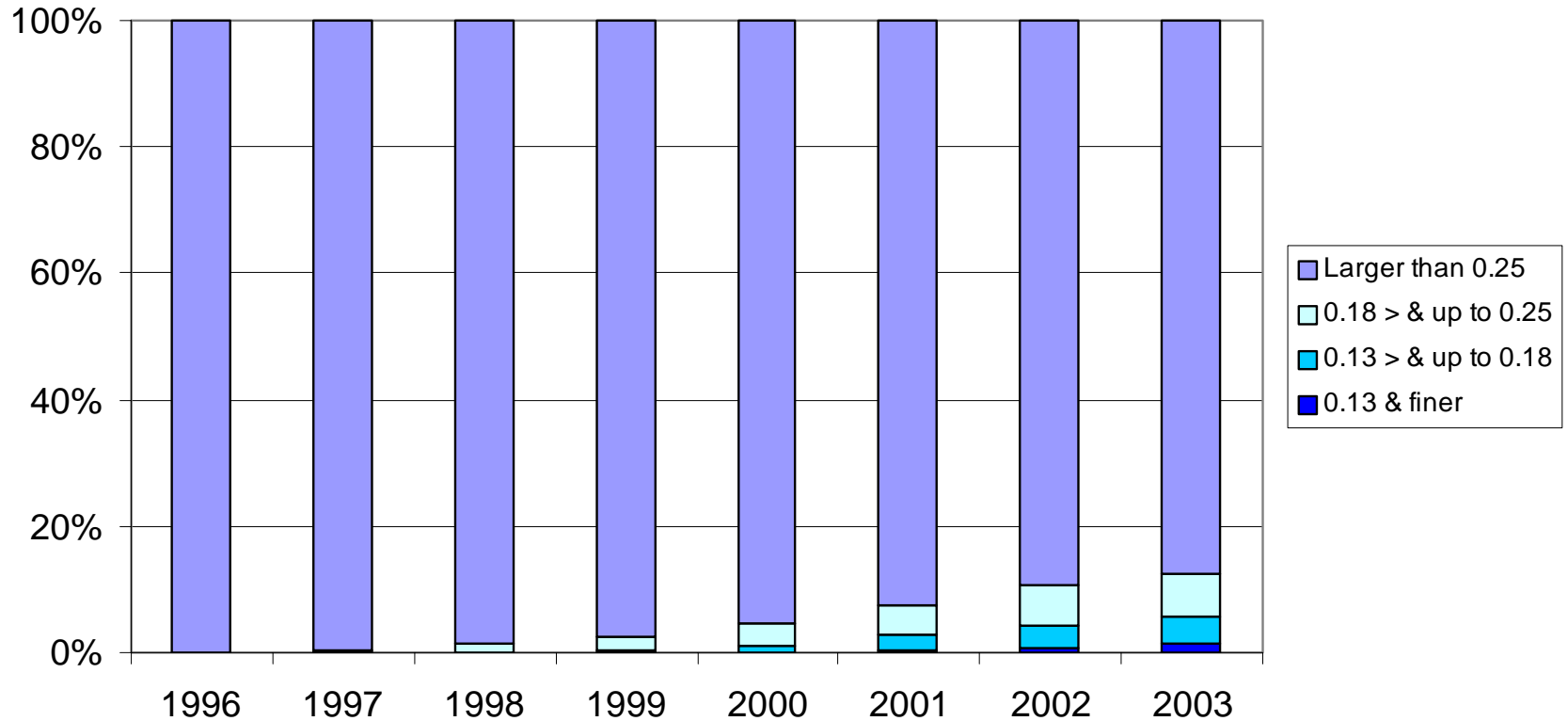


Source: VLSI Research, SIA Databook, Lehman Brothers estimates

WW Mask Technology Node Mix - Quantity

>250nm node ~ 90% of volume

Mask Unit Shipments By Technology Node



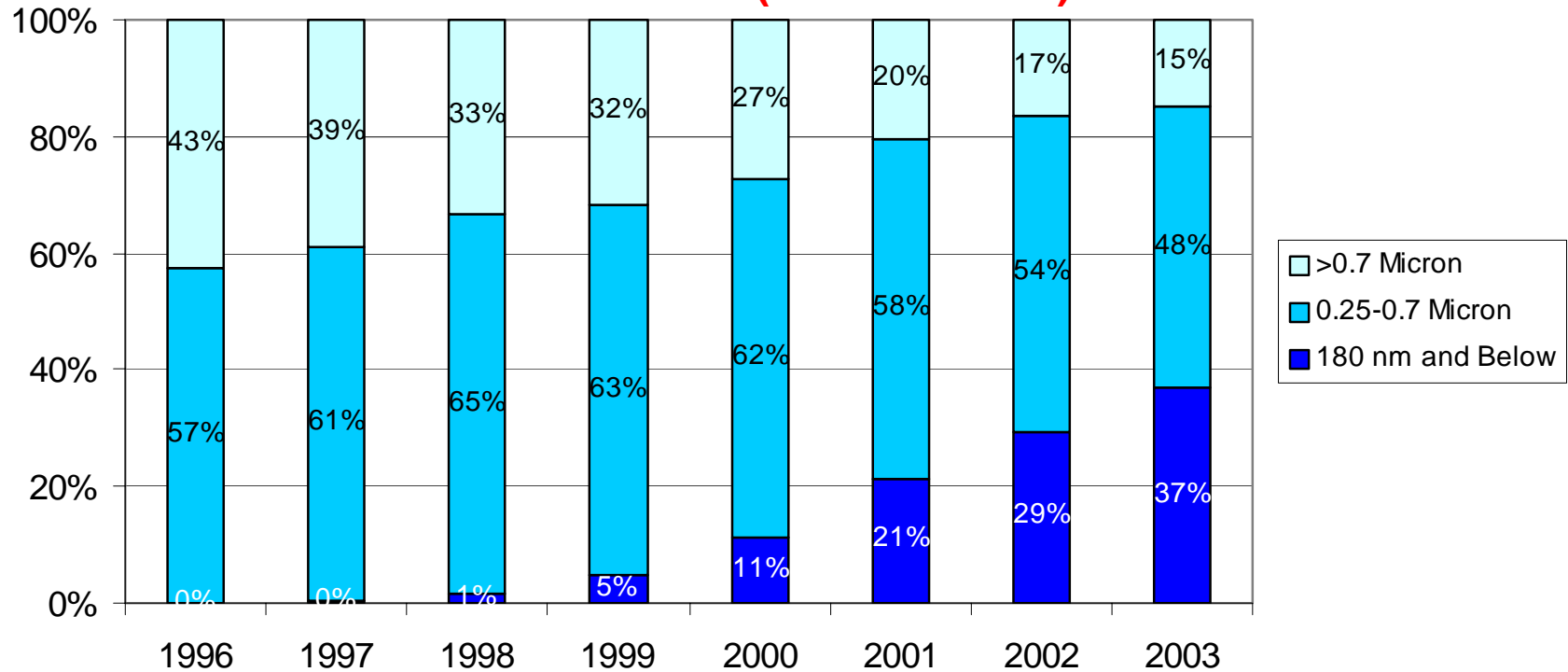
Source: VLSI Research and Lehman Brothers

INTERNATIONAL
SEMATECH

WW Mask Technology Node Revenue Mix

Mask Revenue By Technology Node

15% of volume (<180nm node) drives 37% of revenue



Source: VLSI Research and Lehman Brothers

The Survey

2003 Survey Process Overview

- **April: Survey sent to 2002 edition Grenon Consulting “Maskmakers Handbook” entries**
 - 109 questions total in questionnaire
 - (vs. 28 in 1999 and 102 in 2002 survey)
 - Each participant asked to represent average of last 12 months of data in their answer
- **July: Results sent to consulting firm contracted via SEMI North America**
- **August: Anonymous data sent to International SEMATECH for analysis, summary**
- **September: BACUS presentation and paper**

Survey Respondants: (representing ~80% of global market by revenue)

