The Information Network

450mm Wafers – Solid Foundation or Loose Stones

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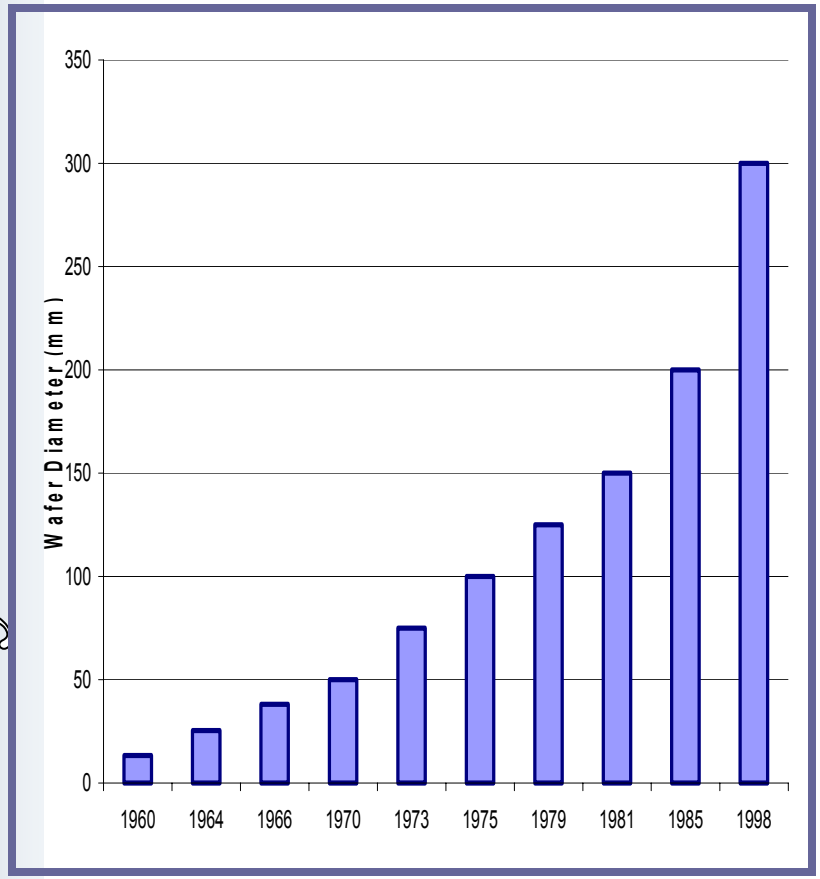
Silicon Wafers In Transition

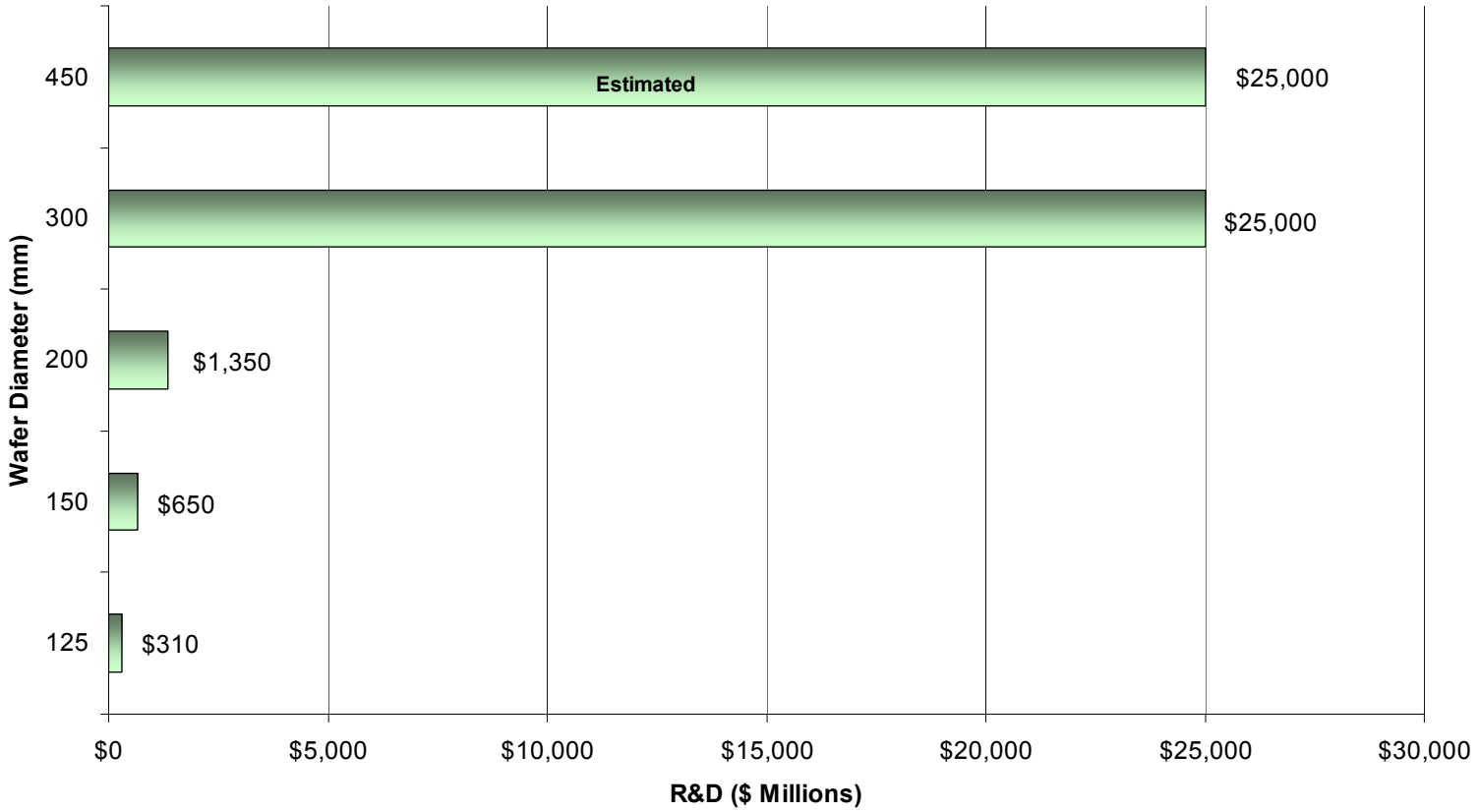
Year	Inches	mm
1960	0.525	13.3
1964	1	25.4
1966	1.5	38.1
1970	2.25	57.2 (50)
1973	3	76.2 (75)
1975	4	101.6 (100)
1979	5	127.0 (125)
1981	6	152.4 (150)
1985	8	203.2 (200)
1998	12	304.8 (300)

