2010 IRI Annual Meeting
R&D in Transition

U.S. Semiconductor R&D in Transition

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Some Semiconductor Industry Facts

- Founded in the U.S. approximately 50 years ago
- Industry is mature and economically indispensable
- 2009 annual sales of $ 226 Billion worldwide enabling Electronics System production of $1,109B
- Major source of high-wage employment in the U.S.
- U.S. semiconductor industry directly employs about 200,000 people in the United States
- Second largest U.S. export performance industry
- 80% of the U.S. industry's sales are overseas

Semiconductor Industry Impact

- The semiconductor industry is critically important with global economy impact on key markets:
  - Energy efficiency management
  - Transportation
  - Communication
  - Industrial
  - Medical
  - Consumer
  - National defense
- Pivotal for the distribution and management of electric power at reduced energy costs

Threats to the U.S. Semiconductor Industry

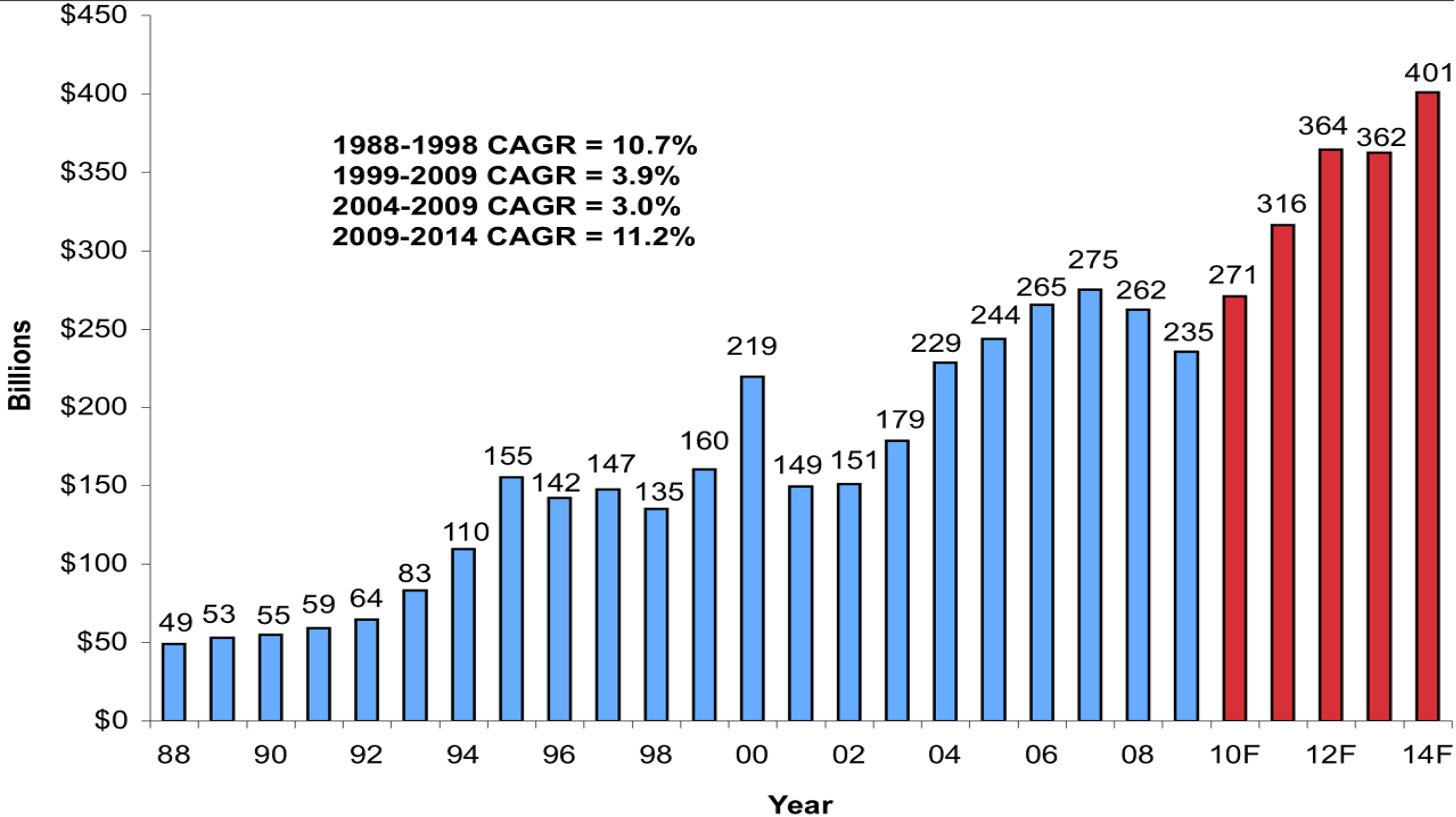
- Dramatic semiconductor product price erosions generate pressures to operate at reduced costs
- Major manufacturing and R&D facilities are being established outside the U.S.
- Silicon wafer fabrication capacity in the U.S. has declined from 42% in 1980 to 16% in 2007
- Concerns that the U.S. has lost its leadership position in semiconductor R&D
- Loss of critical technical skills and jobs

Worldwide Electronic System Production by System Type ($B), Year on Year Changes

System Type	08	09	09/08 % Chg	10F	10/09 % Chg	11F	11/10 % Chg	12F	12/11 % Chg
Computer	383	340	-11%	361	6%	385	7%	409	6%
Telecom	345	304	-12%	332	9%	370	11%	411	11%
Ind/Med/Other	176	160	-9%	167	4%	177	6%	189	7%
Consumer	160	140	-13%	150	7%	165	10%	182	10%
Automotive	102	85	-17%	93	9%	103	11%	115	12%
Gov/Military	78	80	3%	83	4%	88	6%	94	7%
Total	1,244	1,109	-11%	1,186	7%	1,288	9%	1,400	9%

Source: IC Insights

Worldwide Semiconductor Market History and Forecast



Source: IC Insights

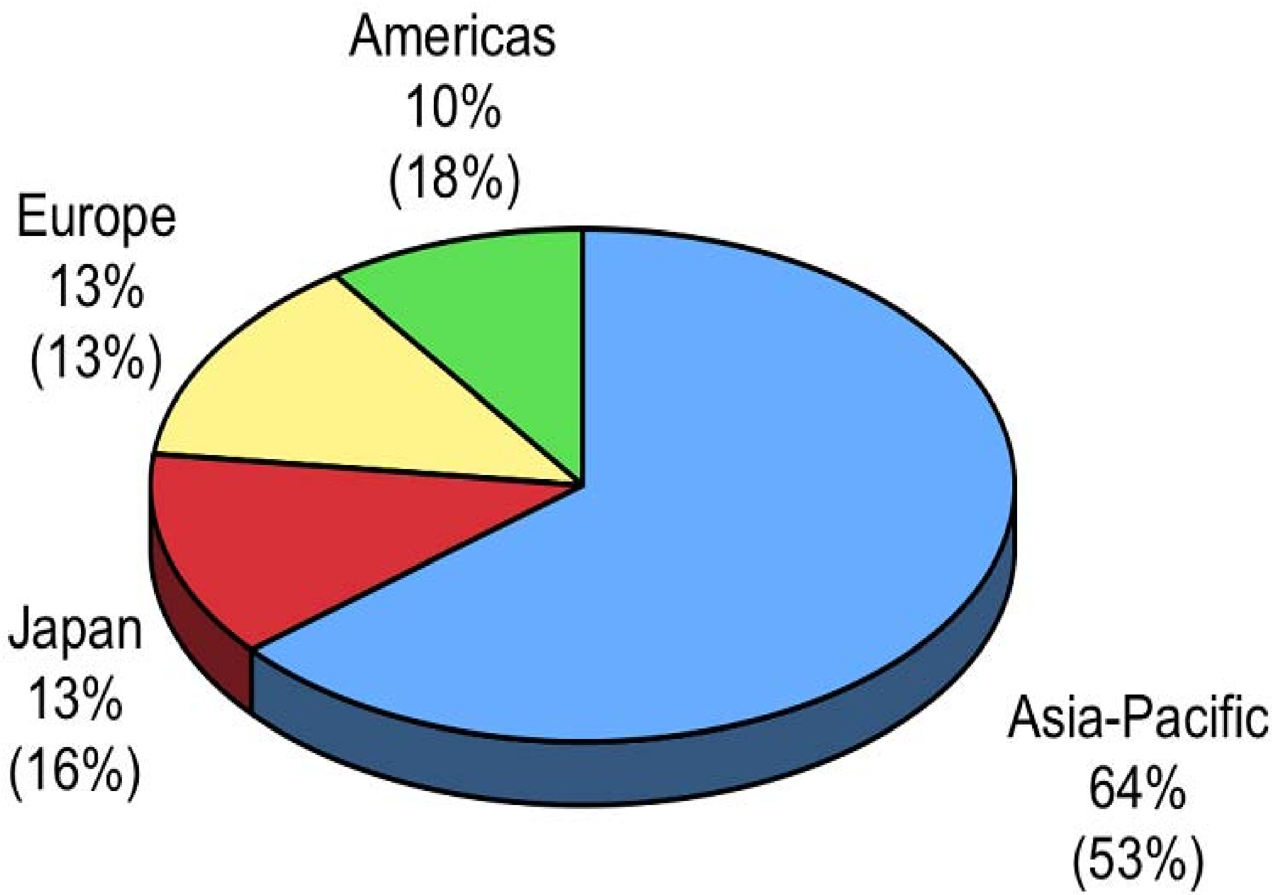
1999-2009 IC (Integrated Circuit) Industry Metrics

Category	1999	2008	2009	99-09 CAGR
IC Market (B)	$139.3	$219.4	$196.8	3.5%
IC Unit Volume Shipments (B)	70.0	159.0	147.2	7.7%
IC Average Selling Price	$1.99	$1.38	$1.34	-3.9%
Total IC Wafers* Started (M)	54.3	114.1	103.8	6.7%
IC Units Shipped per Wafer*	1,292	1,394	1,418	0.9%
IC Revenue per Wafer*	$2,565	$1,923	$1,896	-3.0%

*200mm Equiv.