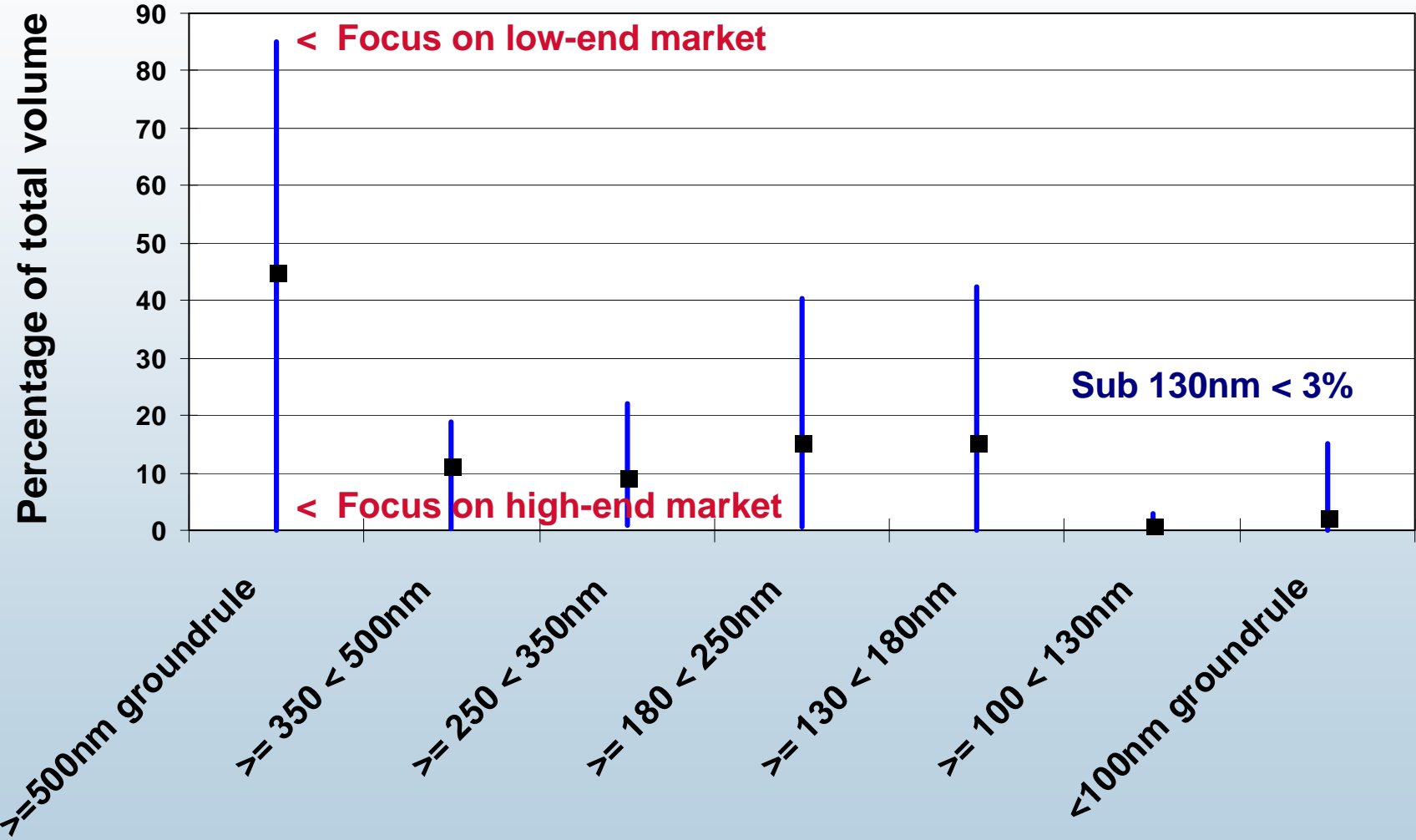
- **Compugraphics**
- **Dai Nippon Printing (DNP)**
- **Dupont Photomasks**
- **Hoya**
- **IBM**
- **Infineon**
- **Intel**
- **Taiwan Mask Corporation (TMC)**
- **Toppan**
- **Taiwan Semiconductor Manufacturing Corp. (TSMC)**

Survey Question Overview

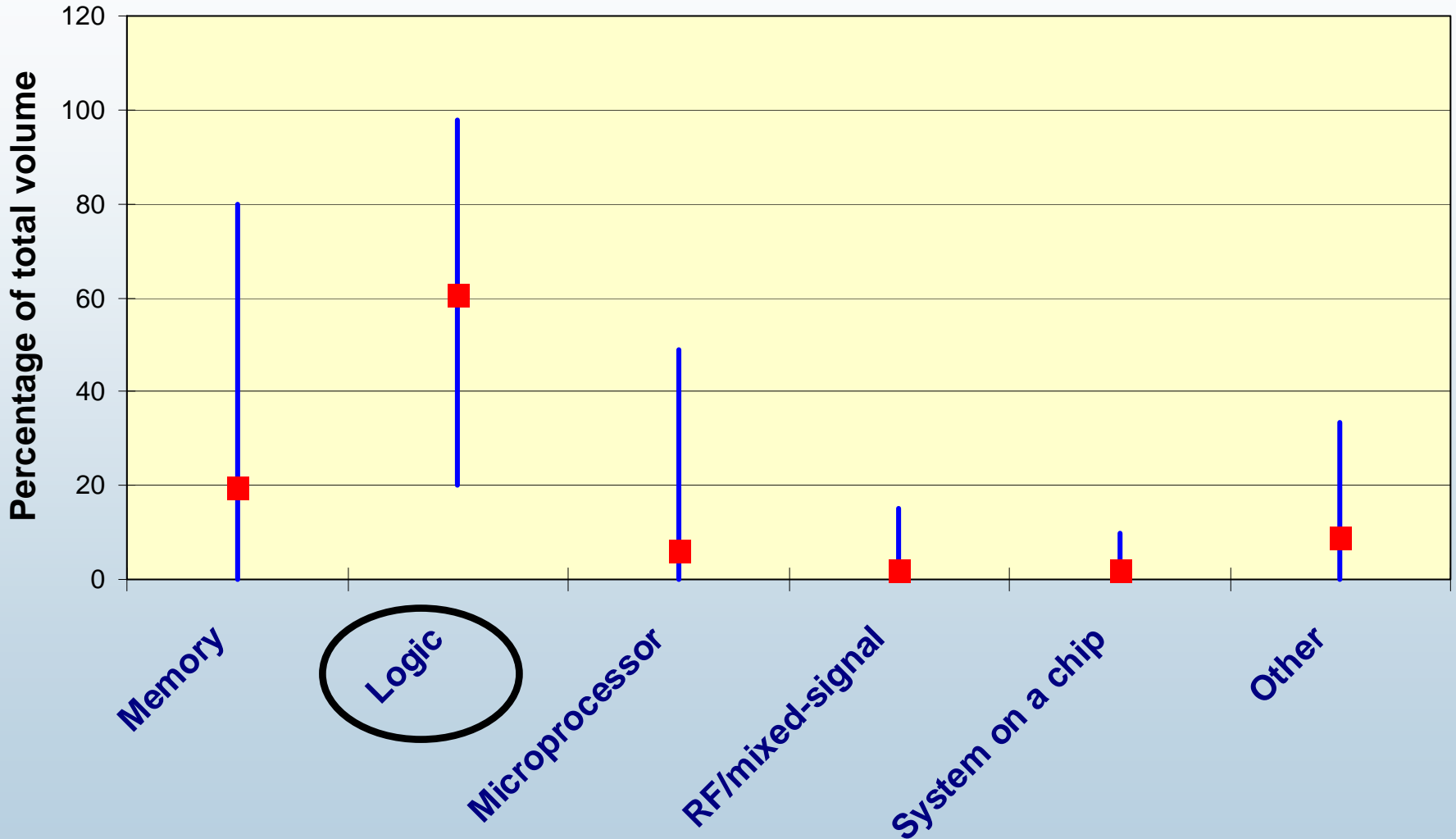
- **General Mask Profile Information**
 - Mask types, applications, glass size, magnification, processes, equipment
- **Data Processing**
 - File sizes, preparation times
- **Yields**
 - Overall yields, yield loss reasons
 - Expanded defect reason partitioning
- **Delivery Time**
 - Delivery performance by mask type
- **Mask Returns**
 - Return reasons, mask maintenance services

