Exponential Trends in the Integrated Circuit Industry

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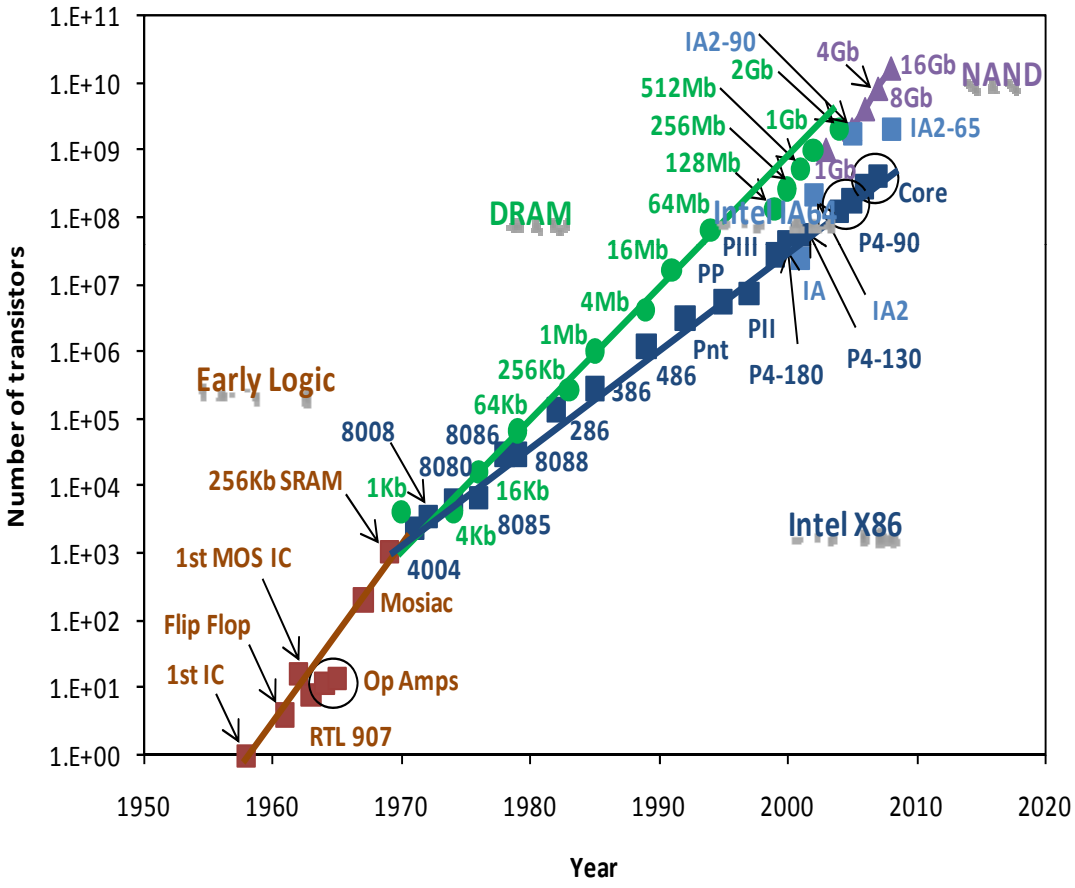
Moore’s Law

In 1965, Gordon Moore, director of research and development at Fairchild Semiconductor wrote a paper for Electronics entitled “Cramming more components onto integrated circuits”. In the paper Moore observed that “The complexity for minimum component cost has increased at a rate of roughly a factor of two per year”. This observation became known as Moore's law. Moore's law was later amended to, the number of components per IC doubles every 18 - 24 months.