Source: IC Insights

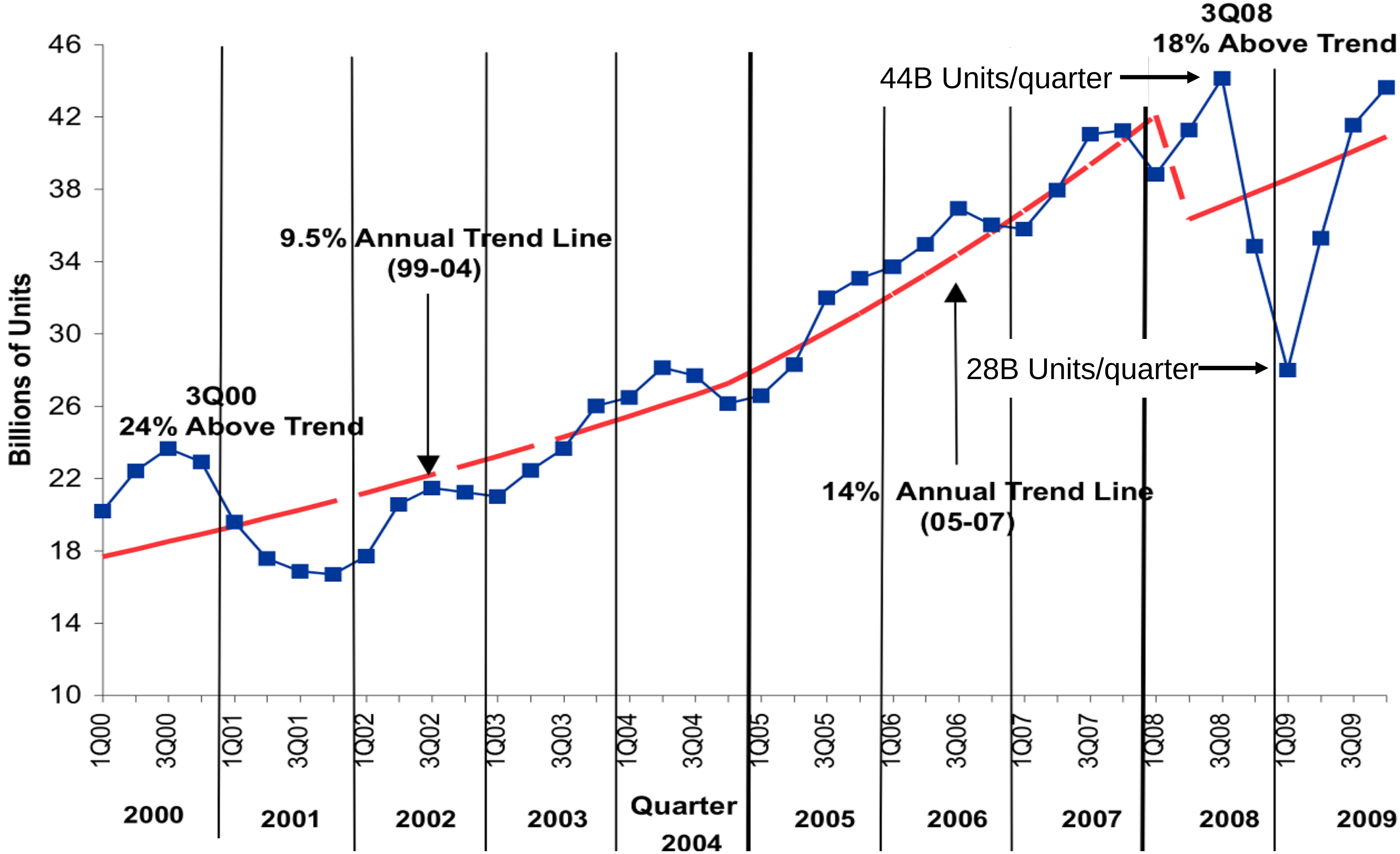
2009 IC Unit Consumption by Region (147.2B Units)