The Survey Results

Mask Volume by Design Node



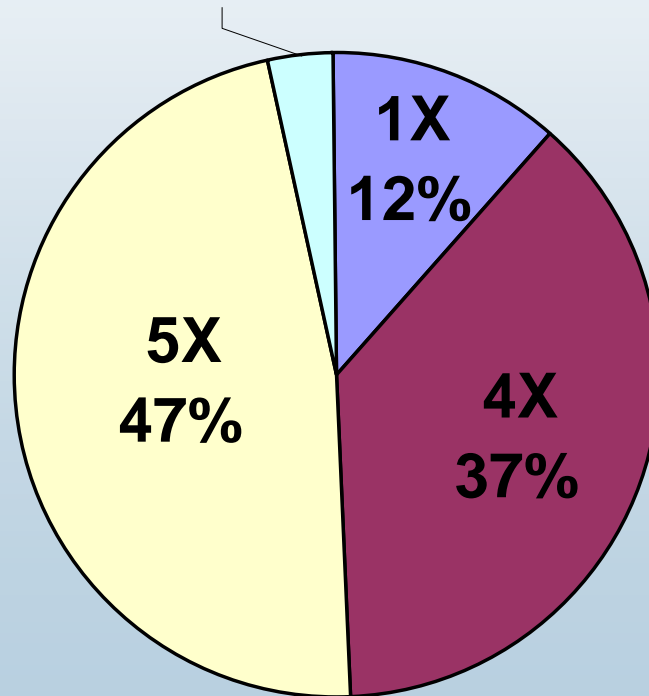
Mask Volume by Device (Chip) Application