Who's Going To Fund The Transition?



- Champions
  - 150mm - Intel
  - 200mm - IBM
  - 300mm - Equipment Vendors
  - 450mm – ISMI* anticipates assisting tool suppliers with some of the costs involved in building a 450 mm tool for use in ISMI's 450 mm program
    - ISMI is a wholly owned subsidiary of SEMATECH

How Much Will It Cost?



Why Did 300mm Cost So Much?

- Two peaks in spending – 1997 and 2000 over an 11 year span
  - Applied Materials took it upon itself in mid-1996 to foster conversion to 300mm by internally funding development of a full suite of 300mm tools at 0.25 microns, except for….
  - Lithography vendors, which spent R&D on DUV at 0.25 microns on 200mm wafers.
  - Selete's roadmap of full production was for 2000 at 0.18 microns
- Various consortia did not promote bridge tools.

Four Camps Strategically Focused On The Debate

- Camp 1 - Sematech, which is spearheading the charge for 450mm.
- Camp 2 - EEMI-450, which is pushing for 450mm development in Europe.
- Camp 3 – Large non-European semiconductor equipment manufacturers that have publicly slammed the idea of the 450-mm wafer transition.
- Camp 4 – SEMI, who is sitting on the sidelines but setting standards as it “is not SEMI's role to encourage or discourage a particular industry decision.”

Camp 1 - Sematech

- Sematech is an association of member companies cooperating pre-competitively in key areas of semiconductor technology whose members make up 50% of the worldwide chip market.
- Members are Intel, IBM, Micron, Hewlett-Packard, National Semiconductor, Globalfoundries, NEC, Samsung, Renesas, Toshiba, Infineon, UMC, and TSMC.

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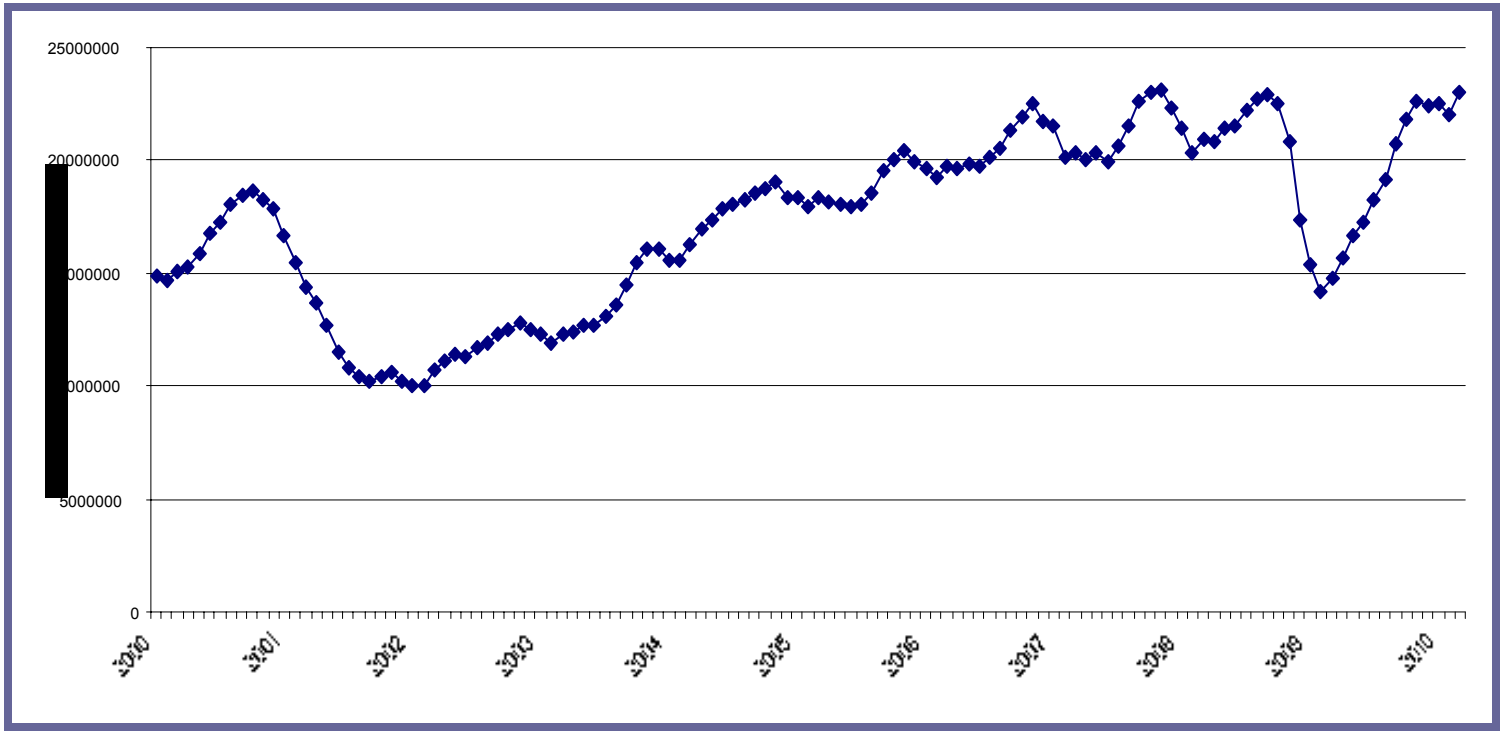
Why is Sematech So Hot for 450mm?