() = Share of $ Market in 2009

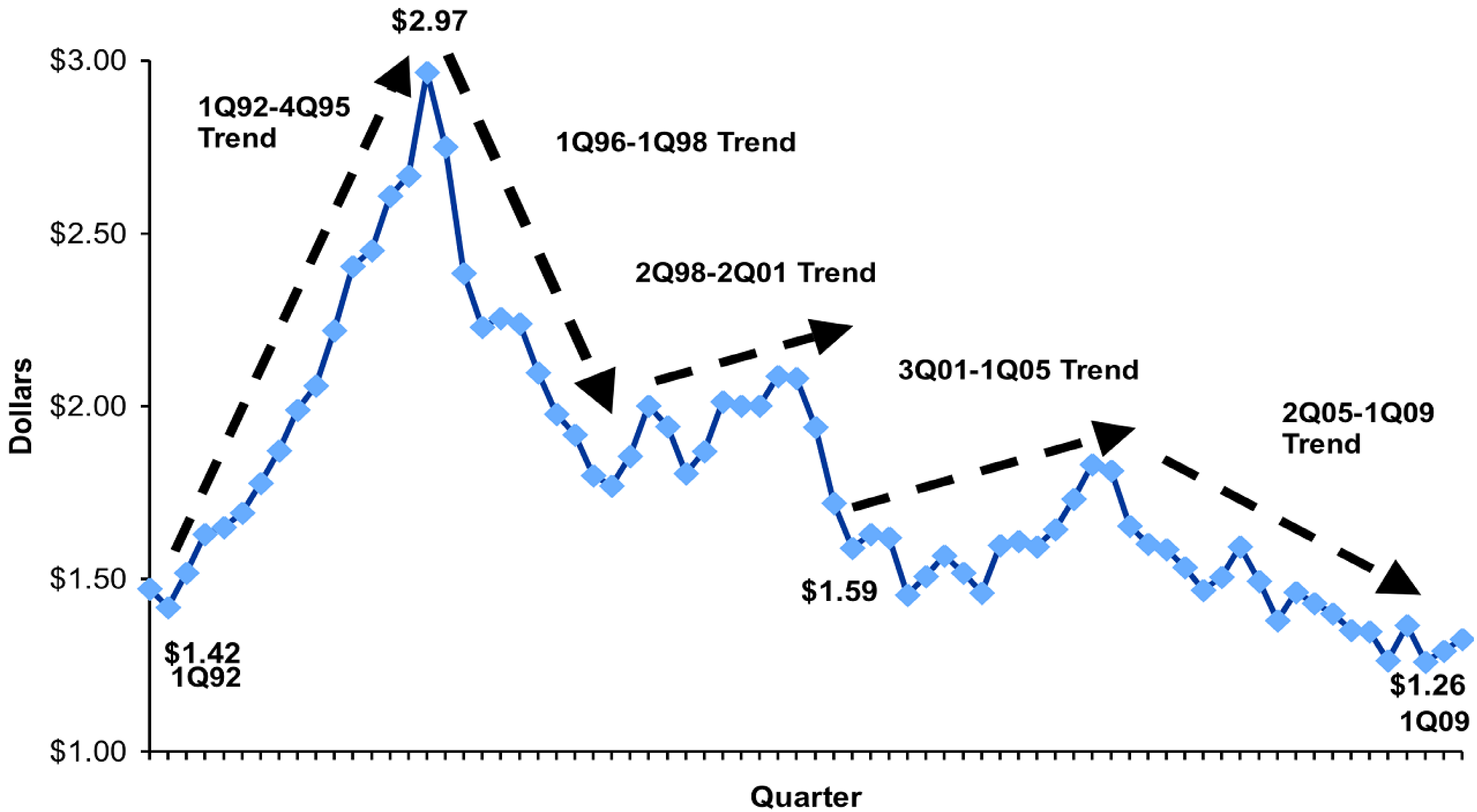
Source: IC Insights

2000-2009 Quarterly IC Unit Volume Shipment Trend



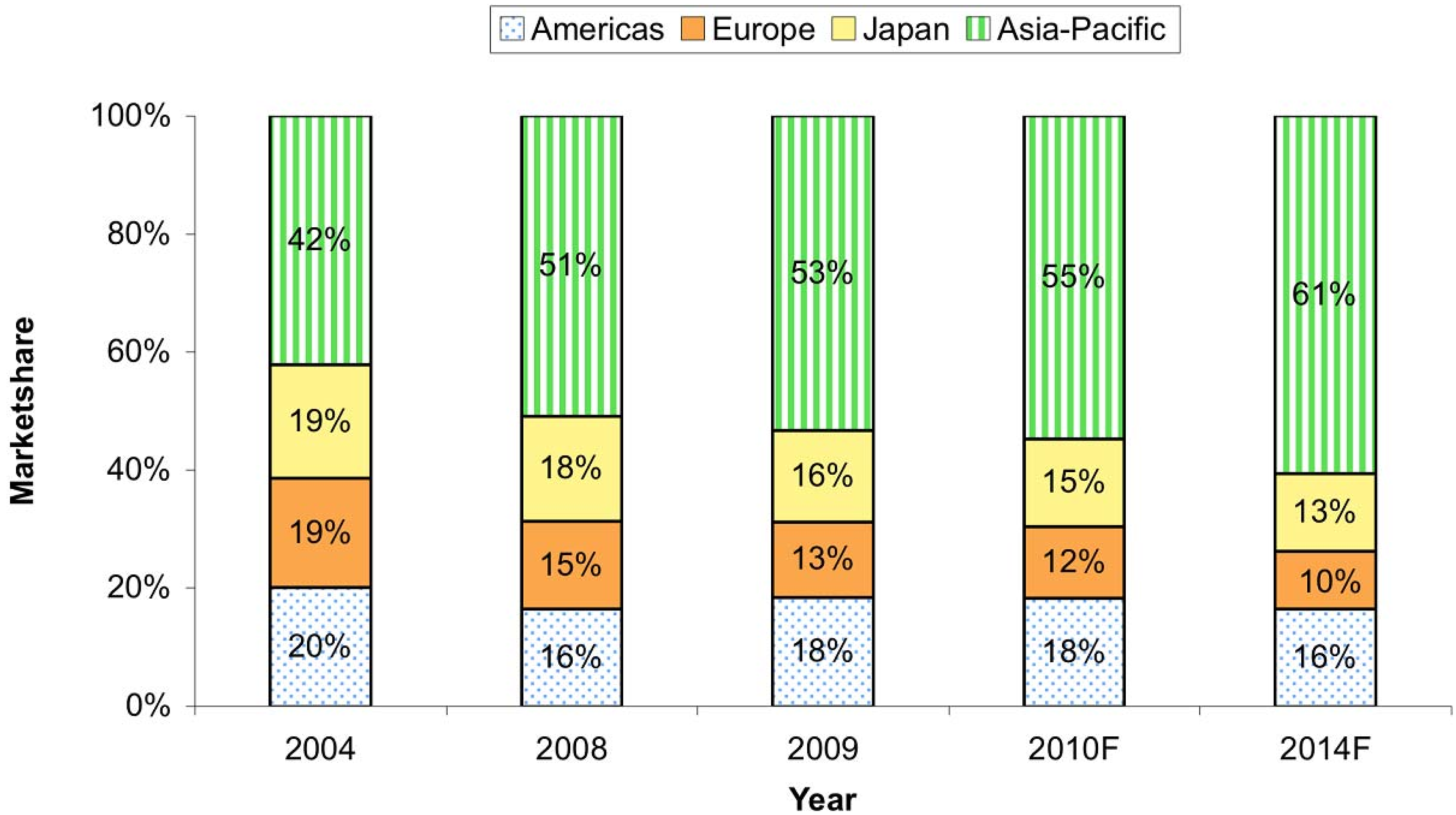
Source: WSTS, IC Insights

1992-2009 Quarterly IC ASP Trend



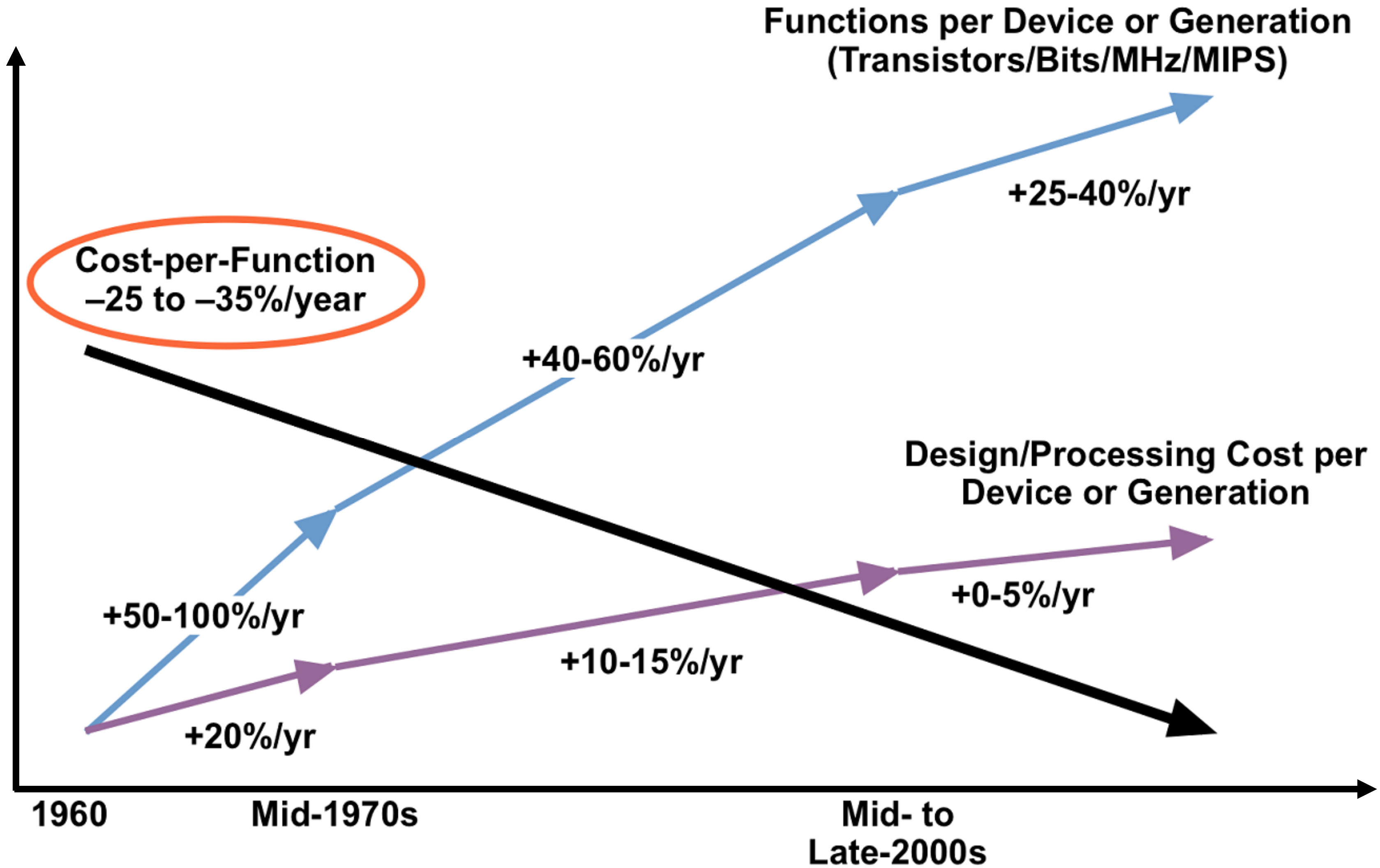
Source: WSTS, IC Insights

Worldwide IC Market by Region (2004-2014)



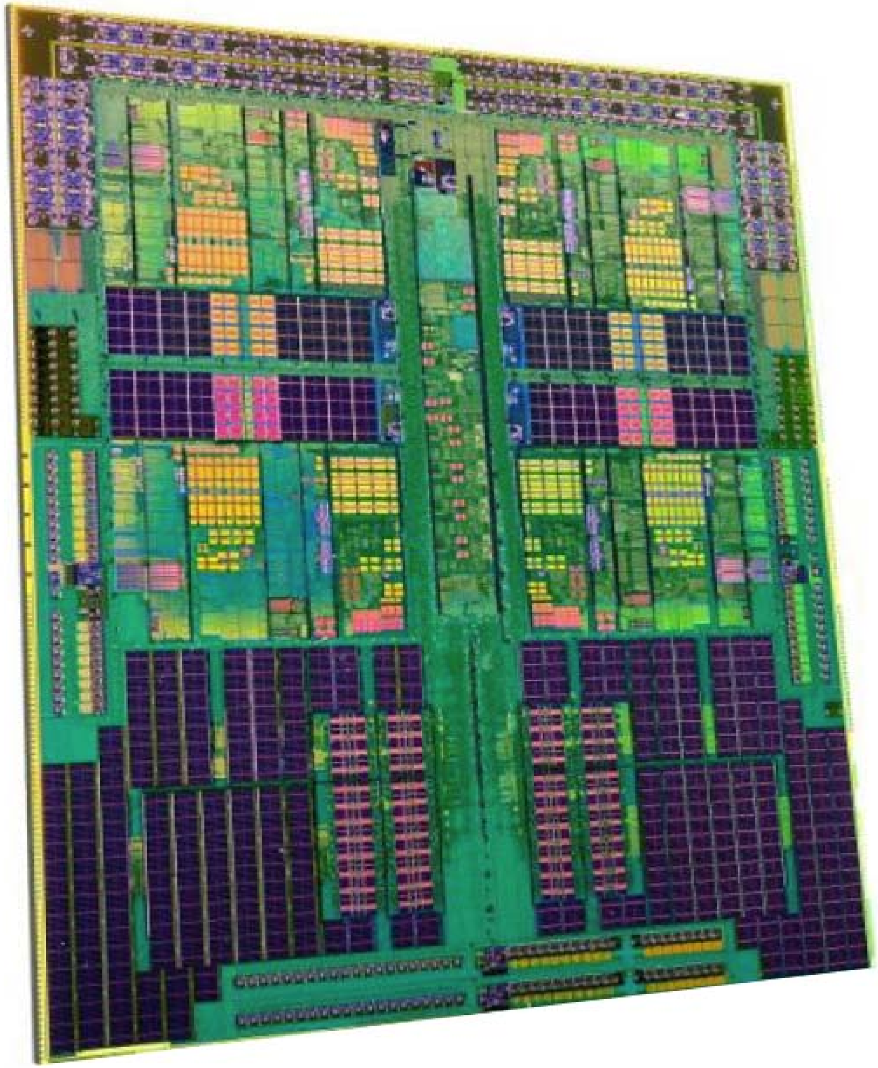
Source: IC Insights

Economic Engine that Drives the IC Industry



Source: IC Insights

AMD's 45nm Quad-Core PC Processor



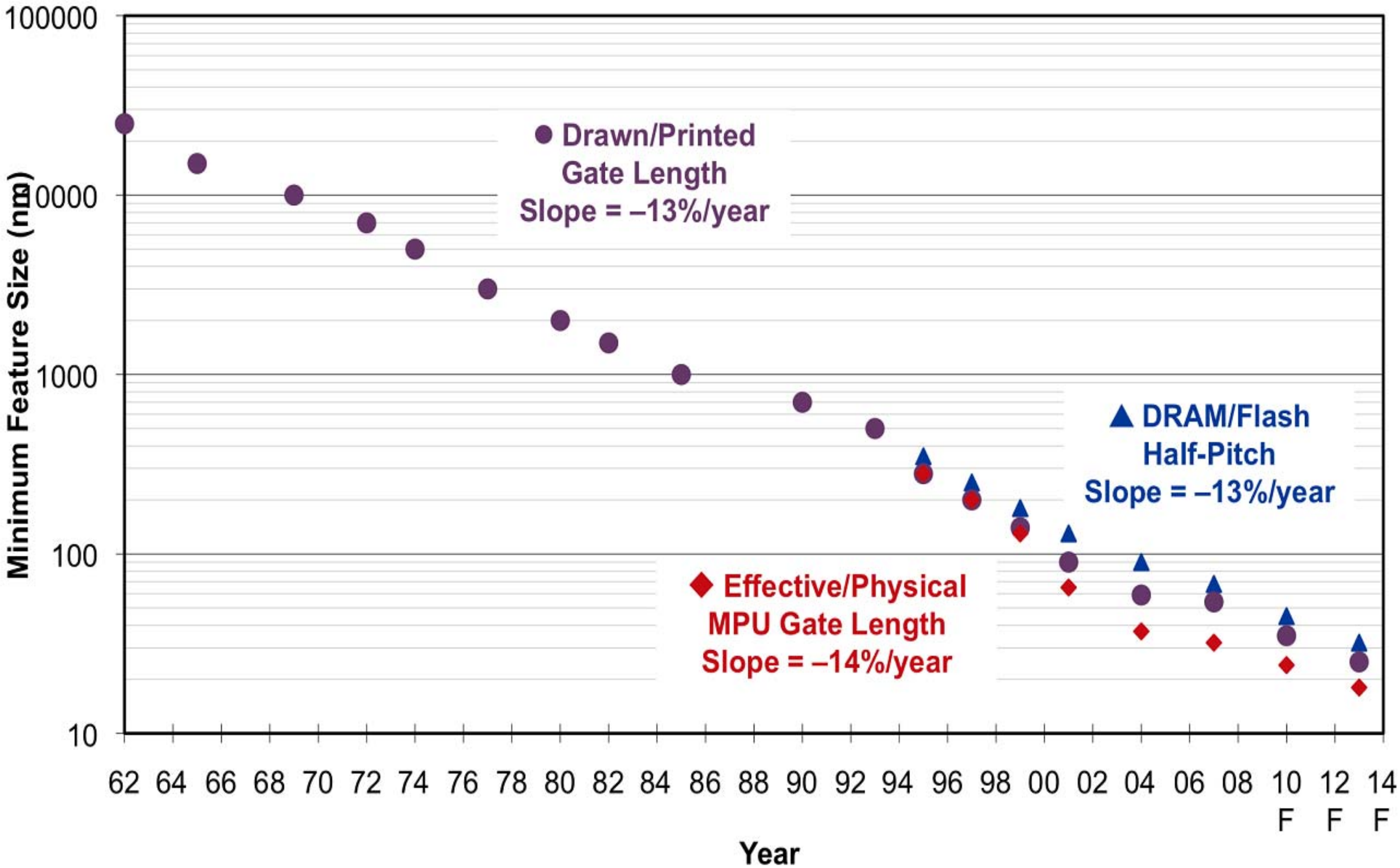
Phenom II X4 quad-core series ("Deneb")

- Architecture: K-10.5 (quad-core die)
- Process technology: 45nm SOI (developed with IBM)
- 2009 clock speeds: 2.4-3.4GHz
- Transistor count: 781 million
- Die size: 256mm^2
- L1 cache: 512KB (128KB per core)
- L2 cache: 2MB (512KB per core)
- L3 cache: 6MB shared
- Integrated memory controller (for DDR2 or DDR3 DRAM)
- AMD HyperTransport 3.0 Support
- Package: 1,207-contact flip-chip land grid array (LGA)