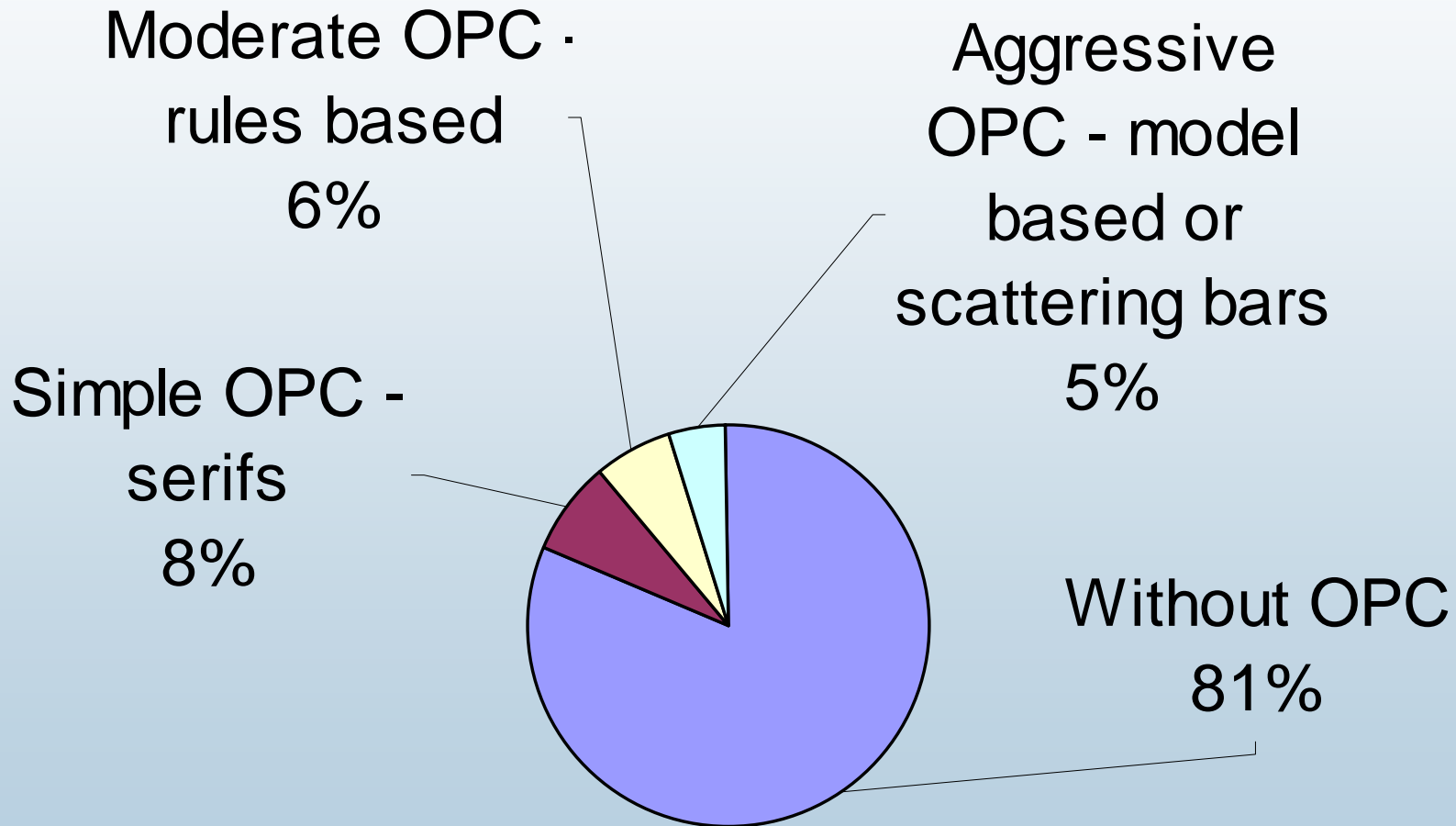
Magnification

All other magnifications

3%

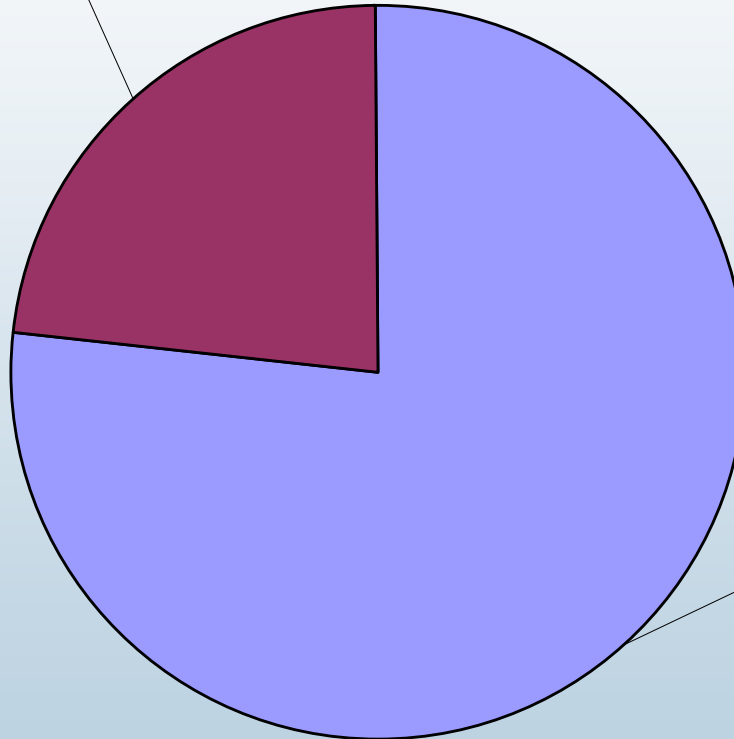


Mask Volume by OPC Level



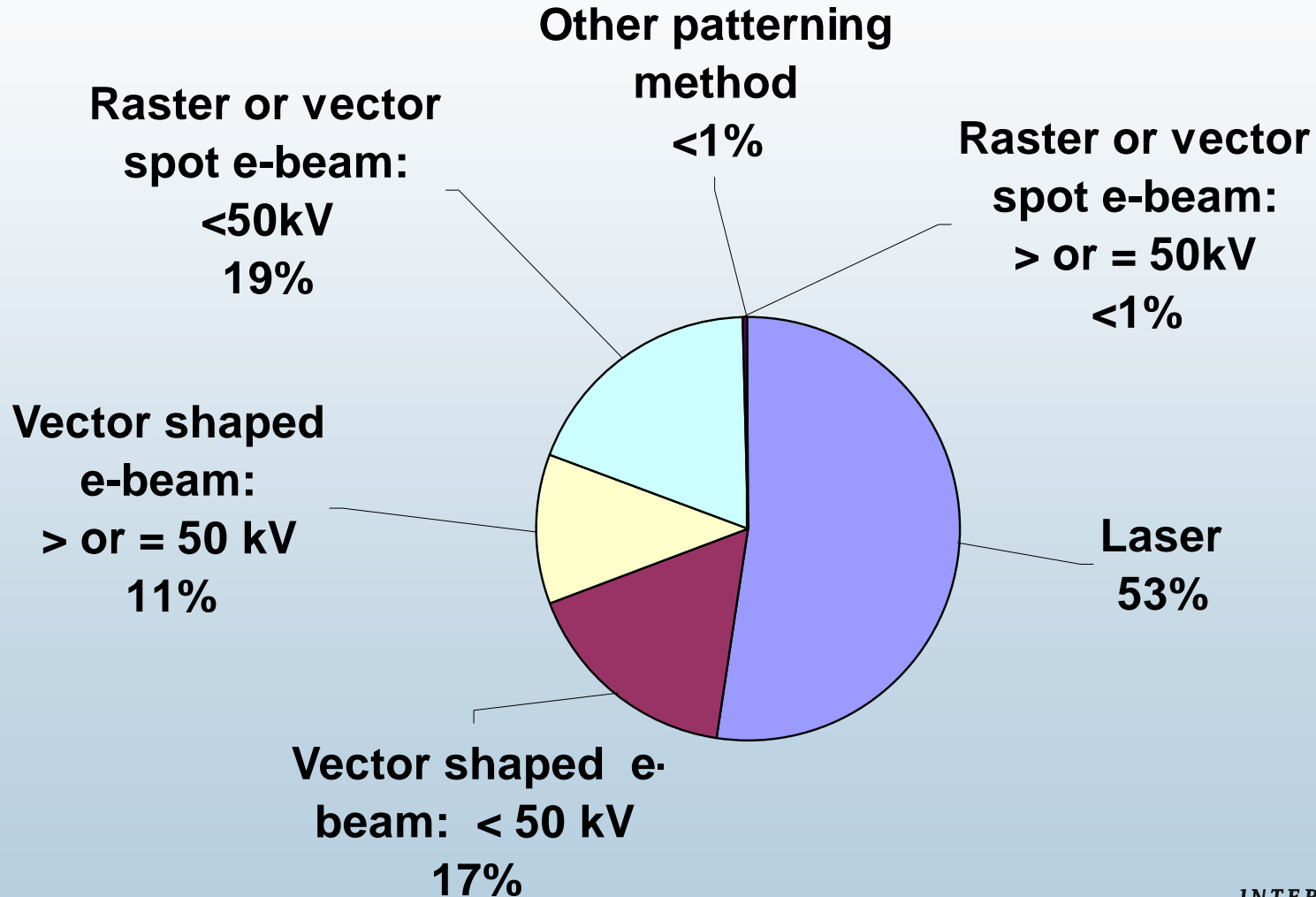
Attenuator Etch Process