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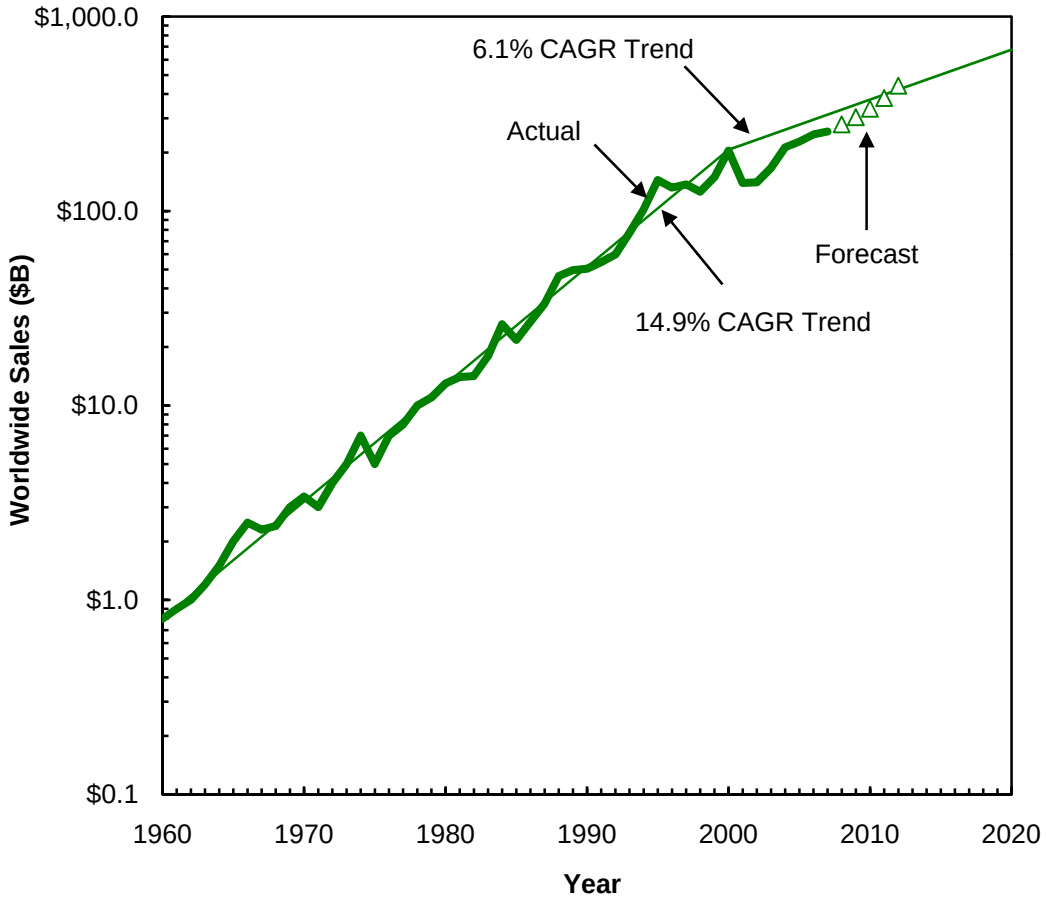
Revenue

Driven by Moore's law and the continually increasing power of the integrated circuit, the worldwide revenue for semiconductors grew at almost 15% per year from 1960 until 2000. More recently the industry has begun to mature growing at approximately 6% per year.