>>>actual size>>>

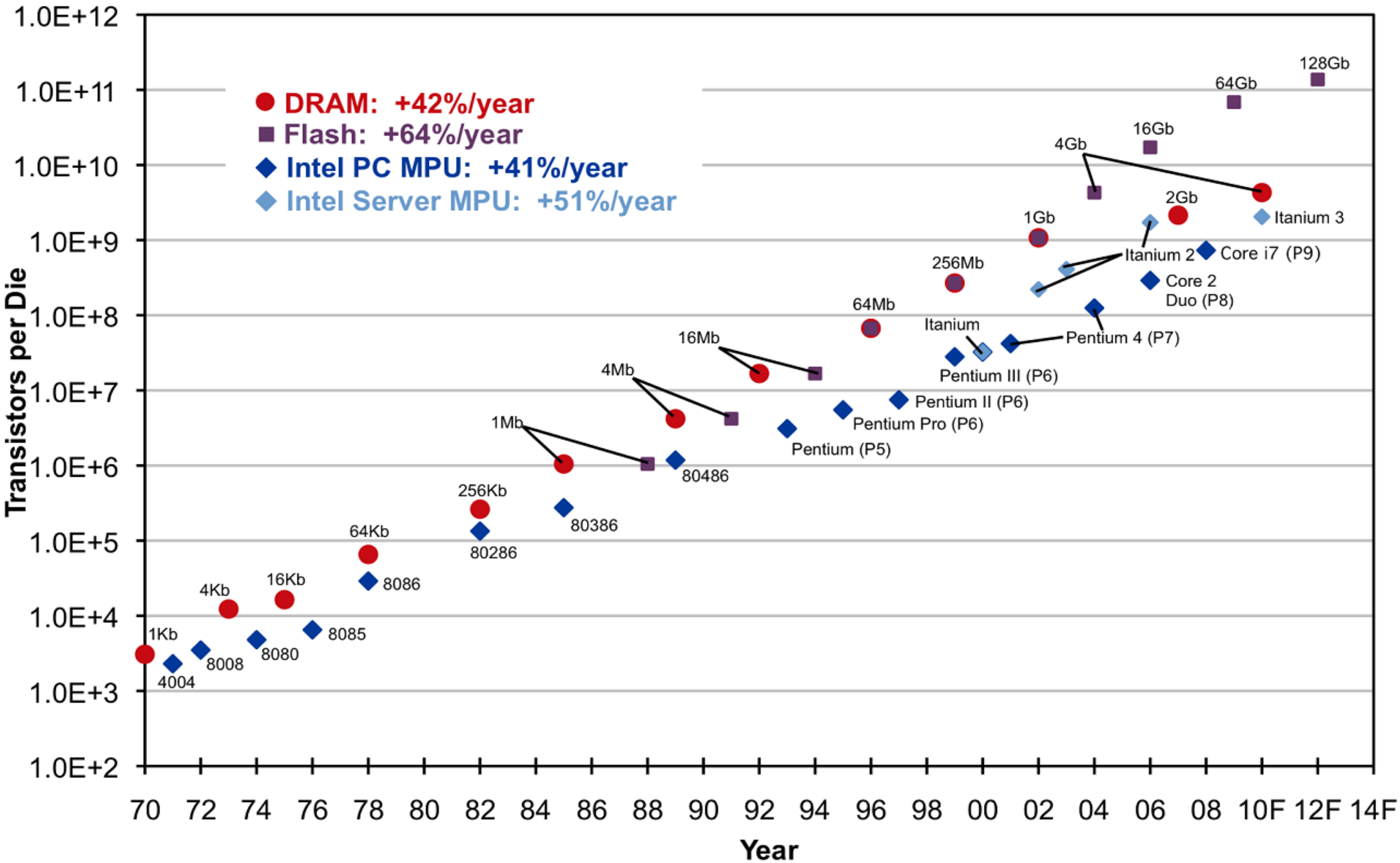
Source: Advanced Micro Devices

Minimum Device Feature Size Trends



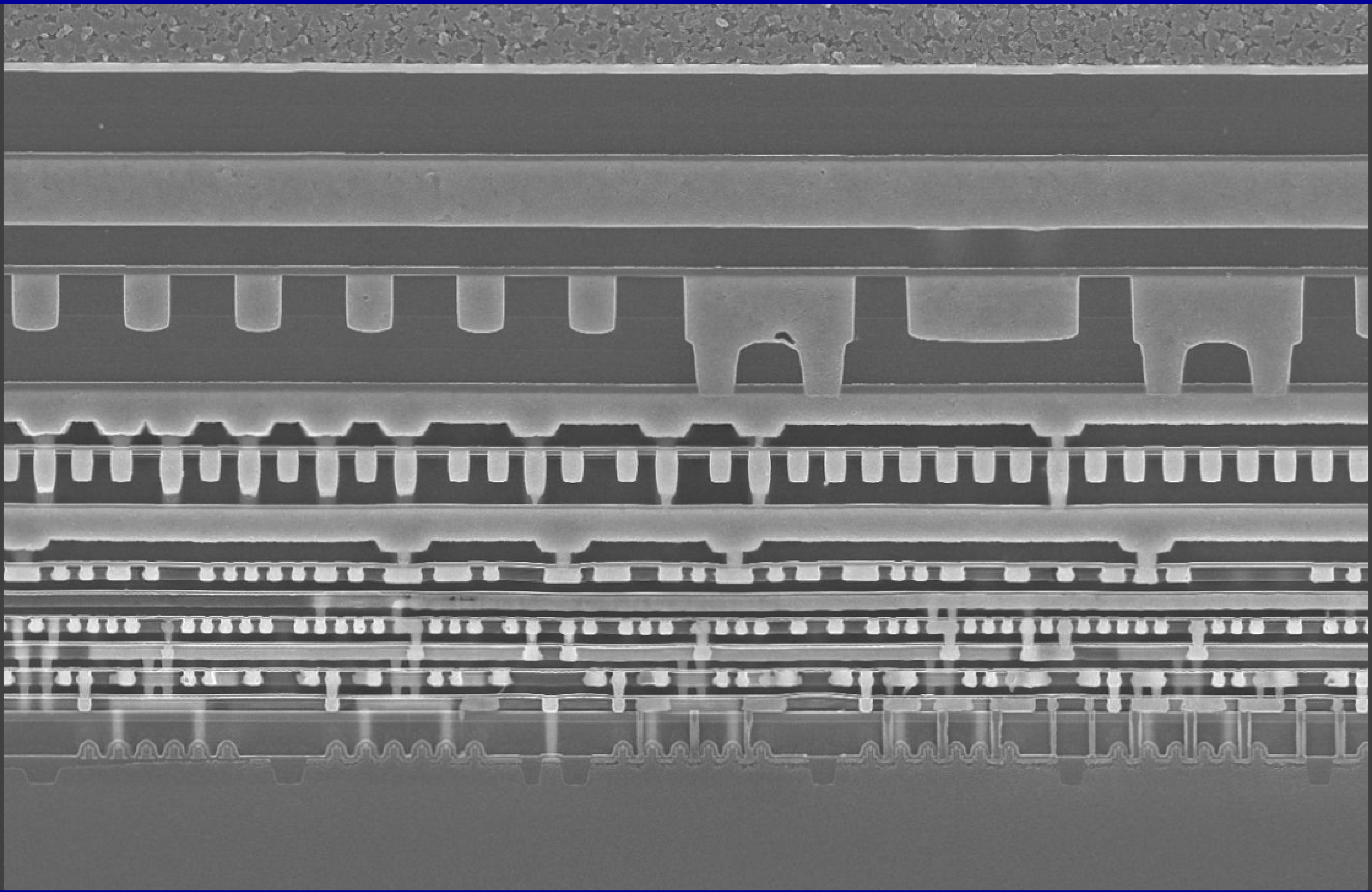
Source: Silicon Processing for the VLSI Era, ITRS 2008

Transistor Count Trends

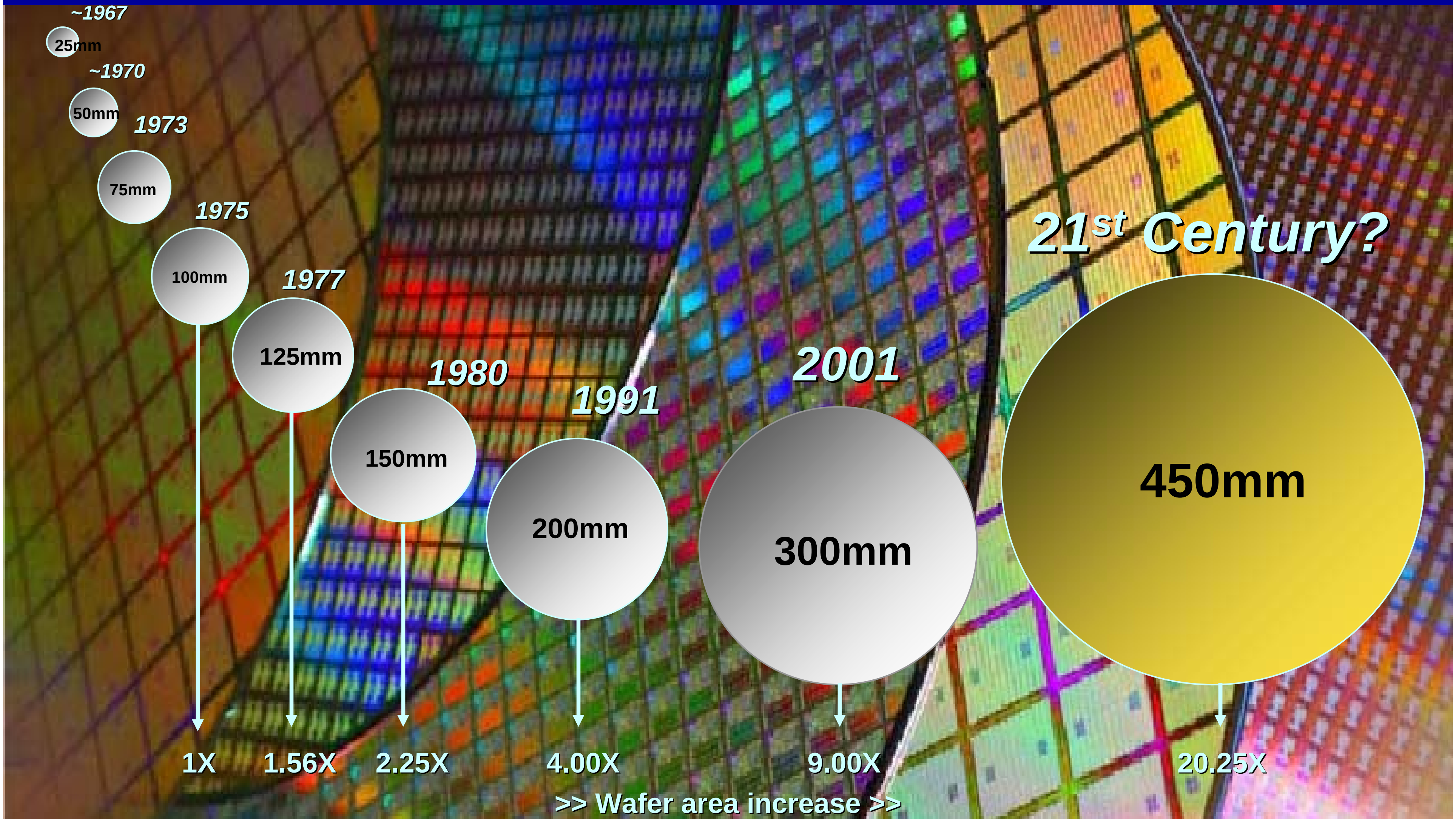


Source: SIA, Intel

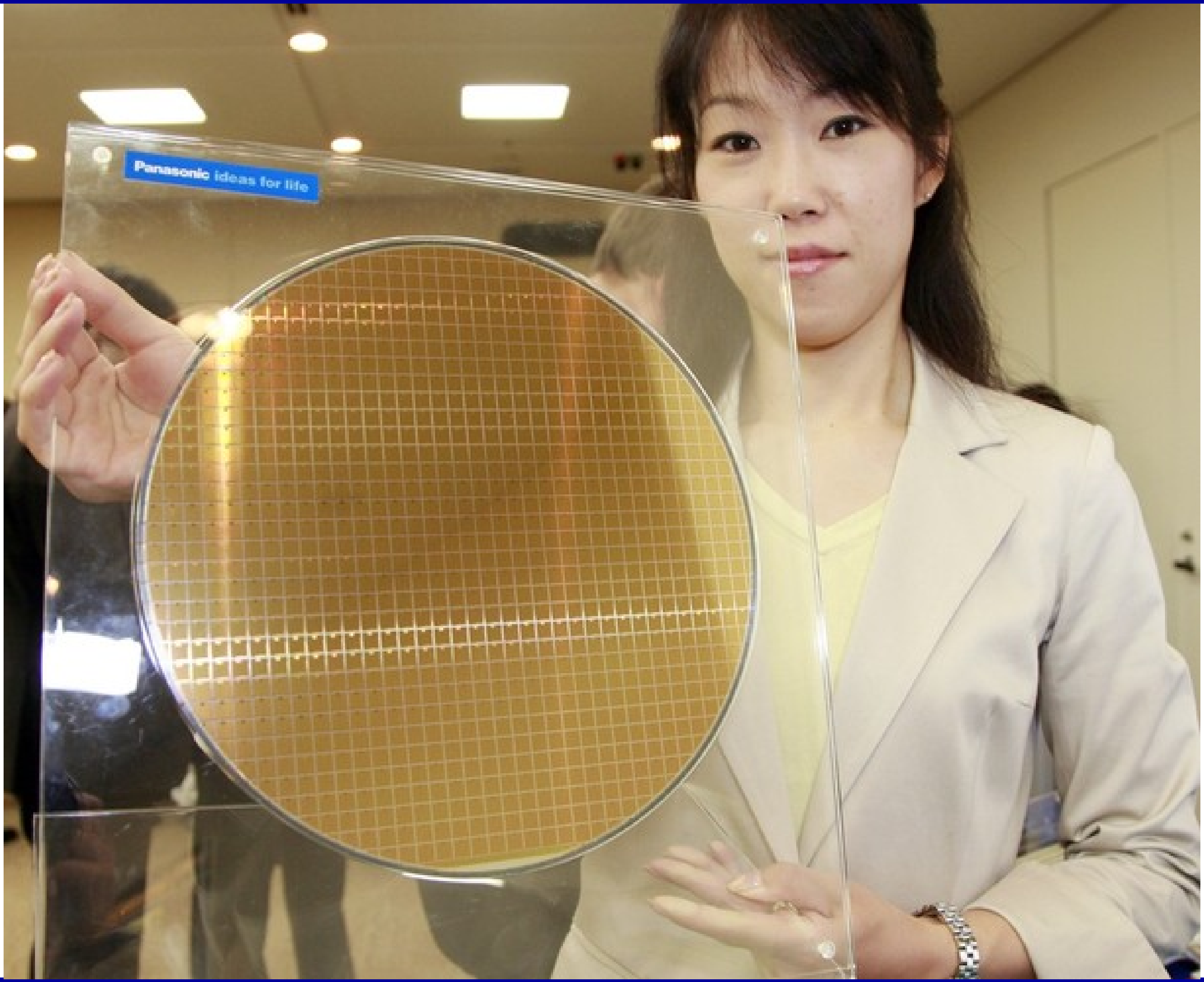
SEM Cross-Section of a Xilinx Virtex-5 FPGA