Dry etched
23%

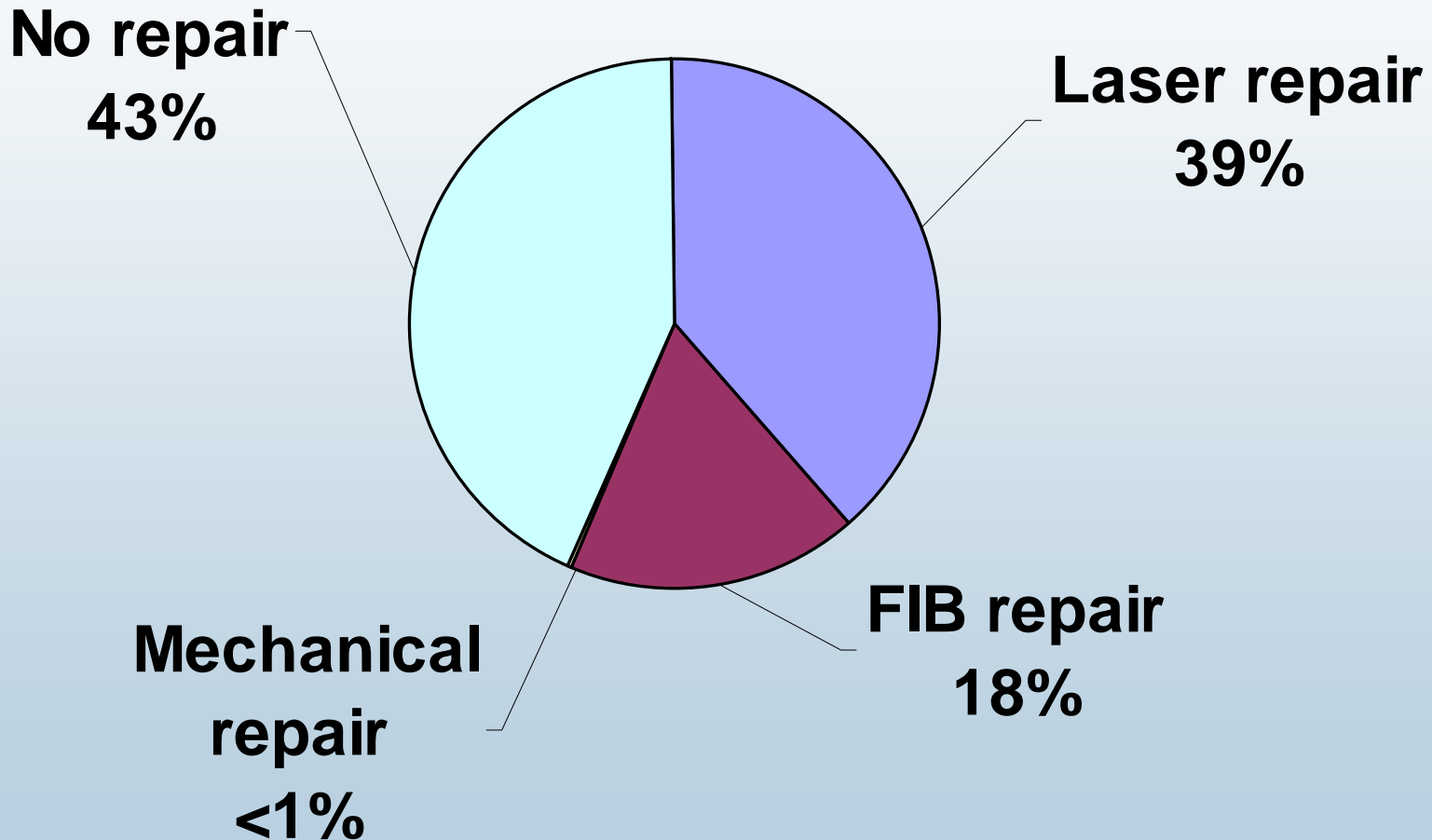


Wet etched
77%

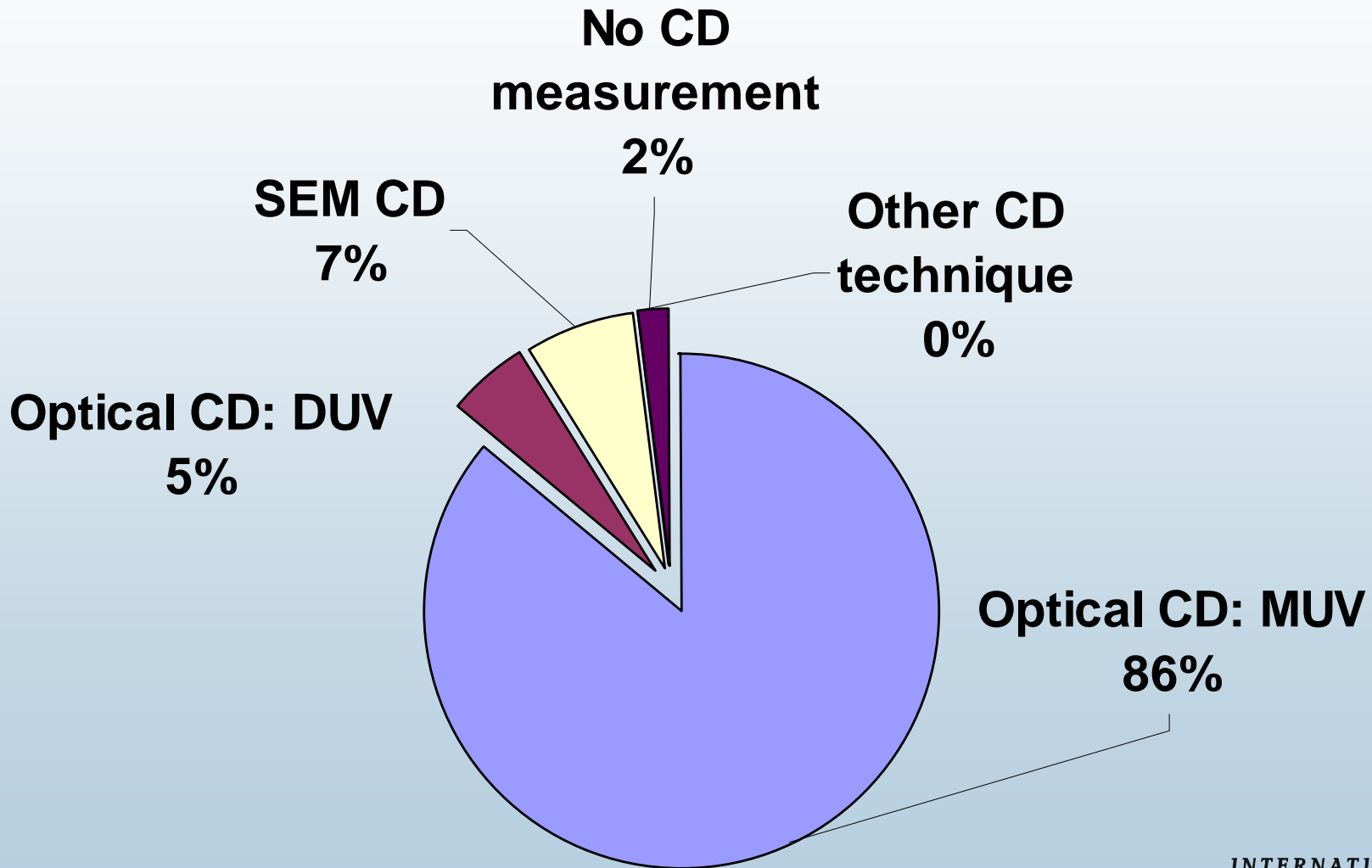
Patterning Method



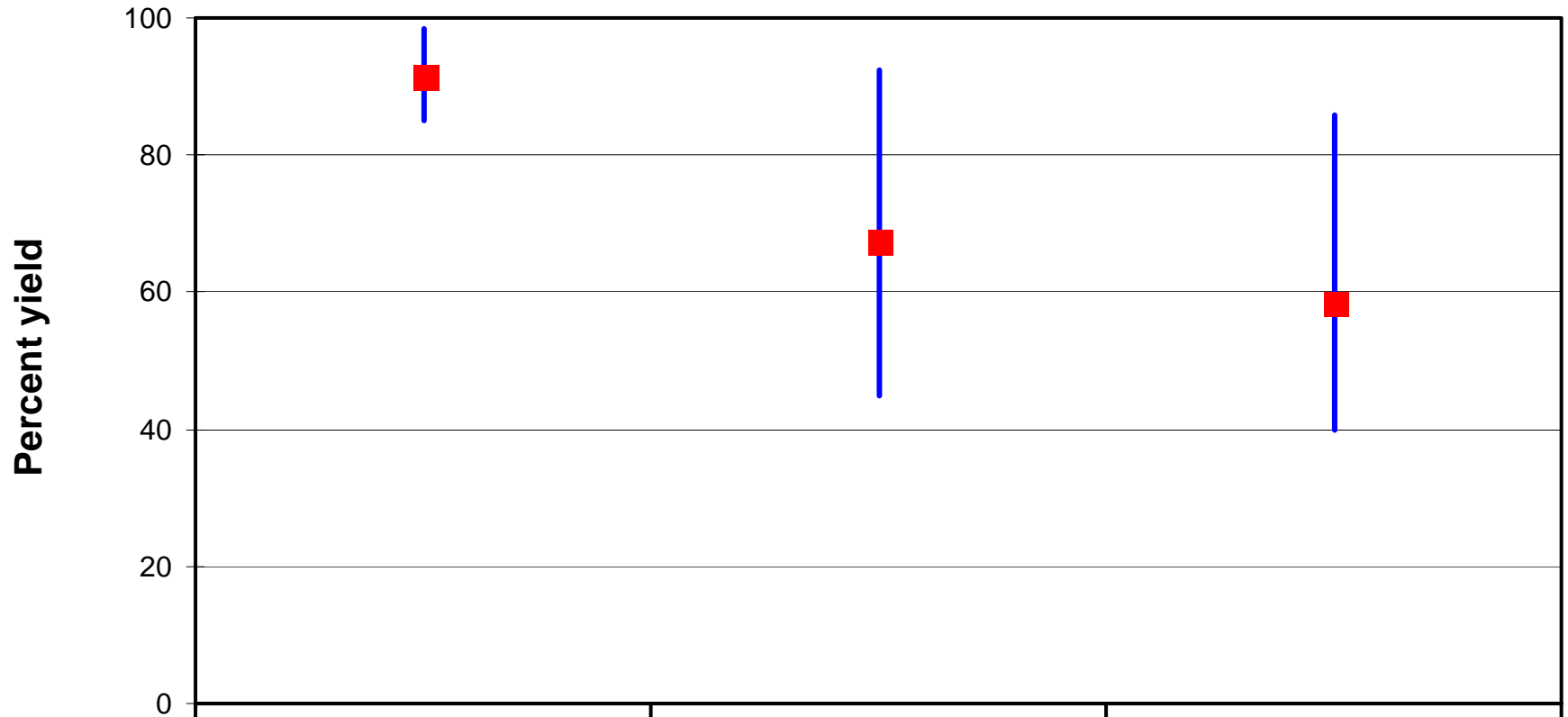
Repair Process



CD Metrology