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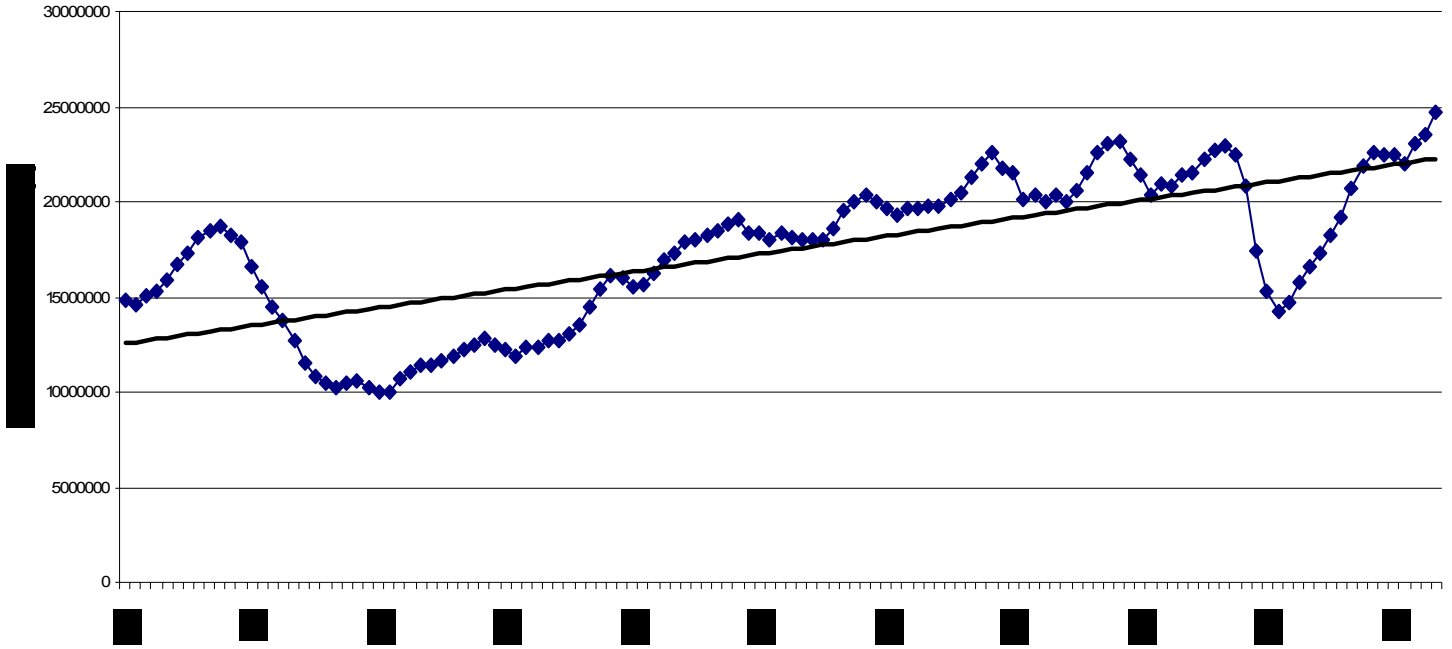
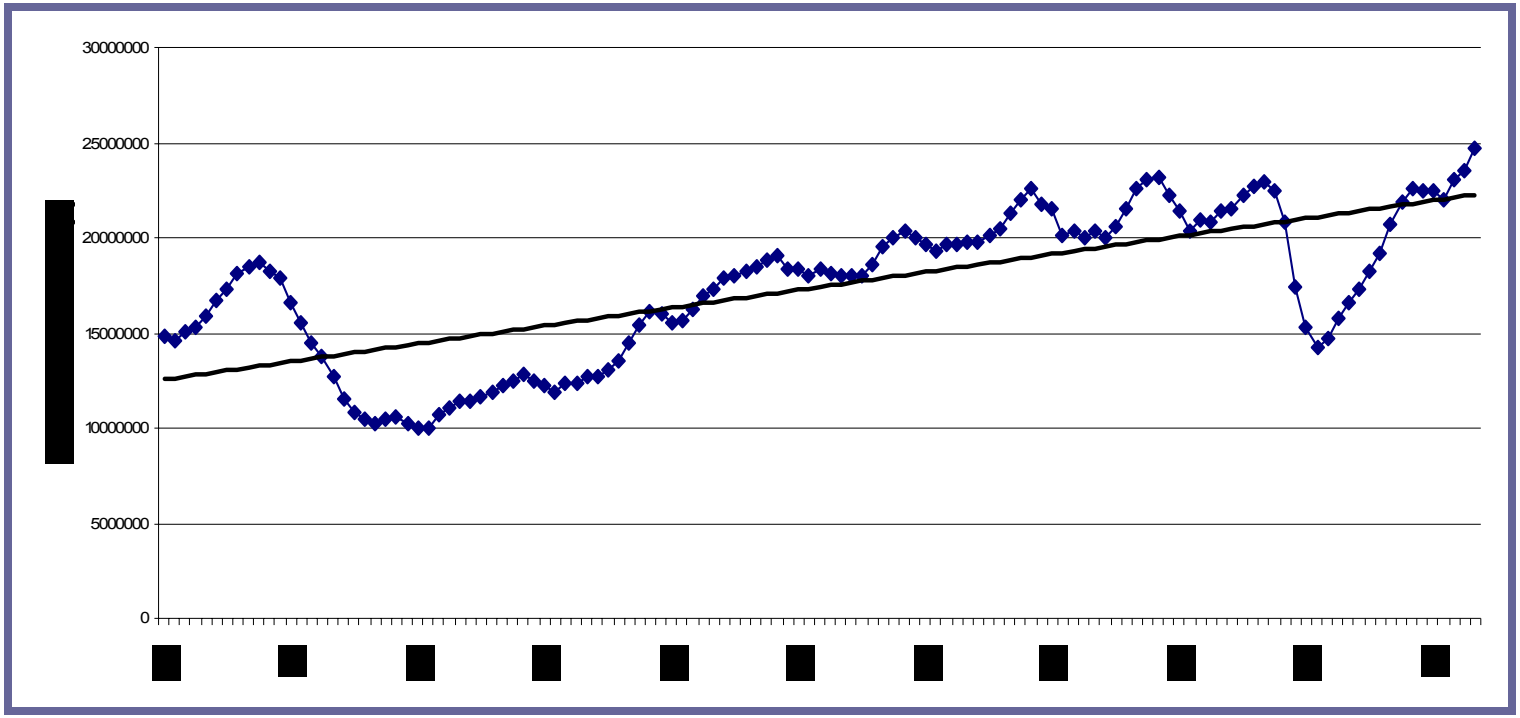