Progress in Silicon Wafer Substrates

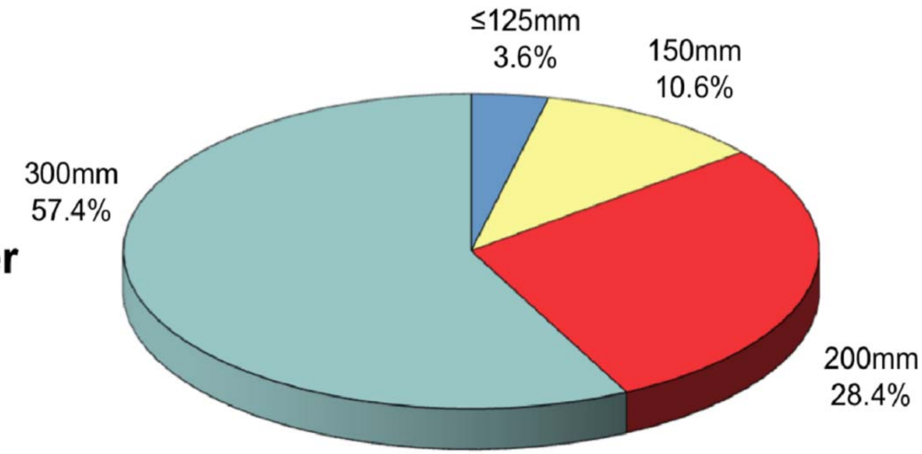


300mm Silicon Wafer Substrates

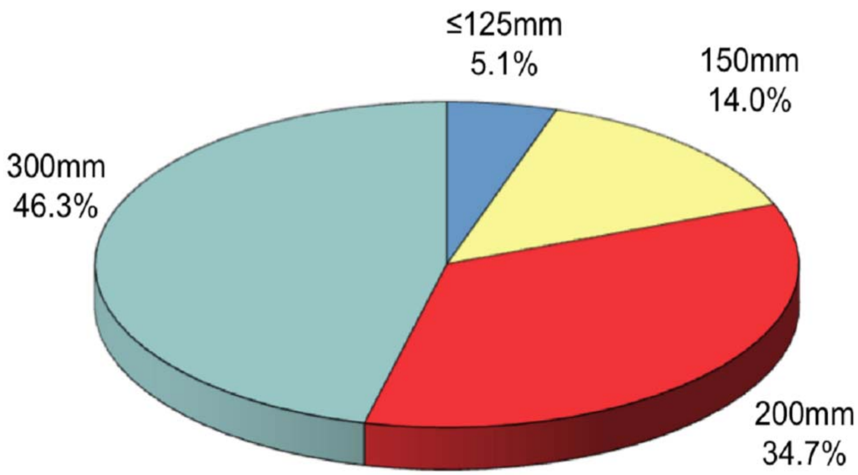


Silicon Wafer Shipments by Diameter

2014 Silicon Wafer Shipments by Diameter
(11.0 Billion Square Inches, Forecast)

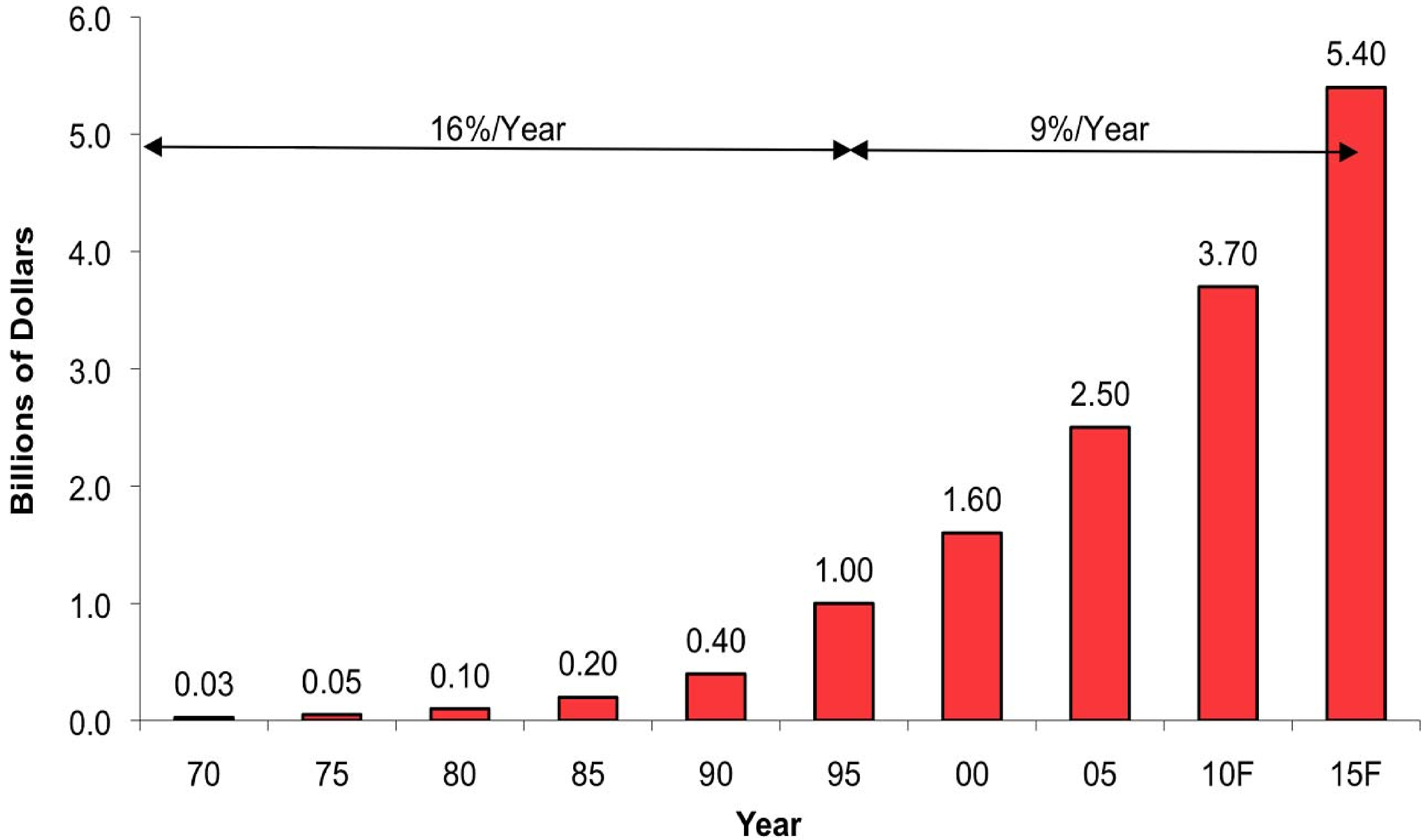


2009 Silicon Wafer Shipments by Diameter
(7.8 Billion Square Inches)



Source: IC Insights

Wafer FAB Cost Trend



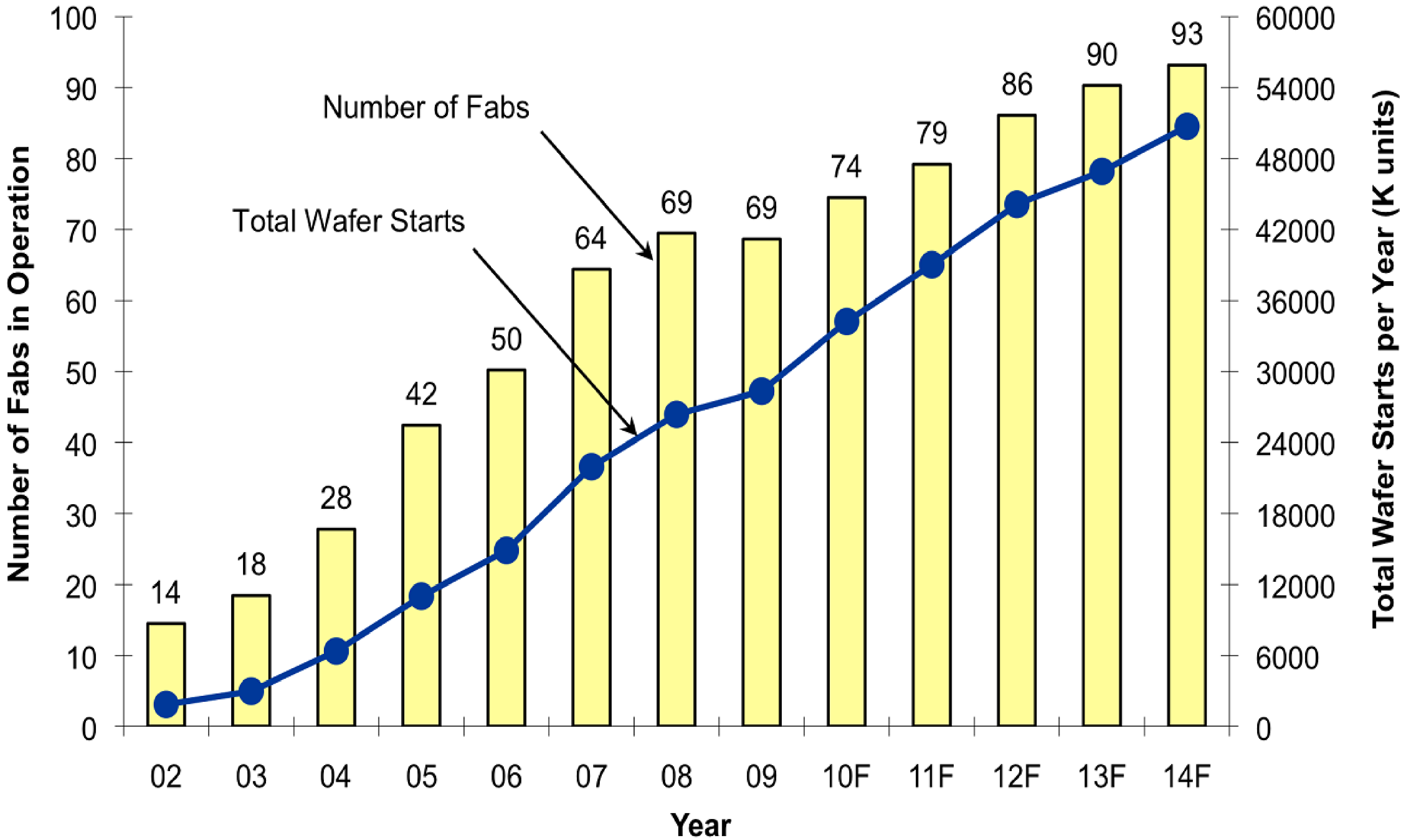
Source: IC Insights

300 mm Wafer Fab Indices

Fab Indices	Low End	Typical	High End	Unit
Wafer Diameter	300	300	300	mm
Line Width	100	70	30	nm
Number of Transistors per Chip	25	100	400	Million
Supply Voltage	1.0	0.8	0.5	Volt
Chip Size	35	50	100	mm2
Wafer Capacity	6,000	8,000	10,000	Wafers/week
Process Cycle Time	30	40	60	Days
Production Volume in Units		500		Million/year
Production Volume in Value	2	5	10	Billion $
Average Selling Price		10		$
Cost of Mask Set	0.6	1.0	2.0	Million $
Fab Investment	2	4	6	Billion $