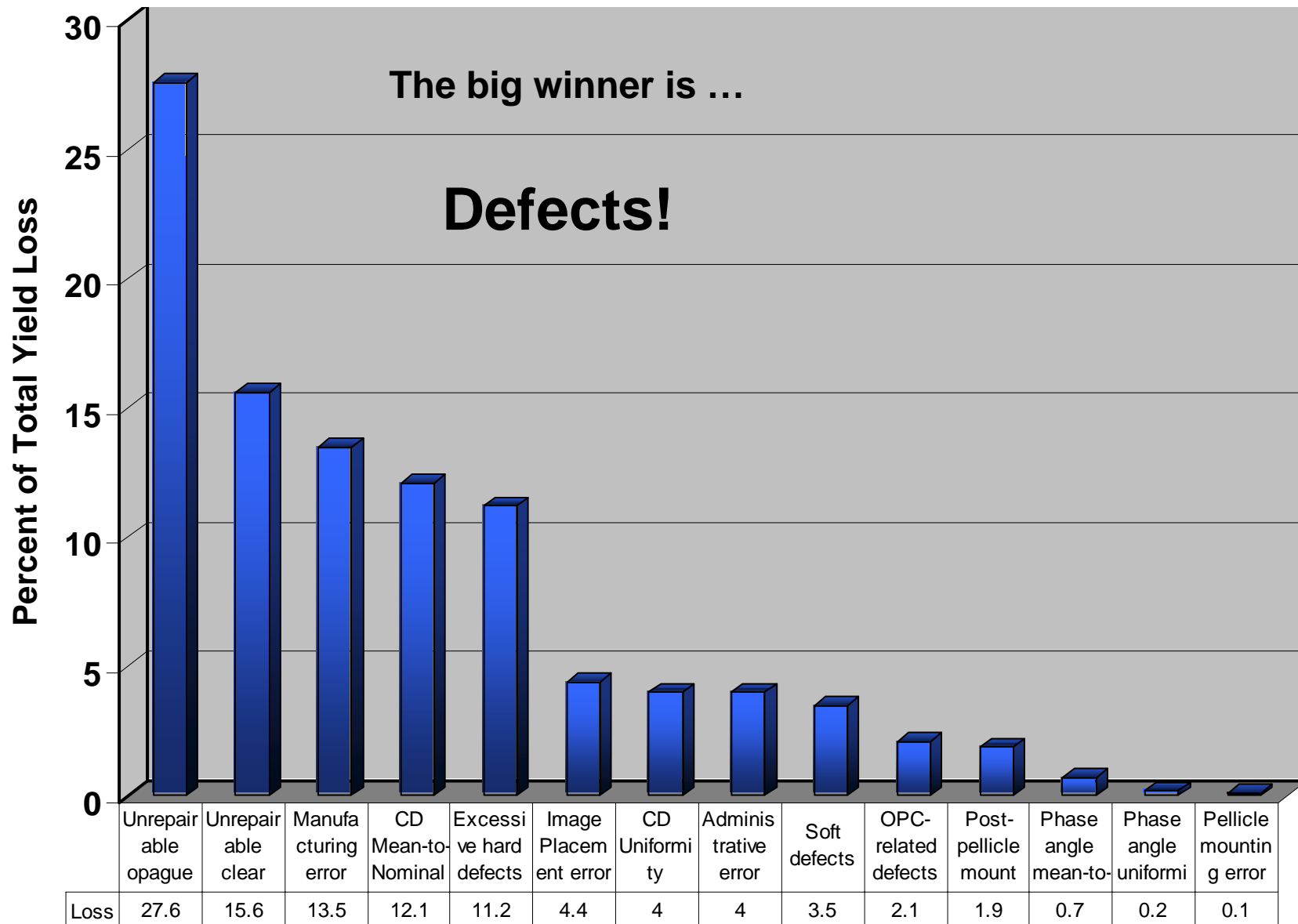


Overall Yields by Mask Type



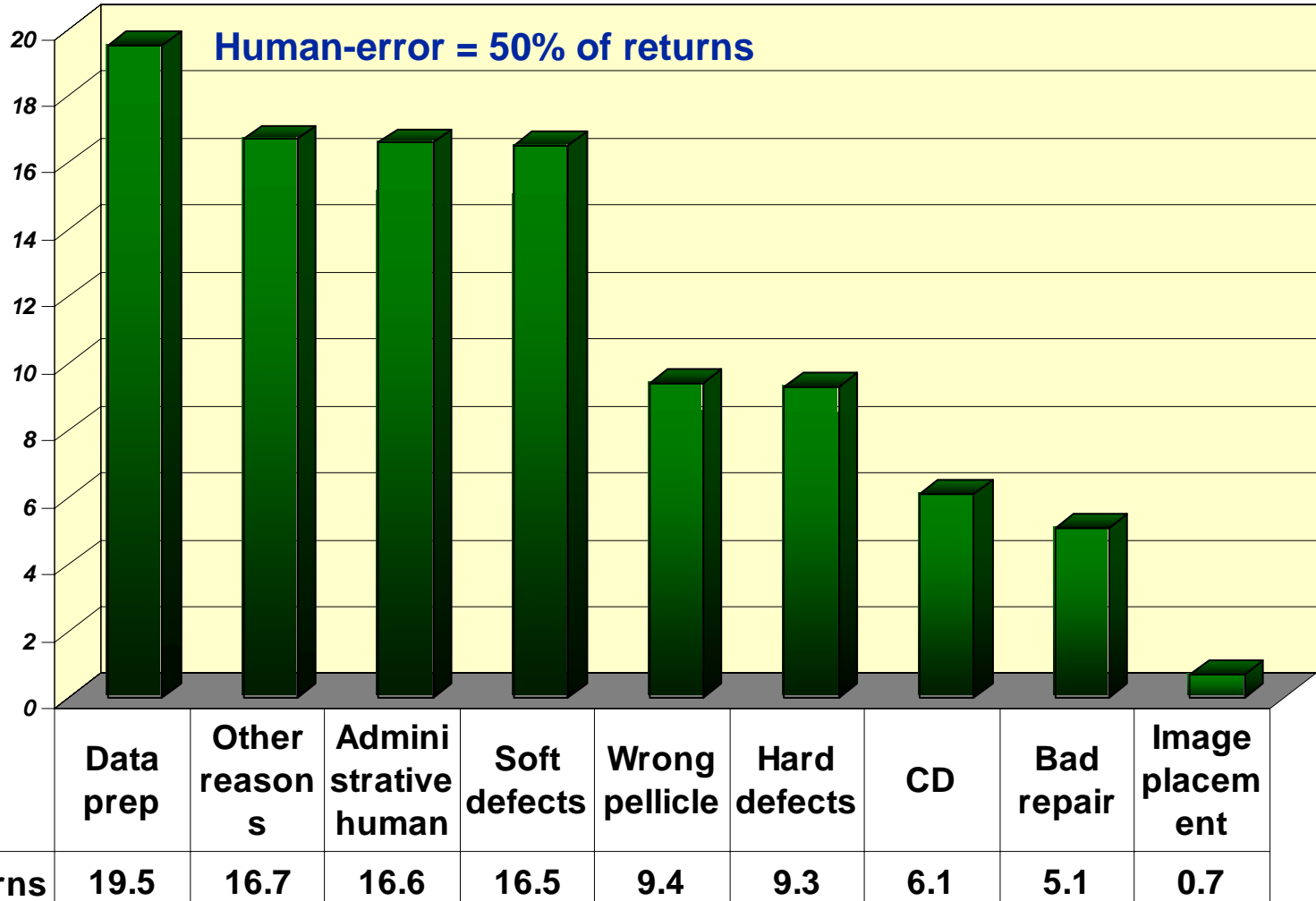
	Binary	Attenuated PSM	Alternating PSM
max	98.5	92.4	85.7
min	85.0	45.0	40.0
average	91.6	67.6	58.5