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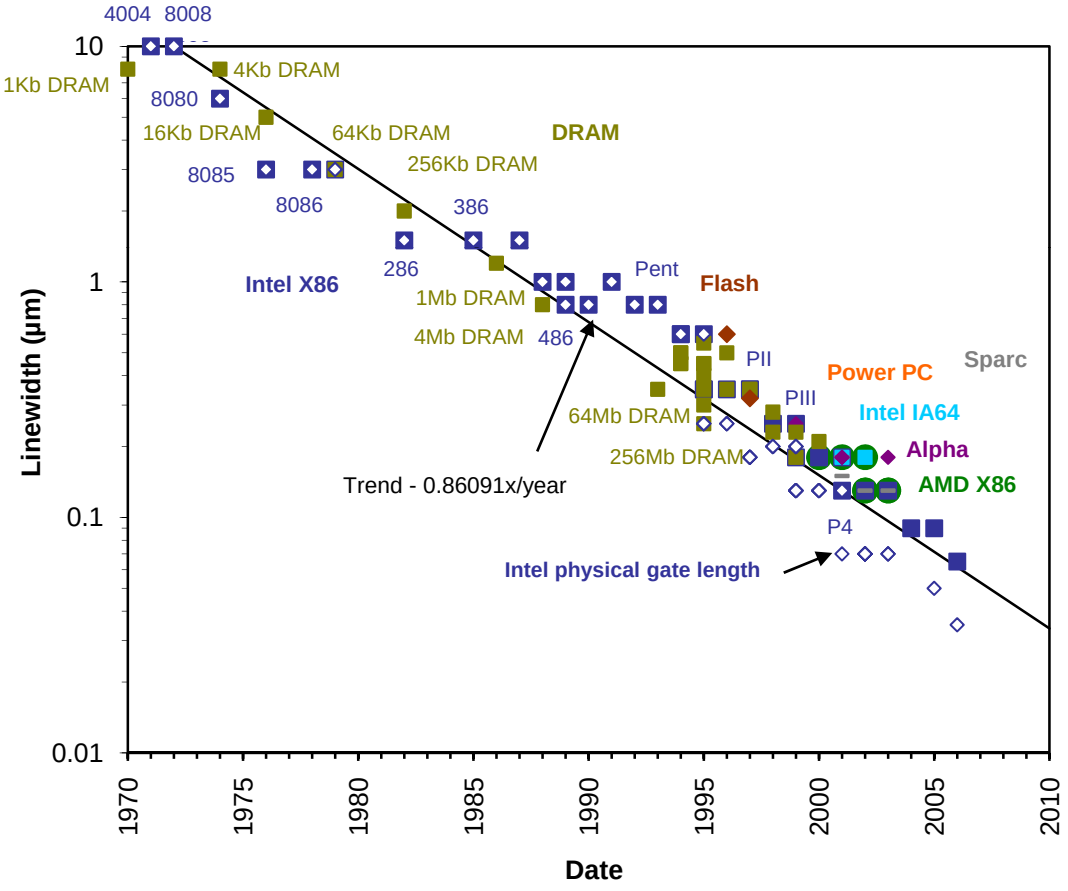
Linewidths

One of the key drivers behind the industries ability to double transistor counts every 18 to 24 months, is the continuous reduction in linewidths. Shrinking linewidths not only enables more components to fit onto an IC (typically 2x per linewidth generation) but also lower costs (typically 30% per linewidth generation).