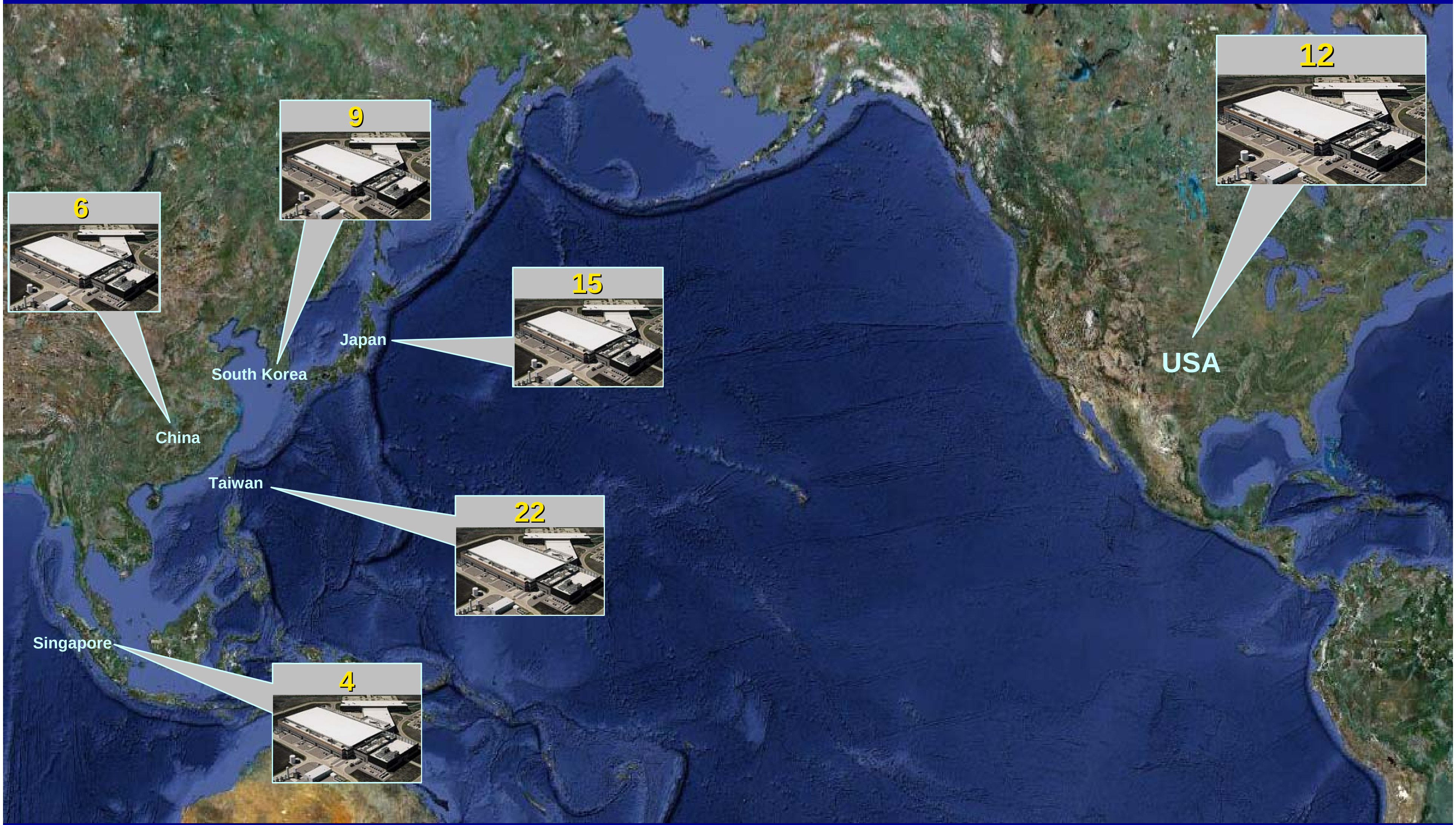
- **Increasingly higher mask costs require extremely high unit volumes to amortize costs**
- **Increasingly higher process complexities stretch process cycle times**

300mm Wafer Starts and Fab Count

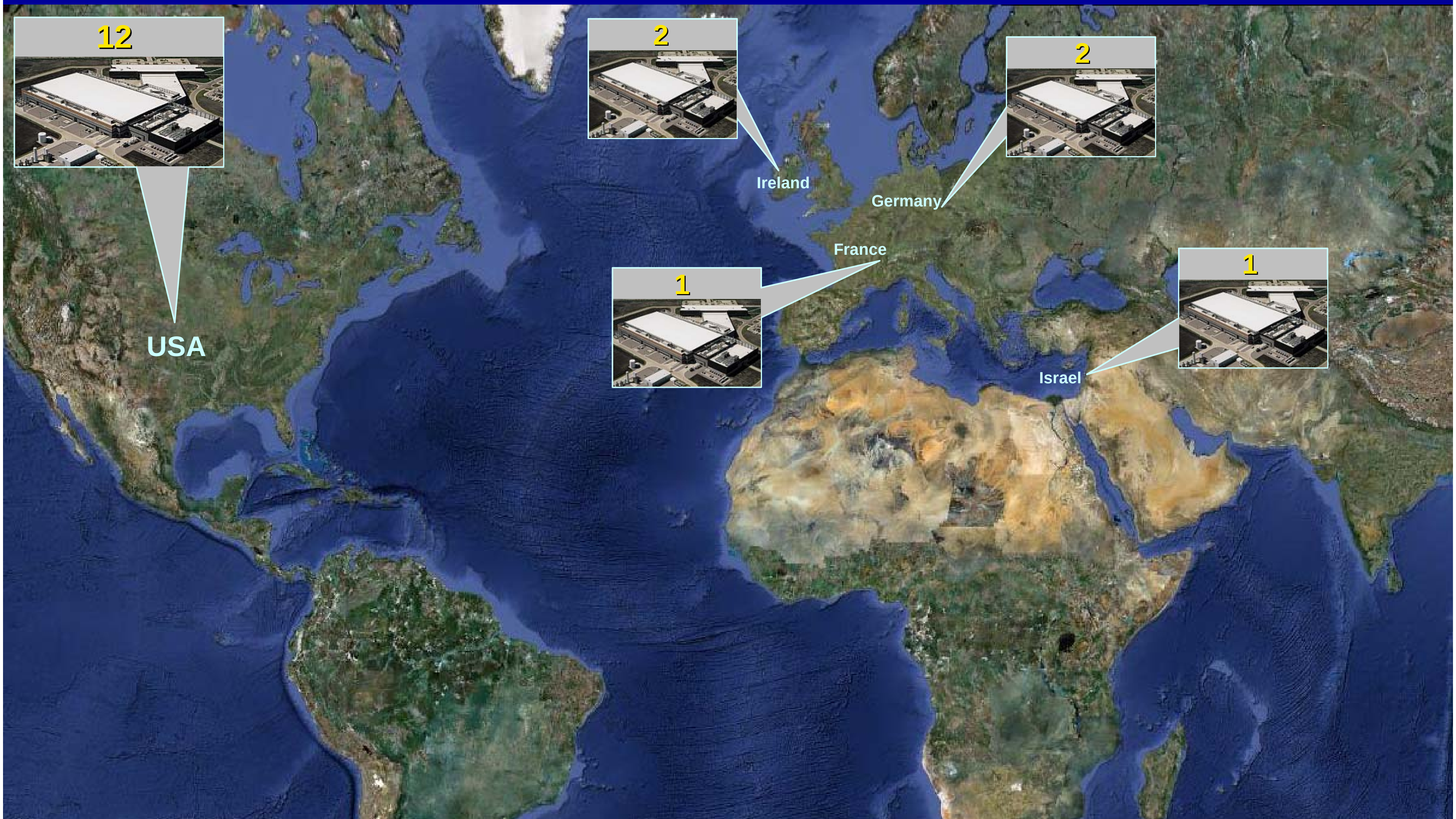


Source: IC Insights

300mm Wafer Fabs 2000-2010F



300mm Wafer Fabs 2000-2010F



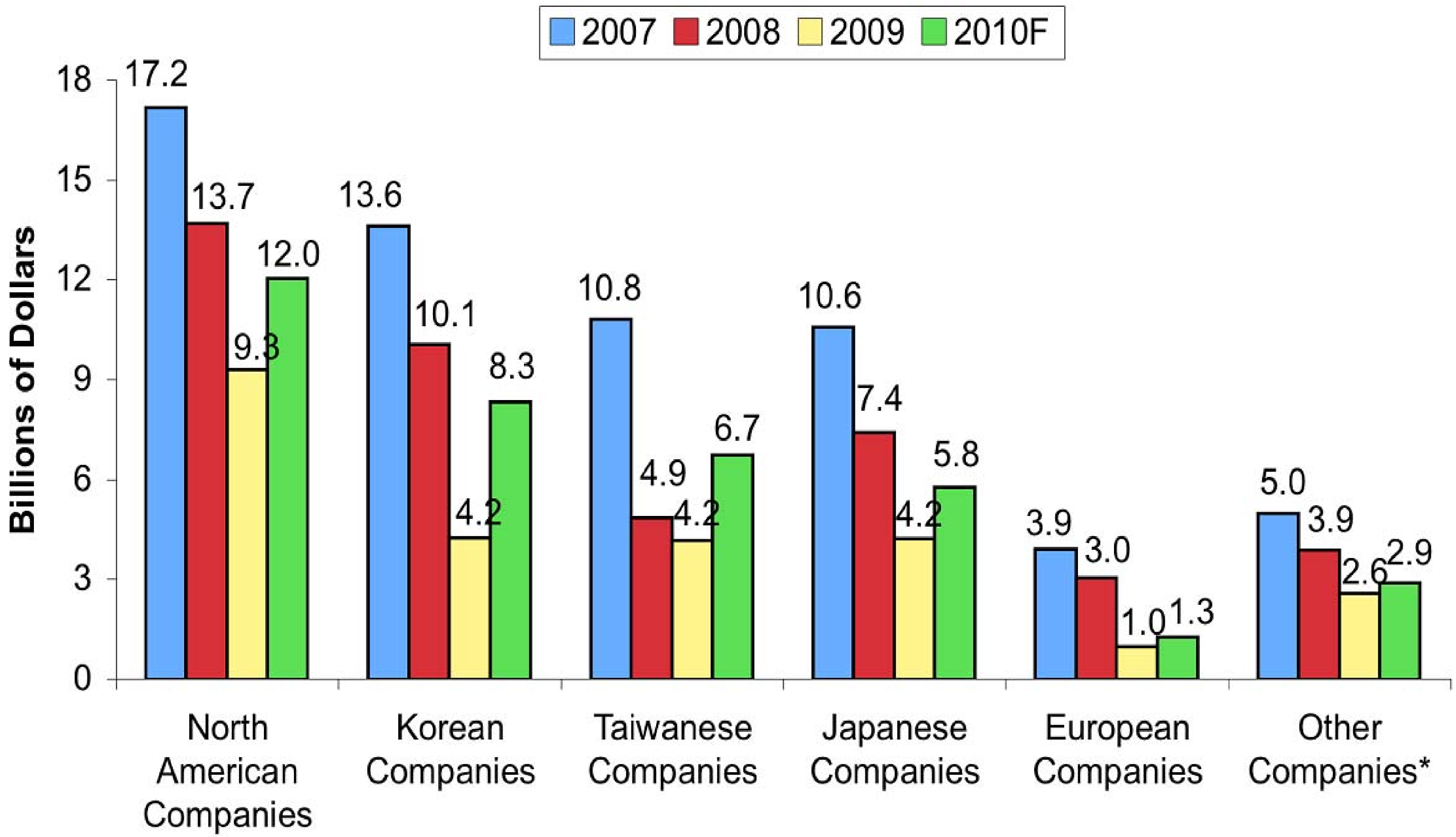
North America (U.S.)
300mm Frontend Semiconductor Fabs