Camp 2 - EEMI-450

- The objective of the ENIAC EEMI-450 and CASA-450 programs is "to improve the competitiveness of the European semiconductor equipment and materials industry and therefore increase the chances to be selected by the tier 1 semiconductor companies in their future 450-mm operations."
- A steering committee for EEMI-405 has been formed with representatives from ASM International, ASML Holding NV, Siltronic AG, Soitec SA, IMEC, Recif Technologies SA, Fraunhofer Institut of Integrated Systems and Device Technology (Fraunhofer-IISB) and **two representatives from Intel**.

Why is Intel Part of EEMI-450 for 450mm?



Who is Part of EEMI-450 for 450mm?

Consortium of 28 partners

- Semiconductor Supplier
  - Intel
- Material companies
  - Siltronic, Soitec
- Equipment Companies
  - Aixtron, ASML, ASM, EVGroup, IBS, Mattson, Oxford instruments, Vistec
- Automation and Handling
  - RecifeTechnologies, AIS Automation, HAP
- Metrology
  - Nanophotonics, PVA TEPLA, Semilab
- OEM suppliers
  - DAS, Semiquarz, Xycarb, SEMCO, Adixen, Bronkhorst High-Tech,
- Institutes
  - CEA-LETI, IMEC, FhG, PTB, TNO

Top 25 Equipment Suppliers 2009

Rank		Company	Country of origin	Revenue
2009	2008			(million $USD)
1	1	Applied Materials	USA	3,597
2	3	Tokyo Electron	Japan	2,324
3	2	ASML	Netherlands	2,268
4	6	Nikon	Japan	1,547
5	4	KLA Tencor	USA	1,321
6	5	Lam Research	USA	1,198
7	9	Dainippon Screen	Japan	805
8	11	ASM International	Netherlands	690
9	10	Novellus Systems	USA	582
10	12	Teradyne	USA	552
11	8	Hitachi High-Tech	Japan	474
12	13	Advantest	Japan	416
13	18	Aixtron	Germany	412
14	14	Varian Semiconductor	USA	396
15	15	Verigy	Singapore	333