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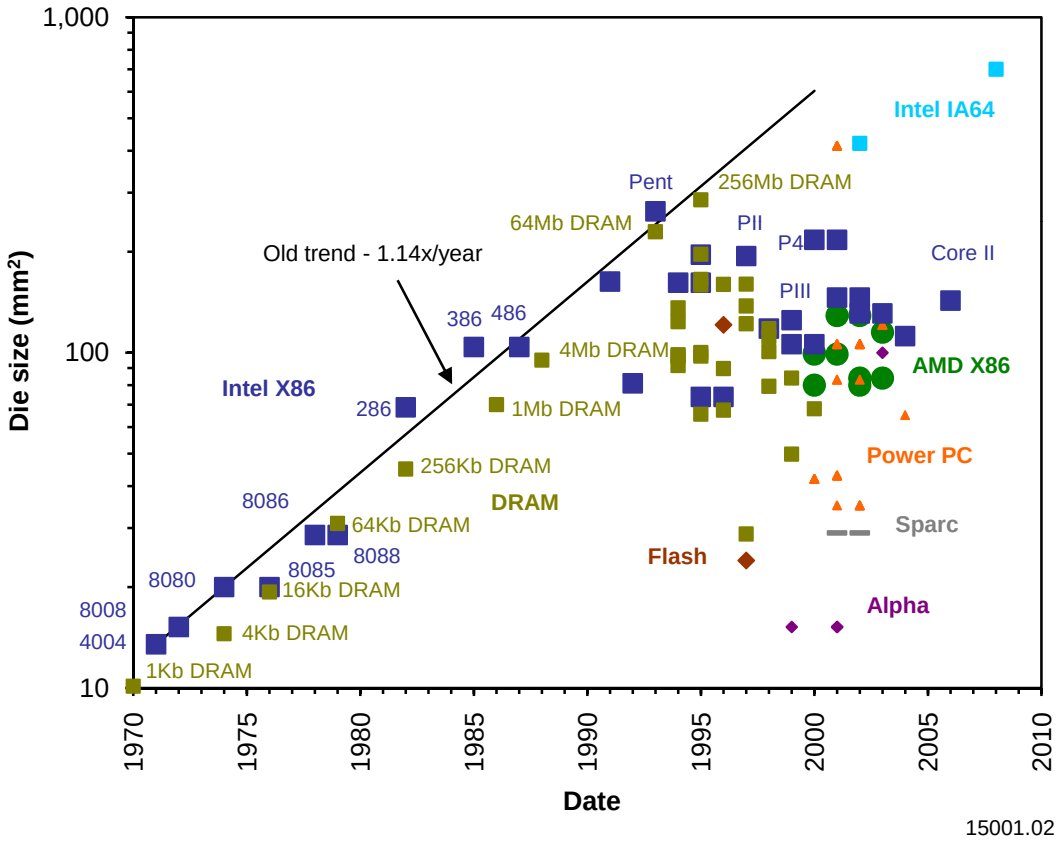
Die size

Shrinking linewidths have slowed the rate of growth in die size to 1.14x per year versus 1.38 to 1.58x per year for transistor counts, and since the mid nineties accelerating linewidth shrinks have halted and even reversed the growth in die sizes.



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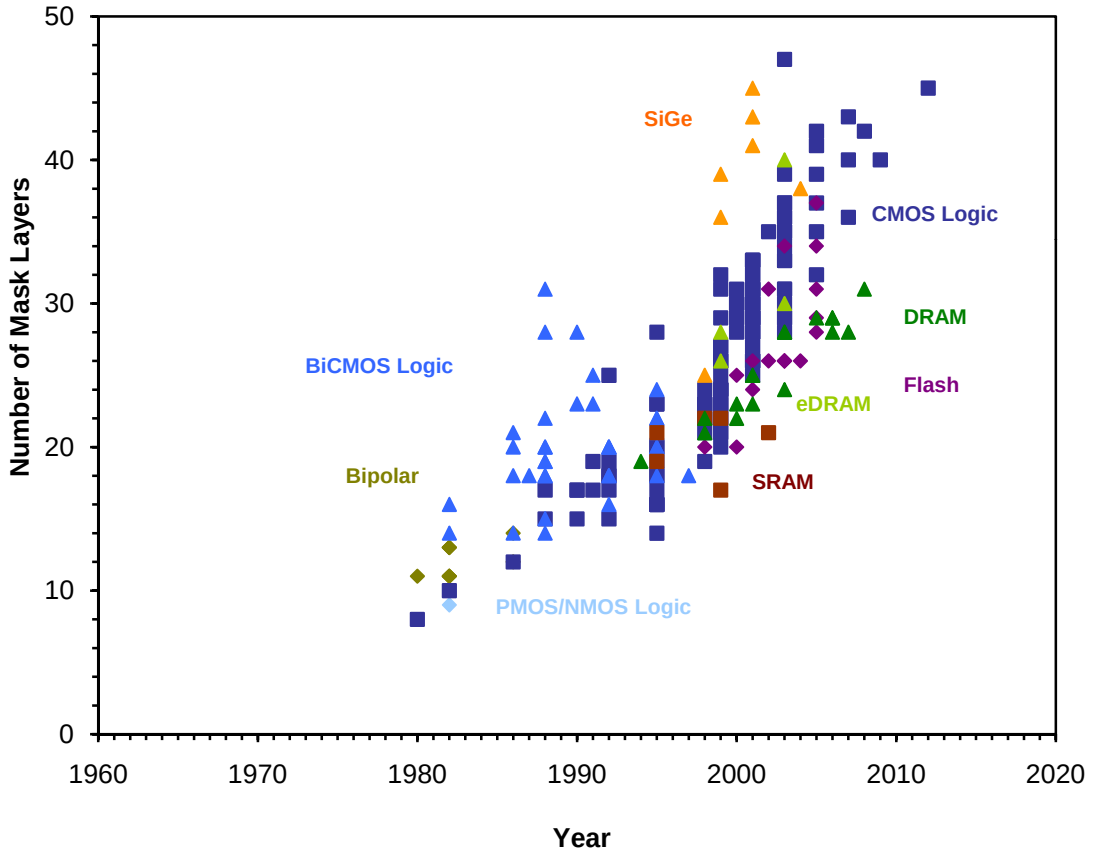
The price of shrinking linewidths 1