Industrial™ Research Institute

Older Frontend Fabs Closed in 2009 or To Be Closed

IRI Online Library
www.iriweb.org

2007-2010F Capital Spending by Nationality



*Includes contract assembly and test houses

Source: IC Insights

10 Top Installed Wafer Capacity Leaders* (200mm-Equivalent Wafers per Month x1000)

2009 Rank	Company	Headquarters Region	Installed Capacity (K w/yr)	% of Worldwide Total
1	Samsung	Korea	12,395	9.6%
2	Toshiba/SanDisk	Japan	10,850	8.4%
3	Intel	Americas	10,500	8.2%
4	TSMC	Taiwan	9,955	7.7%
5	Micron	Americas	6,995	5.4%
6	Hynix	Korea	6,890	5.4%
7	ST	Europe	5,570	4.3%
8	Elpida	Japan	5,270	4.1%
9	UMC	Taiwan	4,850	3.8%
10	Nanya	Taiwan	3,770	2.9%
—	Total	—	77,045	60.0%

*Includes shares of capacity from joint ventures.

Source: IC Insights, Companies

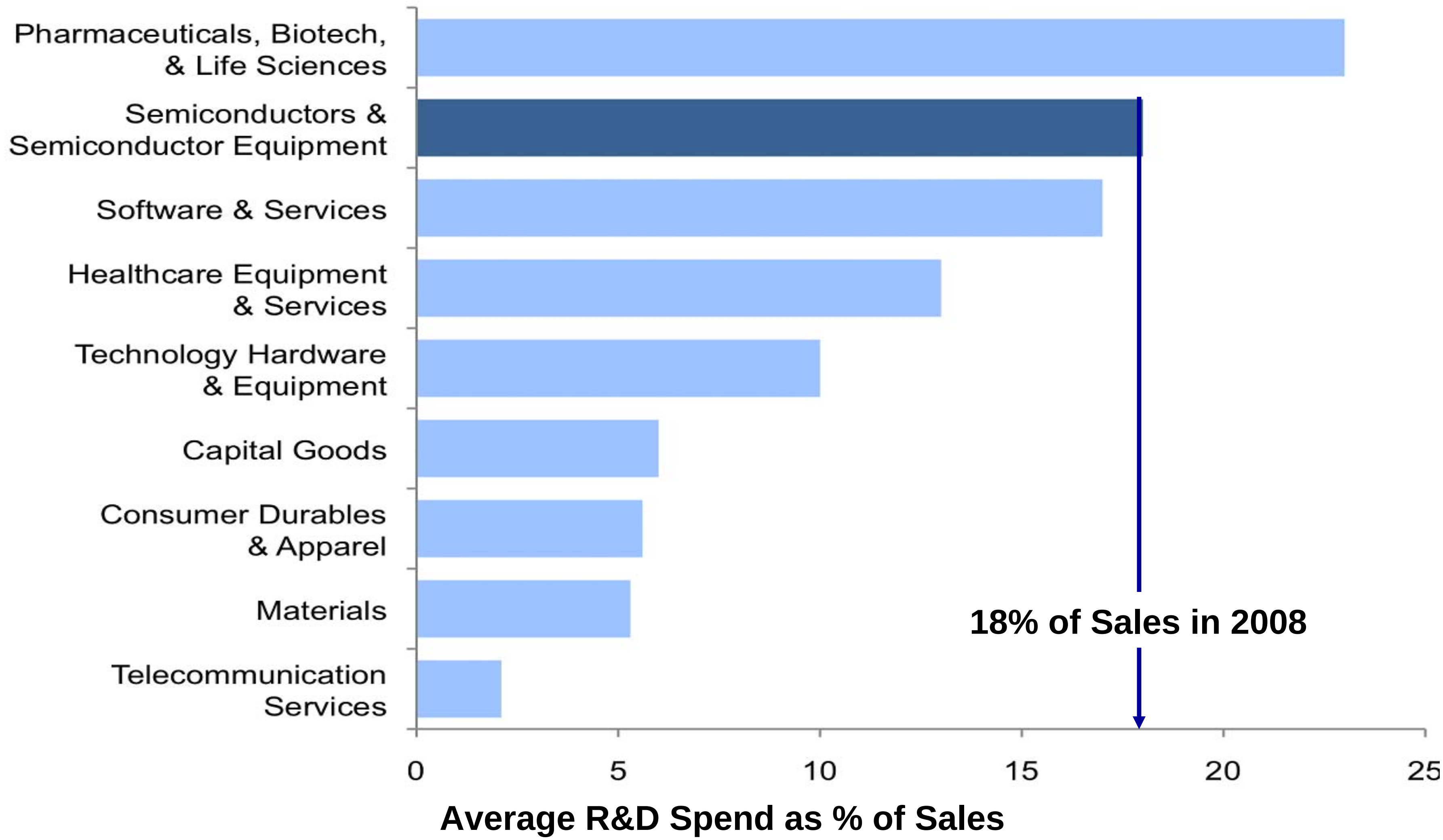
Major IC (Pure-Play) Foundries 2007-2009

2009 Rank	Company	Foundry Type	Location	2007 Sales ($M)	2008 Sales ($M)	08/07 Sales (%)	2009 Sales ($M)	09/08 Sales (%)
1	TSMC	Pure-Play	Taiwan	9,813	10,556	8%	8,989	-15%
2	UMC	Pure-Play	Taiwan	3,430	3,070	-10%	2,815	-8%
3	Chartered*	Pure-Play	U.S.	1,458	1,743	20%	1,540	-12%
4	SMIC	Pure-Play	China	1,550	1,353	-13%	1,075	-21%
5	GlobalFoundries	Pure-Play	U.S.	0	0	N/A	1,065	N/A
6	Dongbu	Pure-Play	South Korea	510	490	-4%	395	-19%
7	Vanguard	Pure-Play	Taiwan	486	511	5%	382	-25%
8	IBM	IDM	U.S.	570	400	-30%	335	-16%
9	Samsung	IDM	South Korea	355	370	4%	325	-12%
10	Grace	Pure-Play	China	310	335	8%	310	-7%
11	He Jian	Pure-Play	China	330	345	5%	305	-12%
12	Tower**	Pure-Play	Europe	231	252	9%	292	16%
13	HHNEC	Pure-Play	China	335	350	4%	290	-17%
14	SSMC	Pure-Play	Singapore	350	340	-3%	280	-18%
15	TI	IDM	U.S.	450	315	-30%	250	-21%
16	X-Fab	Pure-Play	Europe	410	368	-10%	223	-39%
17	MagnaChip	IDM	South Korea	322	290	-10%	220	-24%

*Purchased by GlobalFoundries in 4Q09.
**Tower bought Jazz in 2008.