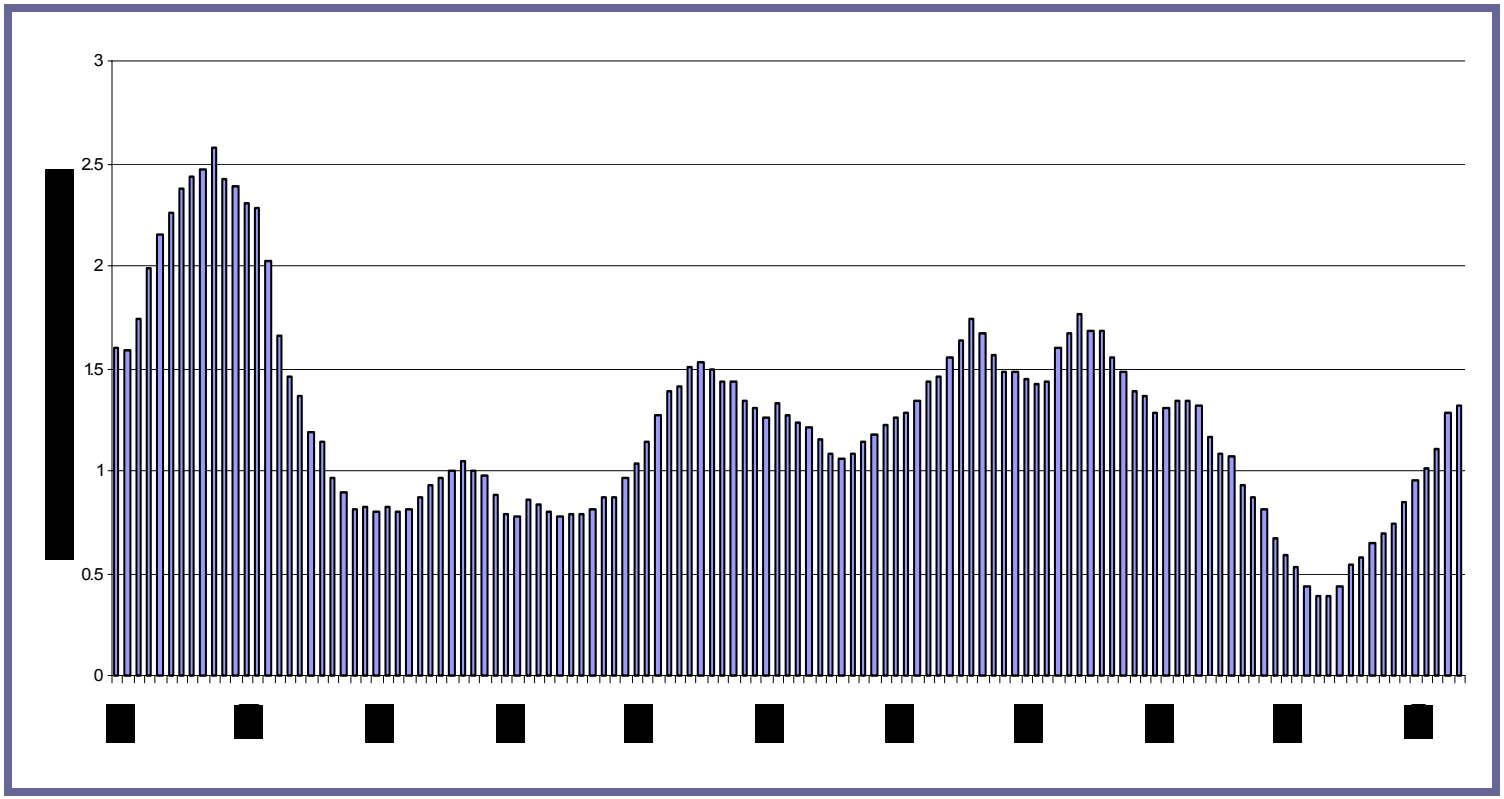
Why is There an EEMI-450?

- To improve the competitiveness of the European semiconductor E&M industry and therefore increase the chances to be selected by the tier 1 semiconductor companies in their future 450mm operations.
- To stimulate a European infrastructure that is leading in 450mm development and as a result will induce tier 1 companies to cooperation programs and possibly equip 450mm fabs in Europe.

Camp 3 – Large Non-European Equipment Manufacturers

Non-European semiconductor equipment manufacturers, including Applied, Novellus, Lam, TEL and others, have **publicly slammed** the idea of the 450-mm wafer transition.

Why Don't Large Non-European Equipment Manufacturers Want It?