Shrinking linewidths isn't free. Linewidth shrinks require process modifications to deal with a variety of issues that come up from shrinking the devices - leading to increasing complexity in the processes being used.



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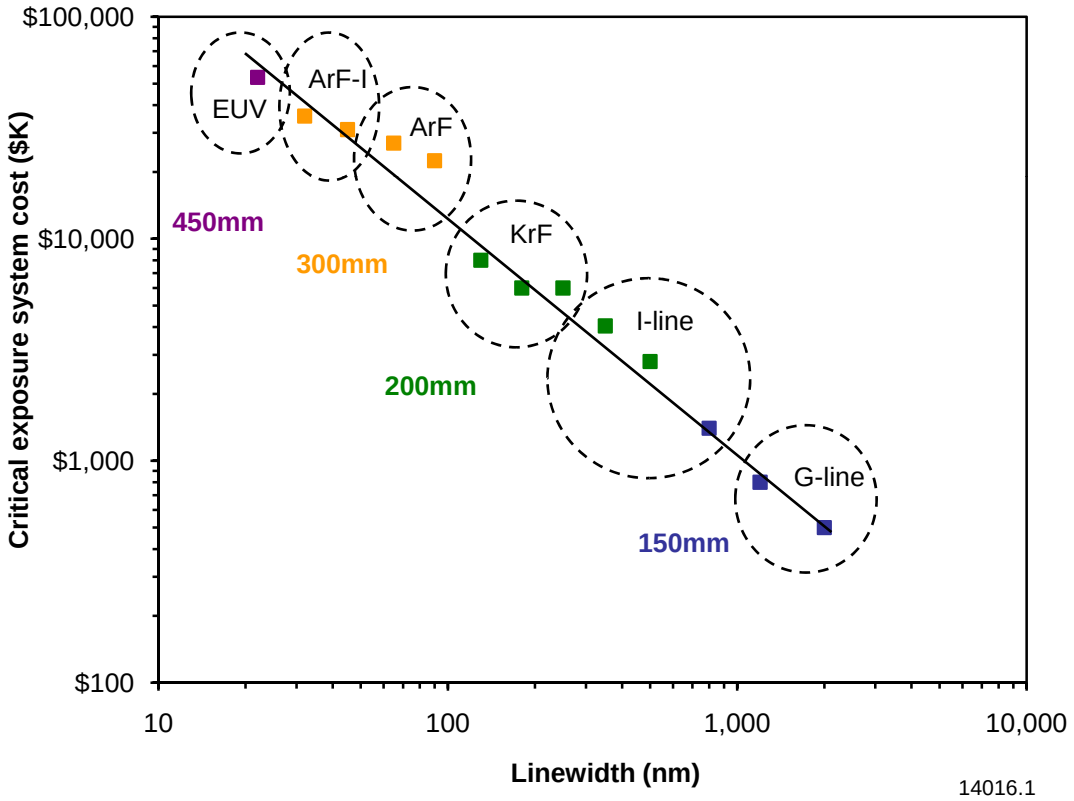
The price of shrinking linewidths 2