Yield Loss Mechanisms

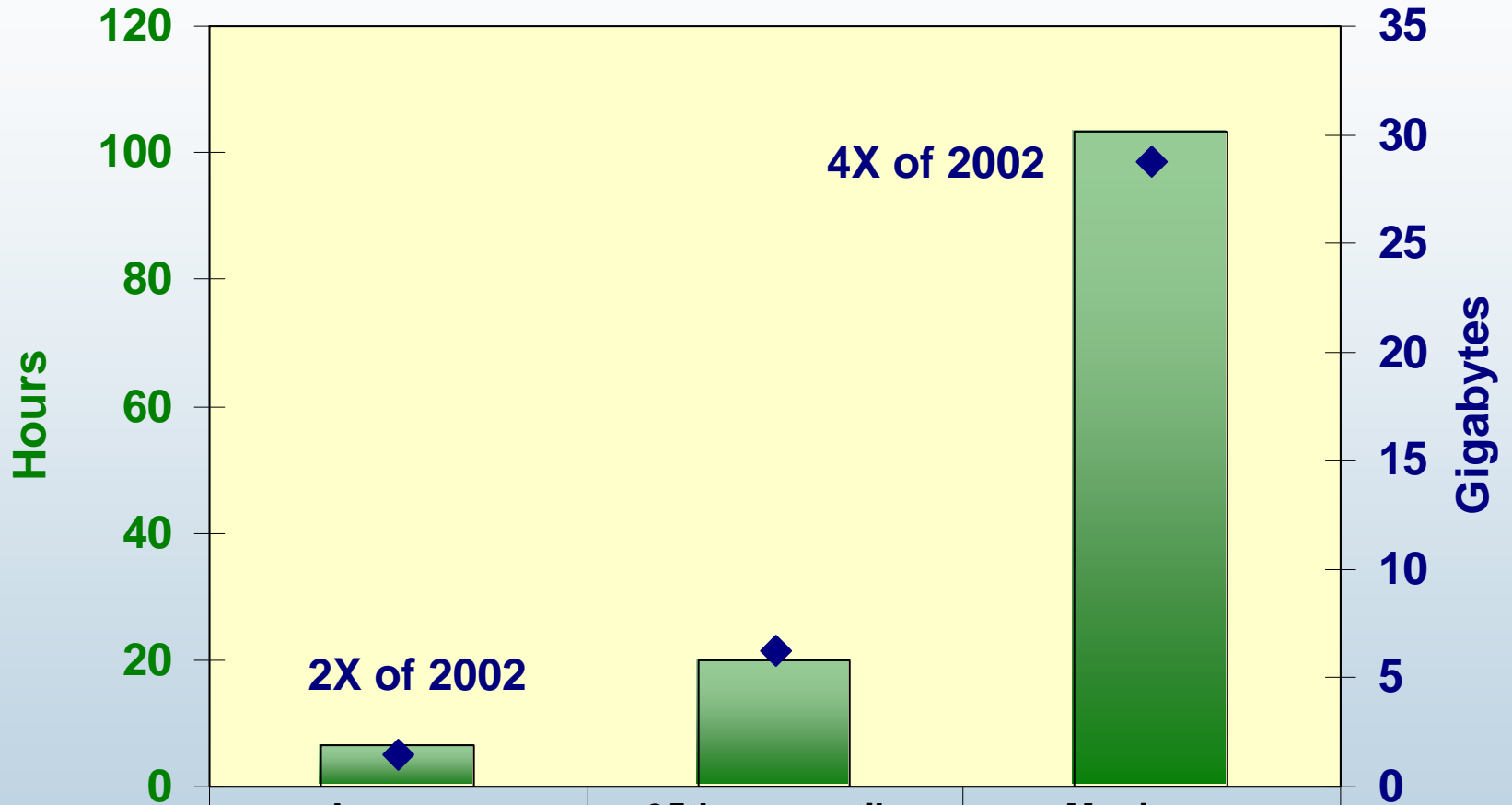


Mask Return Reasons

Returns are <0.2% of total mask volume

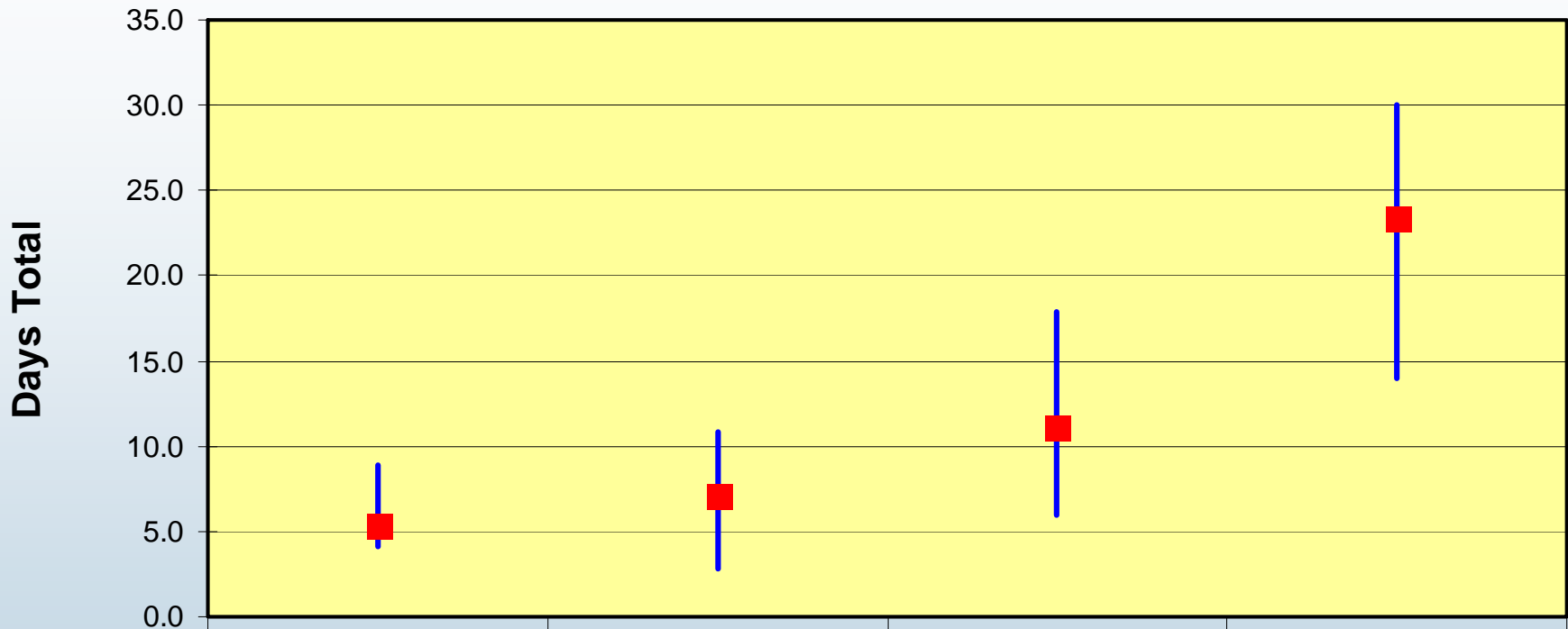


Design Data Size and Prep Time



	Average	95th percentile	Maximum
data prep time	6.5	19.9	103.4
data file size	1.51	6.21	28.77