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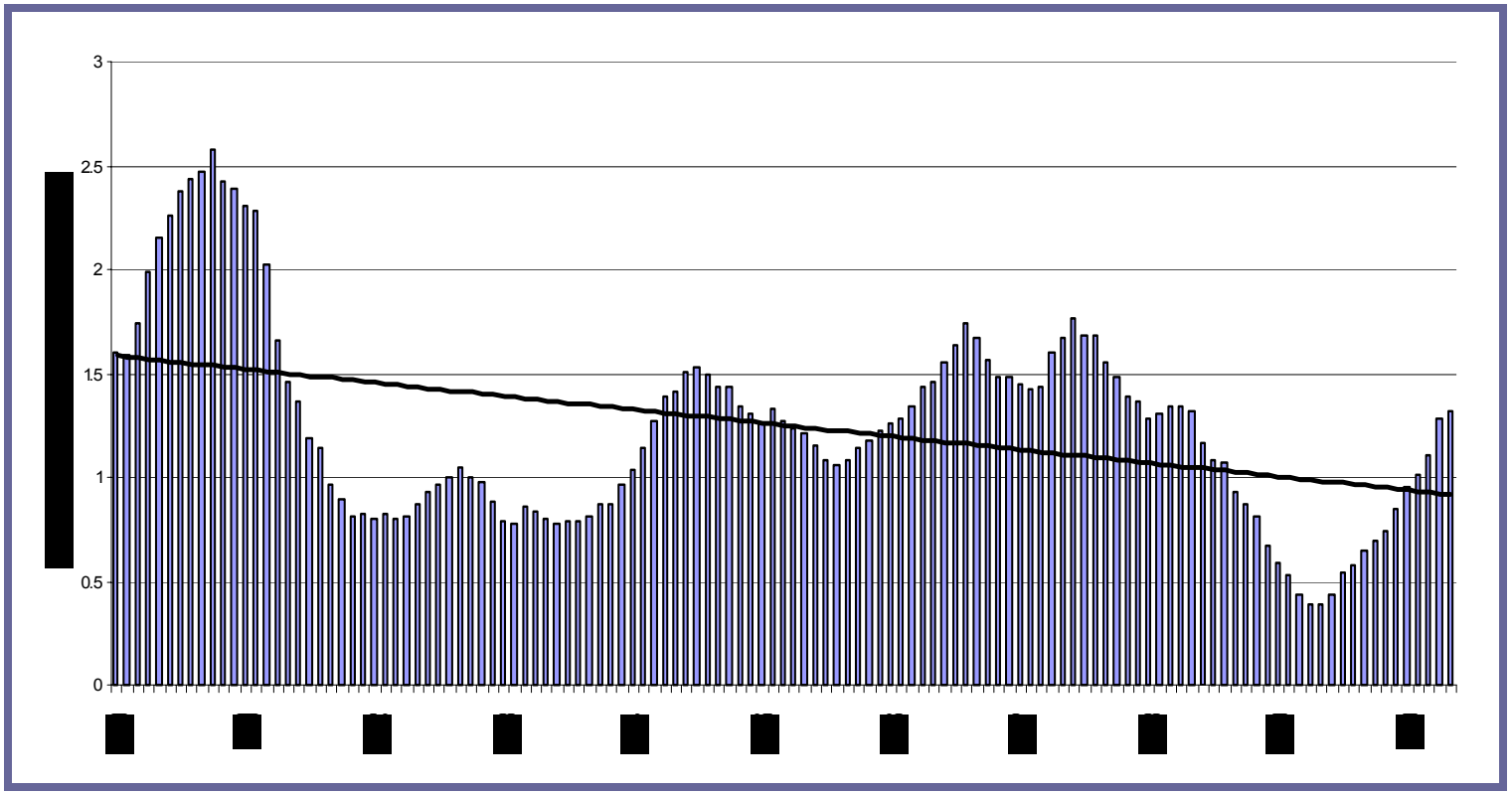
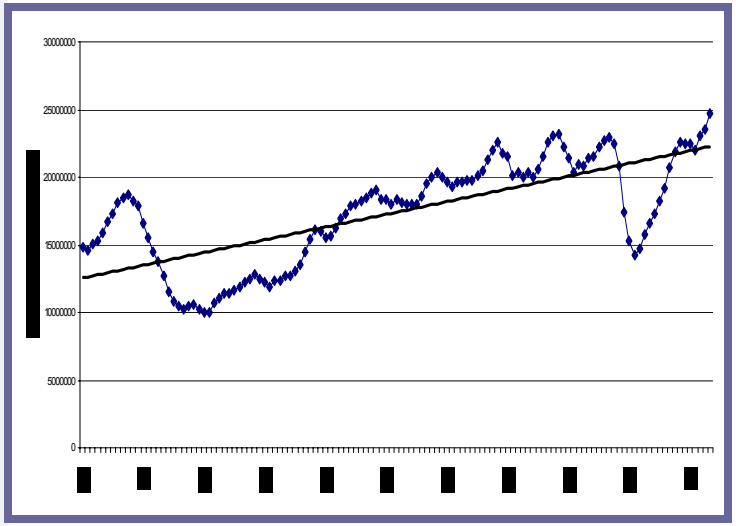
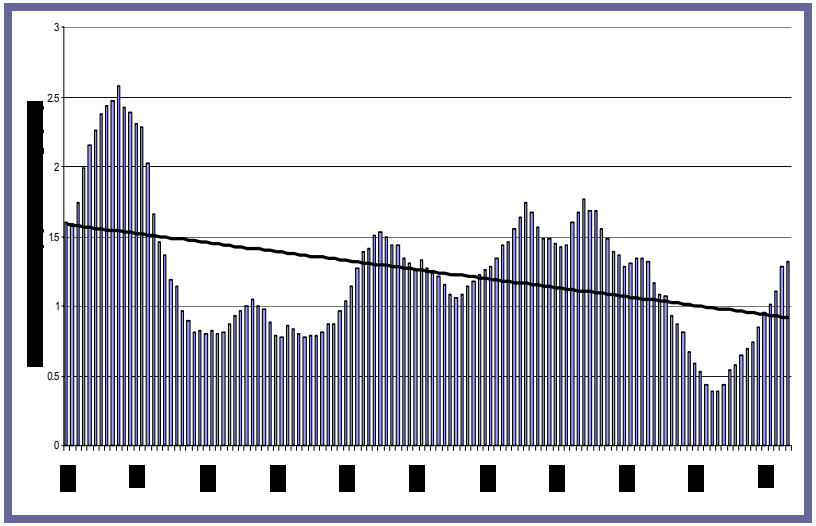
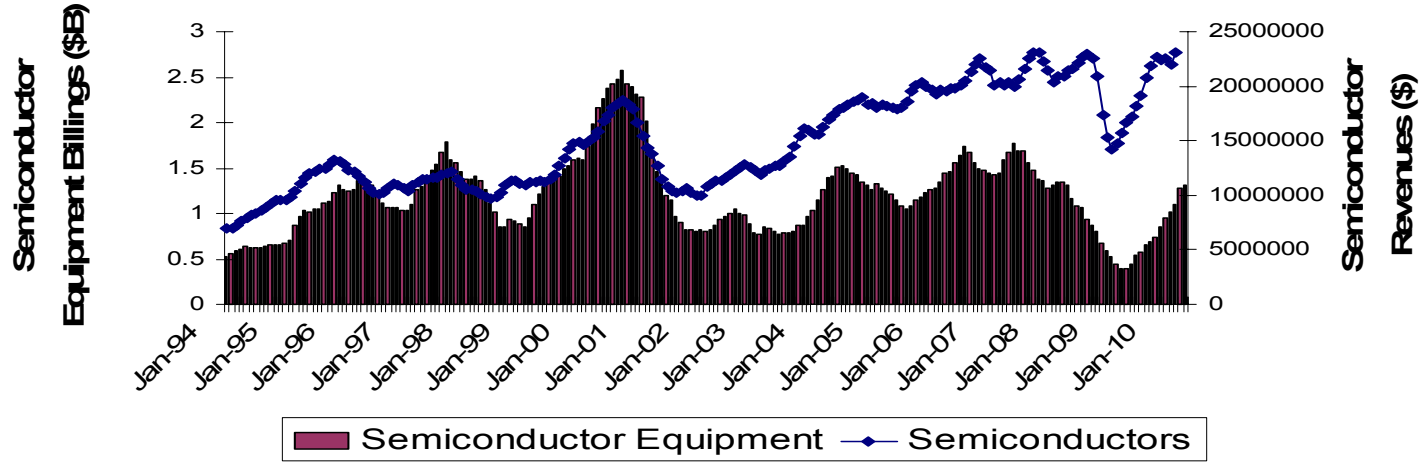