Printing ever smaller linewidths combined with larger wafer sizes requires equipment of ever increasing precision and size driving the cost of the equipment up. Exposure system costs have risen from ten of thousands of dollars, to tens of million of dollars with no end in sight.



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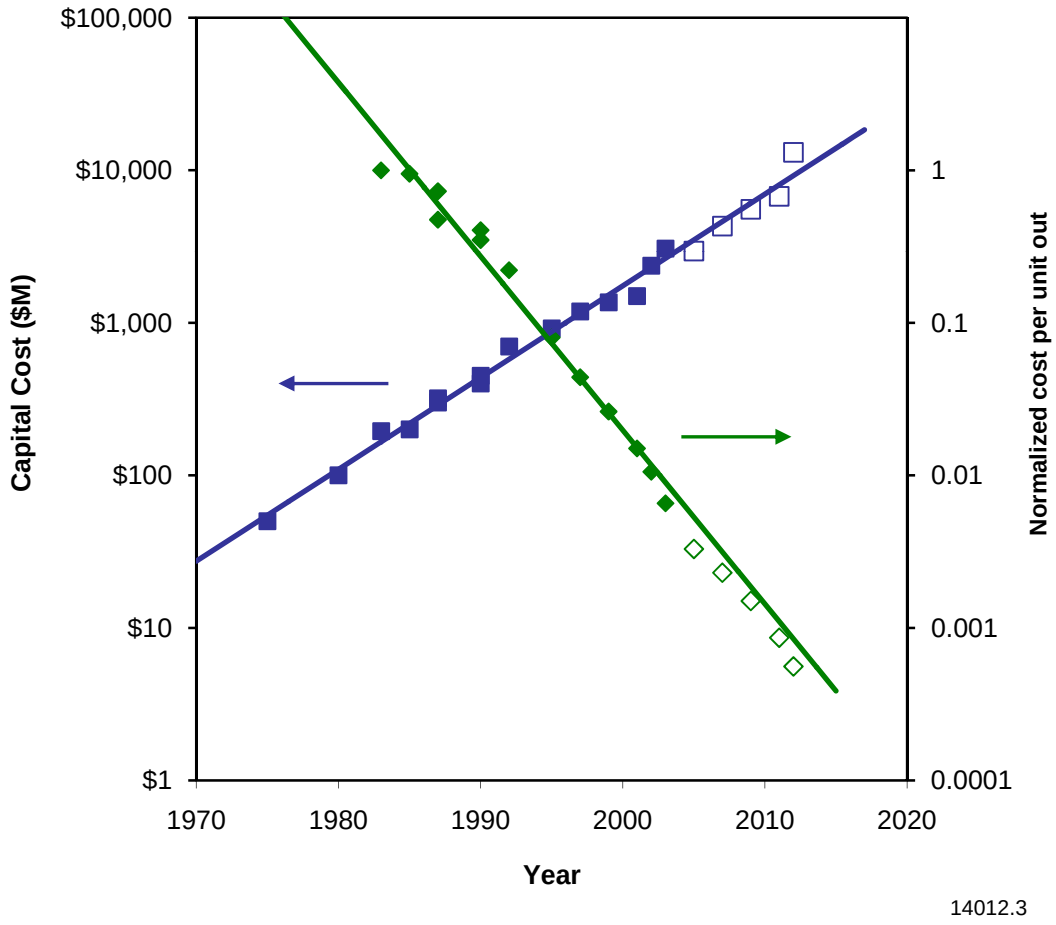
The price of shrinking linewidths 3

The cost of a semiconductor wafer fab has risen from less than ten million dollars in 1970 to several billions dollars today. However, when productivity improvements such as shrinking linewidths, larger capacity factories and larger wafer sizes are accounted for, the cost per unit-out has fallen!