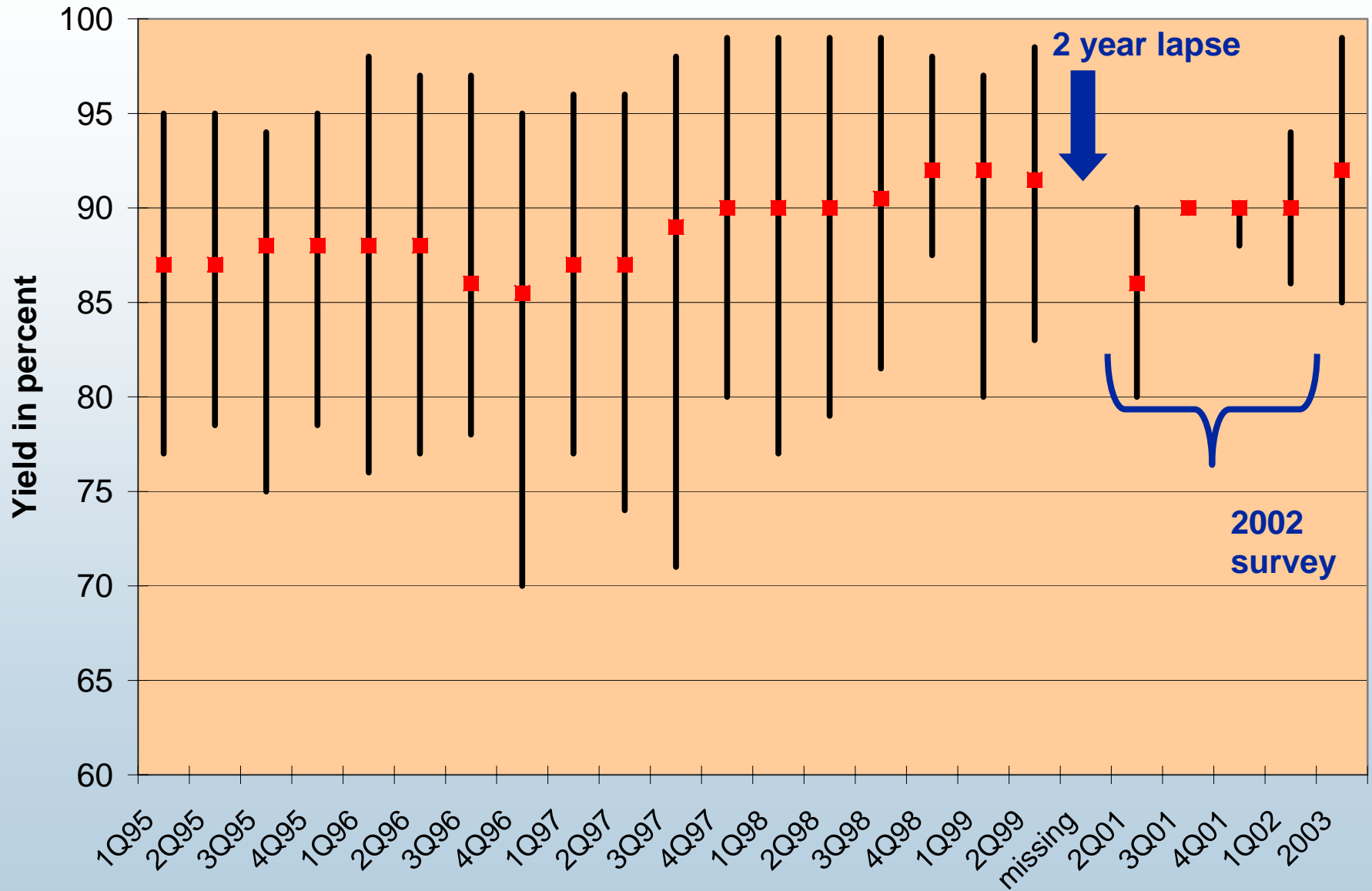
Delivery Time



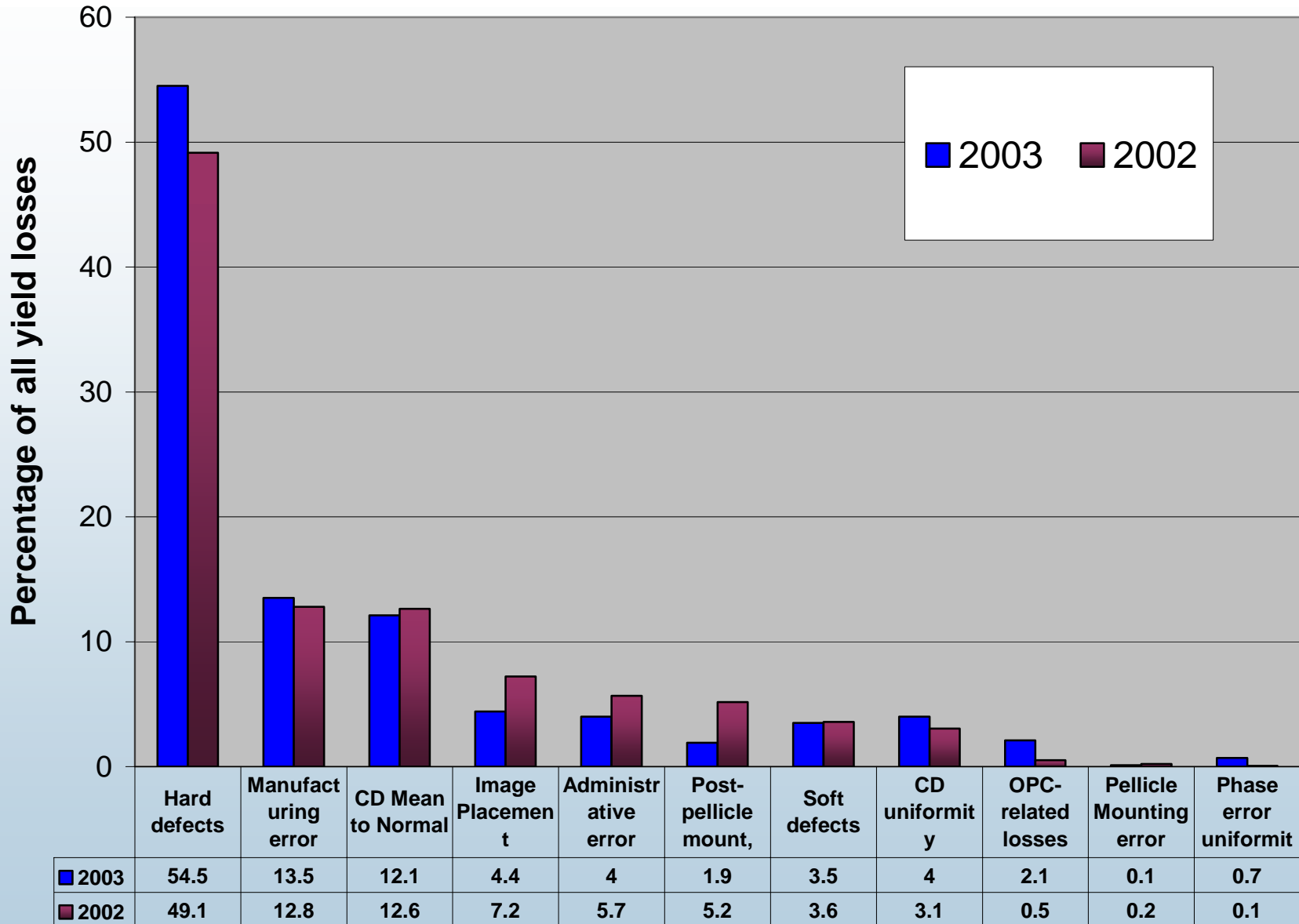
	Binary (days)	Binary with moderate or aggressive OPC	Attenuated PSM (days)	Alternating PSM (days)
Longest	8.9	10.8	17.9	30.0
Shortest	4.1	2.8	6.0	14.0
■ Average	5.5	7.2	11.1	23.4

Selected Trend Data 1995-2003 Survey

Binary Yield Trend 1995 - 2003



Yield Loss Mode Trend 2002 - 2003



Summary Observations: Yield

- **Hard defects are primary problem (54%)**
 - Hard defects often start as soft defects
- **Manufacturing (13.5%) + Administrative (4%) Errors are a primary opportunity area**
 - Automation needs further penetration in Mask industry
 - Data handling, order processing, production/process control
- **CD control (12%) second major process issue**
 - Mean-to-target control issue: adaptive processing
- **Other components < 5%**
 - Image Placement error losses (4.4%)
- **APSM and EPSM average yields similar but with large variance for each (40-90%!)**

Other Observations

- **Top 4 merchants command 65% of market**
- **Mask revenue as percent of semi revenue is flat at ~1.5%**
- **Mask Returns remain <1% but issues the same: administrative and human error**
 - Automation of data / job flow is an opportunity
- **57% of masks get repaired**
 - Yet 43% of yield loss is for non-repairable defects
 - Improved repair technology is critical
- **Delivery times have not changed significantly**
- **Logic drives >60% of mask volume**
- **<180nm nodes drive 6% of quantity but 37% of revenue**
- **>500nm nodes drive about 90% of volume but ~20% of revenue**

Changes for Next Time....

- **Yield loss reasons by mask type: bin, EPSM, APSM**
- **Yield by technology node**
- **More participation: build from 10+ top players**
 - Start survey earlier? Will it improve data submission timing?
- **Lower frequency? Bi-annual?**
- **New author... International SEMATECH continues**
- **Your inputs and suggestions welcome:
kkimmel@us.ibm.com**

Sincere Appreciation to the Survey Participants for their cooperation in competition:

- **Compugraphics**
- **Dai Nippon Printing (DNP)**
- **Dupont Photomasks**
- **Hoya**
- **IBM**
- **Infineon**
- **Intel**
- **Taiwan Mask Corporation (TMC)**
- **Toppan**
- **Taiwan Semiconductor Manufacturing Corp. (TSMC)**

**Thank you for your
attention.**

Questions?