Semiconductor Versus Semiconductor Equipment





Semiconductor Versus Semiconductor Equipment – Pre- and Post-300mm



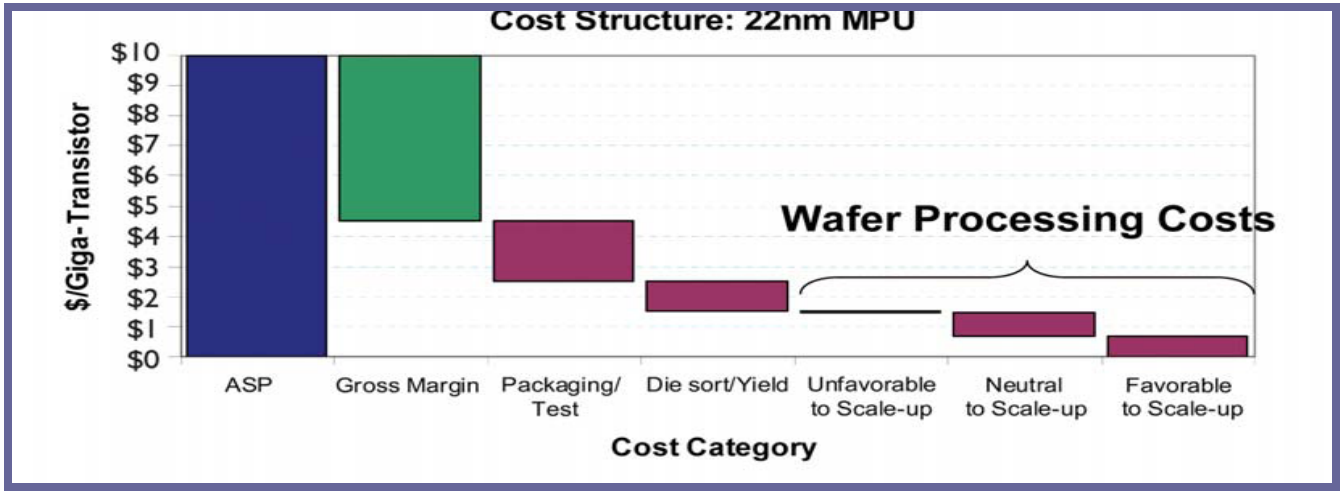
- Prior to 2000 (which is prior to 300mm), we saw correlations between semi and equipment sales peaks and valleys
- After 2000 (after 300mm), we see a divergence

Camp 4 – SEMI

- SEMI Standards program is actively pursuing development of standards that are 450mm wafer-size specific.
- Working Group 450 mm Economic Findings and Conclusions
  - 450 mm Offers Little—If Any—Upside Opportunities
  - 450 mm Introduces Significant Downside Risks
  - Questionable 450 mm Benefits Cannot Justify the Required Investment

SEMI - 450 mm Offers Little—If Any—Upside Opportunities

- The basic cost of wafer processing represents about 15% of price/function for advanced MPU
- Perhaps 8% of the overall costs would be reduced by a scale-up.
- This leads to the obvious question -- is a projected $25B investment in equipment R&D justified for 8% improvement?