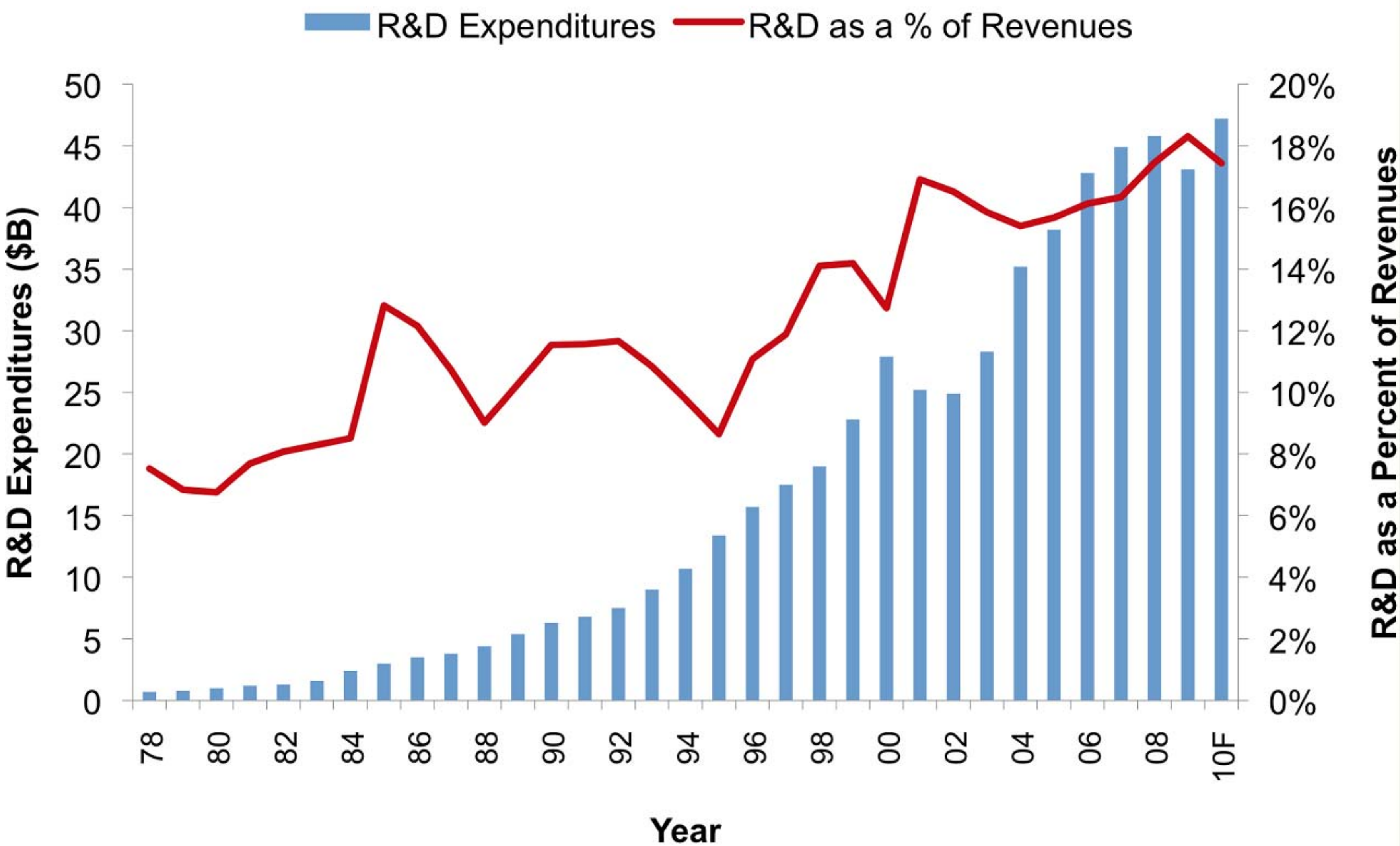
Source: IC Insights, company reports

Semiconductor Industry One of Top R&D Spenders



Source: IEEE Spectrum/Standard & Poor's

Industry R&D Costs Move Higher



Source: IC Insights

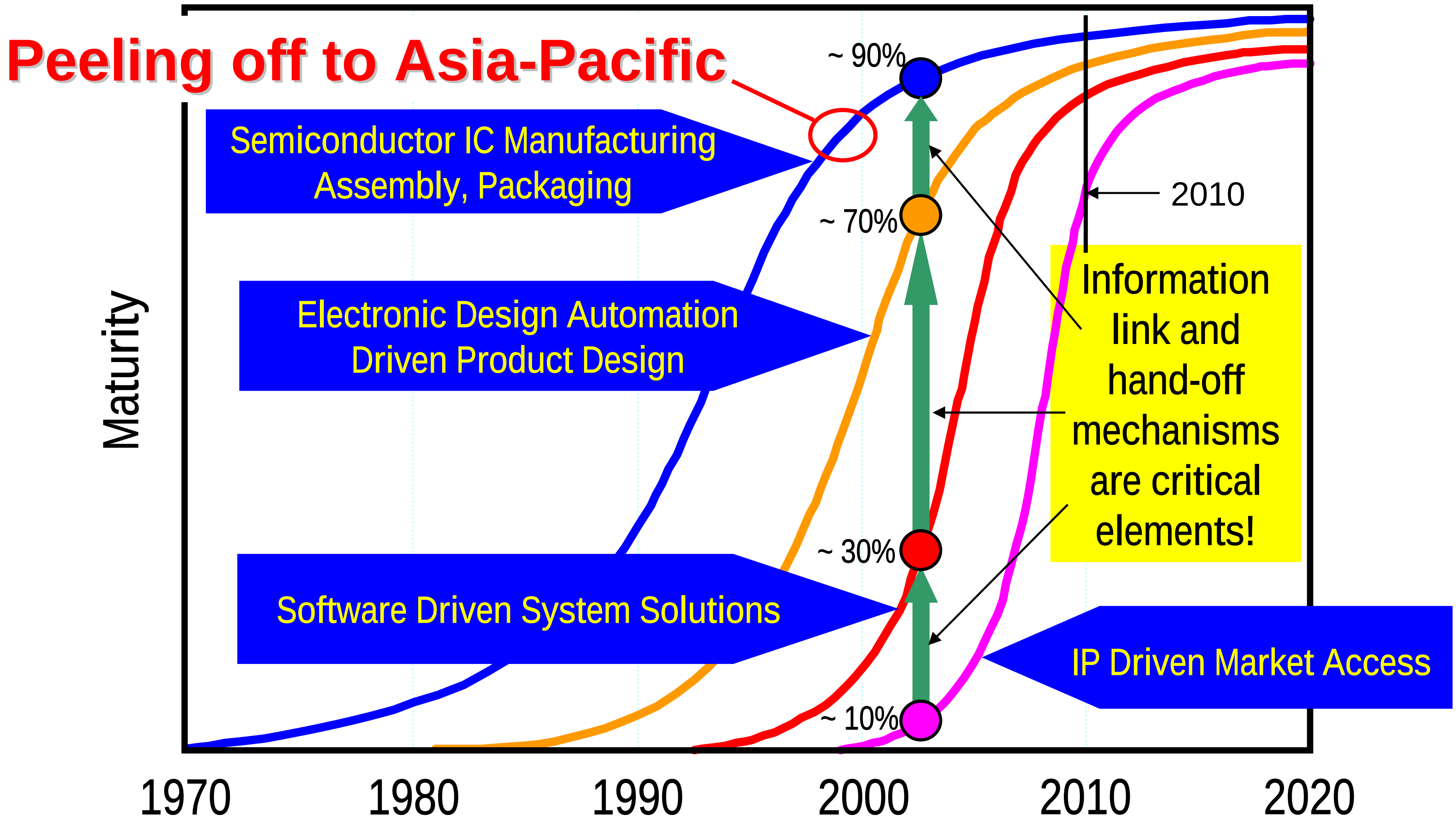
2009 Worldwide Semiconductor R&D Spending (Companies with >$800M in Spending)

2009 Rank	2008 Rank	Company	Region	2008 Sales ($M)	2008 R&D ($M)	R&D/ Sales	2009 Sales ($M)	2009 R&D ($M)	R&D/ Sales
1	1	Intel	Americas	34,490	5,722	17%	31,900	5,590	18%
2	3	STMicroelectronics	Europe	9,842	2,152	22%	8,346	2,317	28%
3	2	Samsung	Asia-Pacific	20,272	2,310	11%	21,065	2,185	10%
4	6	AMD*	Americas	5,808	1,848	32%	5,252	1,748	33%
5	5	Toshiba	Japan	10,422	1,890	18%	10,640	1,725	16%
6	4	TI	Americas	11,618	1,940	17%	9,682	1,550	16%
7	7	Broadcom*	Americas	4,509	1,498	33%	4,188	1,530	37%
8	8	Qualcomm*	Americas	6,477	1,420	22%	6,586	1,520	23%
9	10	Renesas Technology	Japan	7,017	1,190	17%	5,878	1,060	18%
10	15	Nvidia*	Americas	3,660	915	25%	3,133	905	29%
—	—	**Top 10 Total**	—	114,115	20,885	18.3%	106,670	20,130	18.9%
11	13	NEC	Japan	5,732	1,056	18%	4,357	870	20%
12	11	Freescale	Americas	4,959	1,140	23%	3,312	865	26%
13	14	Marvell*	Americas	3,055	930	30%	2,700	835	31%

*Fabless

Source: IC Insights, Vendors

Semiconductor Industry Productivity Drivers
- Four Maturity Curve Linkage -



Semiconductor Associated Sciences and R&D

Natural sciences:
- Chemistry
- Physics
- Environmental sciences

Formal sciences:
- Computer sciences
- Mathematics
- Statistics
- Systems science

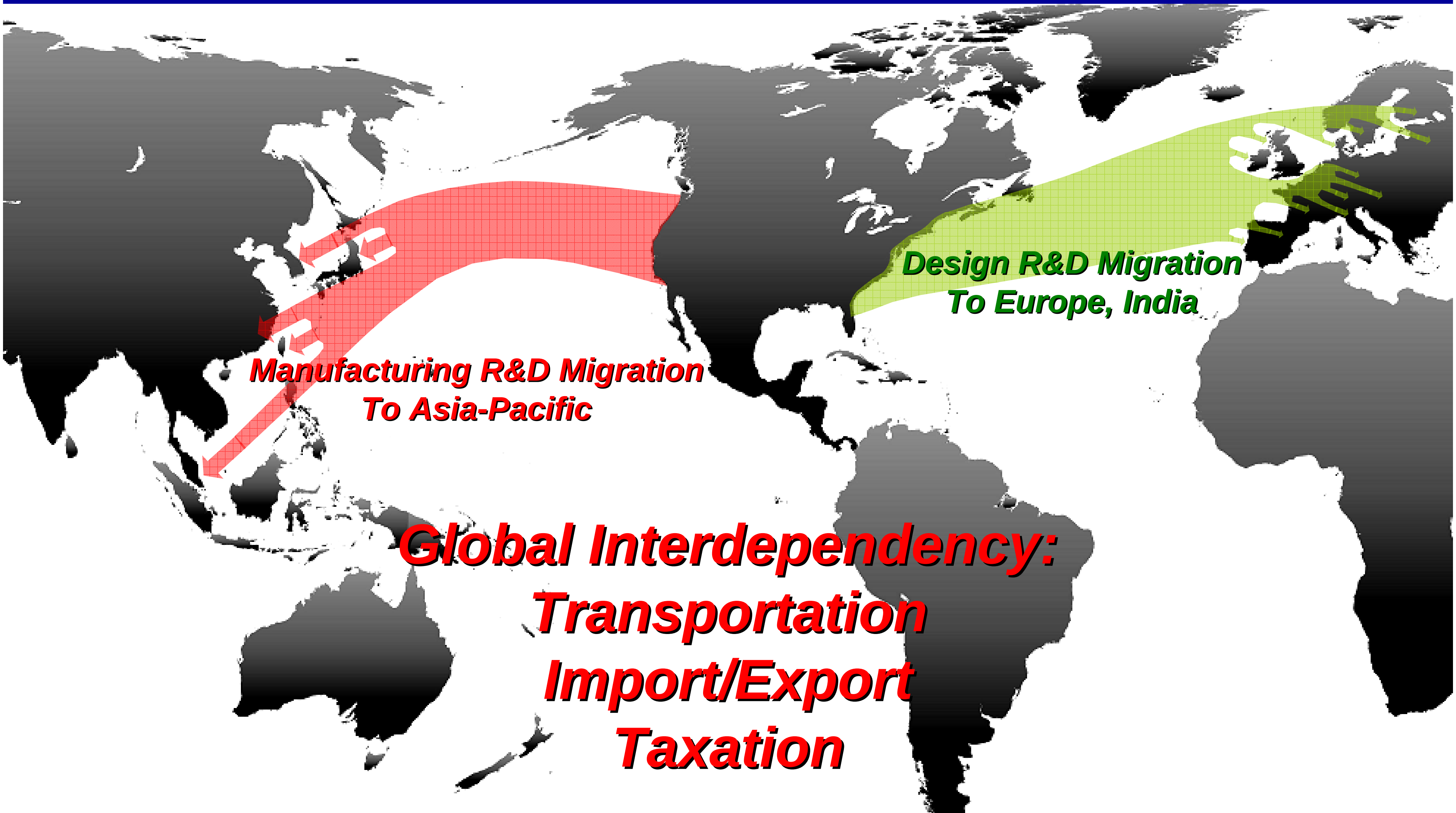
Social sciences:
- Economics

Applied sciences:
- Technology Architecture
- Engineering
- Health sciences
- Management

Engineering:
- Chemical engineering
- Computer engineering
- Control engineering
- Electrical engineering
- Industrial engineering
- Materials engineering
- Mechanical engineering
- Physical engineering
- Software engineering
- Systems engineering

Management:
- Accounting
- Business Strategy
- Finance Marketing
- Operations
- Organizational

Semiconductor Industry R&D Migration



Semiconductor Process R&D Issues

- Wafer manufacturing process related R&D must be conducted in manufacturing environments
- Semiconductor process R&D activities migrate to countries in which new fabrication lines are established:
  - Taiwan
  - Japan
  - South Korea
  - Singapore
  - China
  - Malaysia

Semiconductor Design R&D Issues

- Semiconductor product design related R&D is not bound to the location of manufacturing sites
- Design R&D can be established wherever highly skilled resources exist
- Concerns that a high percentage of the U.S. semiconductor industry's design R&D is also migrating to other countries
- High quality, low cost design R&D talent exists in:

  India, Brazil, Russia, Israel, Romania, several Eastern Europe countries, various design R&D locations in China

What Can Semiconductor Companies Do?

- It is not obvious which counter-measures individual semiconductor companies can take by themselves to drive company decisions for R&D and manufacturing investments in the U.S.
- Several public policies have to work in concert to create an environment that:
  - Attracts capital intensive semiconductor manufacturing operations
  - Creates incentives for developing the necessary research and engineering talent base required to sustain the semiconductor industry in the U.S.
- Seriously assess all opportunities to restore semiconductor R&D and manufacturing in the U.S.

What Can U.S. Policy Makers Do?

- Foreign governments have implemented tax and investment incentives that have resulted in major semiconductor investment and R&D job creation opportunities in their regions; copy them!
- U.S. policy makers must recognize the need for:
  - Tax and investment incentive policies
  - Government R&D funding for advanced science and technology
  - Education and technical training for a first-class workforce
  - Immigration policies for foreign top talent and strategic infrastructure
- The key to future U.S. innovation is to ensure that U.S. policies are at least as competitive as those of our trading partners

We Do Not Have To Go Down That Road Again!