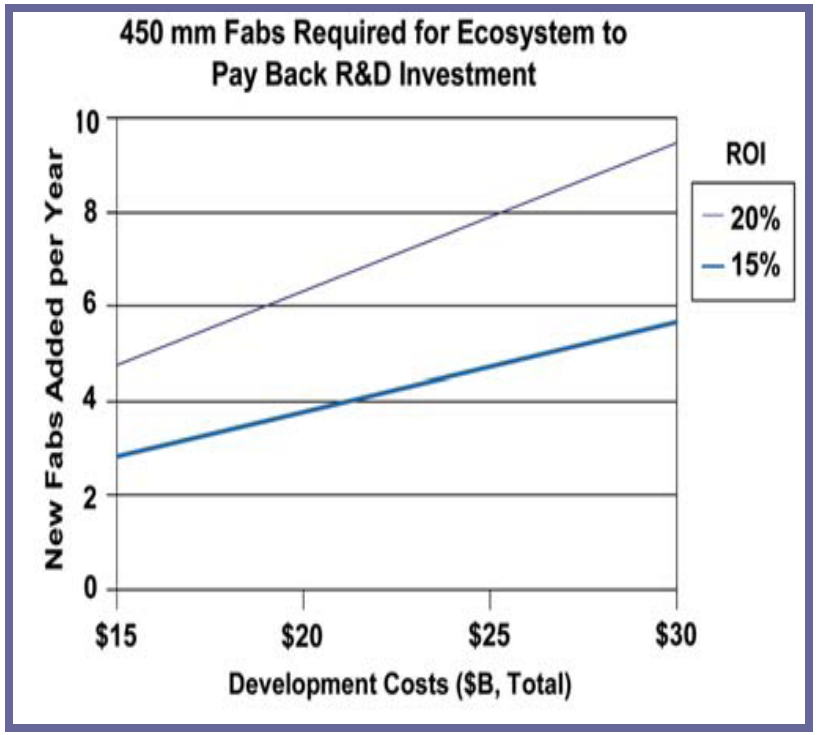


SEMI - 450 mm Introduces Significant Downside Risks

- A 450 mm transition would undermine the semiconductor industry's ability to meet end-user requirements for fast-cycle-time delivery.
- While demand to quick-cycle-time production is increasing, 450 mm could introduce a significant cycle time penalty, which early estimates put at more than 50%.
- This would be a dangerous move away from recognizing and meeting market requirements.
- As a result, manufacturers will have to operate their fabs at lower utilization in order to realize acceptable cycle times, thereby eroding and eliminating any conceivable cost advantage provided by 450 mm.

SEMI - Questionable 450 mm Benefits Cannot Justify the Required Investment

- Earning a 15% to 20% ROI would require the construction of four to eight 450 mm fabs per year every year over at least 15 years for the semiconductor ecosystem to pay back the development costs—even with optimistic cost savings.
- Such a massive building boom is highly unlikely to happen in the best of cases.



What-If For the Industry

- The ROI for 450mm tools is questionable, since the equipment market for the next wafer generation is projected to be limited at best.
- Only a few chipmakers—Intel, Samsung and possibly Toshiba and TSMC—can afford to build 450mm fabs, which could cost $10 billion or more.

What-If for the Semi Manufacturers

	Rank	Company	Country	$M
•	1	Intel Corporation	USA	32,410
•	2	Samsung Electronics	South Korea	17,496
•	3	Toshiba Semi	Japan	10,319
•	4	Texas Instruments	USA	9,617
•	5	STMicroelectronics	France Italy	8,510
•	6	Qualcomm	USA	6,409
•	7	Hynix	South Korea	6,246
•	8	AMD	USA	5,207
•	9	Renesas Technology	Japan	5,153
•	10	Sony	Japan	4,468
•	11	Infineon Technologies	Germany	4,456
•	12	NEC Semiconductors	Japan	4,384
•	13	Micron Technology	USA	4,293
•	14	Broadcom	USA	4,278
•	15	Elpida Memory	Japan	3,948
•	16	MediaTek	Taiwan	3,551
•	17	Freescale Semi	USA	3,402
•	18	Panasonic Corp	Japan	3,243
•	19	NXP	Netherlands	3,240
•	20	Sharp Electronics	Japan	2,977
•	21	NVIDIA	USA	2,826
•	22	Rohm	Japan	2,586
•	23	Fujitsu Micro	Japan	2,574
•	24	Marvell Technology	USA	2,572
•	25	IBM Microelectronics	USA	2,253

- Companies in Black - immediate transition to 450mm
- Companies in Blue - within 5 years
- Companies in Red - never to +10 years
- (Based on revenue increases past 10 years – Foundries not included)
- **The Result**
  - A bifurcation in industry with 450mm versus 300mm semiconductor companies
  - The smallest companies using 300mm will not be competitive to large companies on 450mm
  - Consolidation is bound to occur

What-If for the Equipment Manufacturers

Rank	Company	Country	$M
1	Applied Materials	USA	3,597
2	Tokyo Electron	Japan	2,324
3	ASML	Netherlands	2,268
4	Nikon	Japan	1,547
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11	Hitachi High-Tech	Japan	474
12	Advantest	Japan	416
13	Aixtron	Germany	412
14	Varian Semiconductor	USA	396
15	Verigy	Singapore	333

- Companies listed - immediate transition to 450mm
- Companies ranked below #15 - never to +10 years
- **The Result**
  - A bifurcation in industry with 450mm versus 300mm companies
  - Largest semi companies moving to 450mm will erode customer base for 300mm equipment suppliers
  - Consolidation is bound to occur

The Whole 450mm Wafer Thing Is A Puzzle

- Most of the equipment industry feel they haven't yet had a return on the development cost of 300mm.
  - The largest equipment maker of them all, Applied, has publicly said it's doing nothing about 450mm.
- TSMC, Intel and Samsung have announced they want 450mm.
  - **But none of them wants to pay for it.**

Conclusion

- Clearly the semiconductor equipment manufacturers were the losers in the 200-to-300mm transition.
- There is no rational explanation that I can think of that will change the picture in the 300-to-450mm transition.
- A bifurcation in the semi and equipment sectors will lead to competitive pressures and consolidation of the industry.