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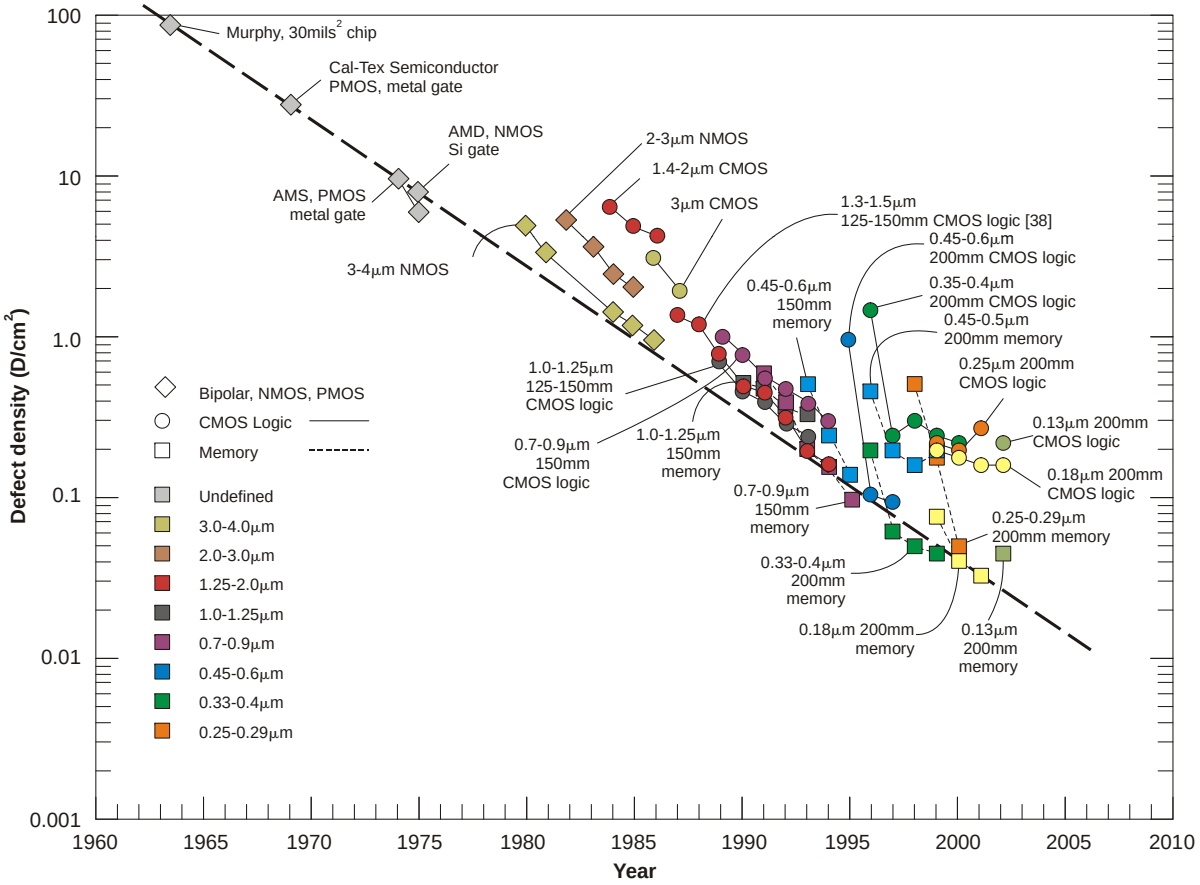
Defect densities

Investments in new equipment and technology have driven down defect densities and improved yields. The rate that new technologies reach mature yields has also accelerated.



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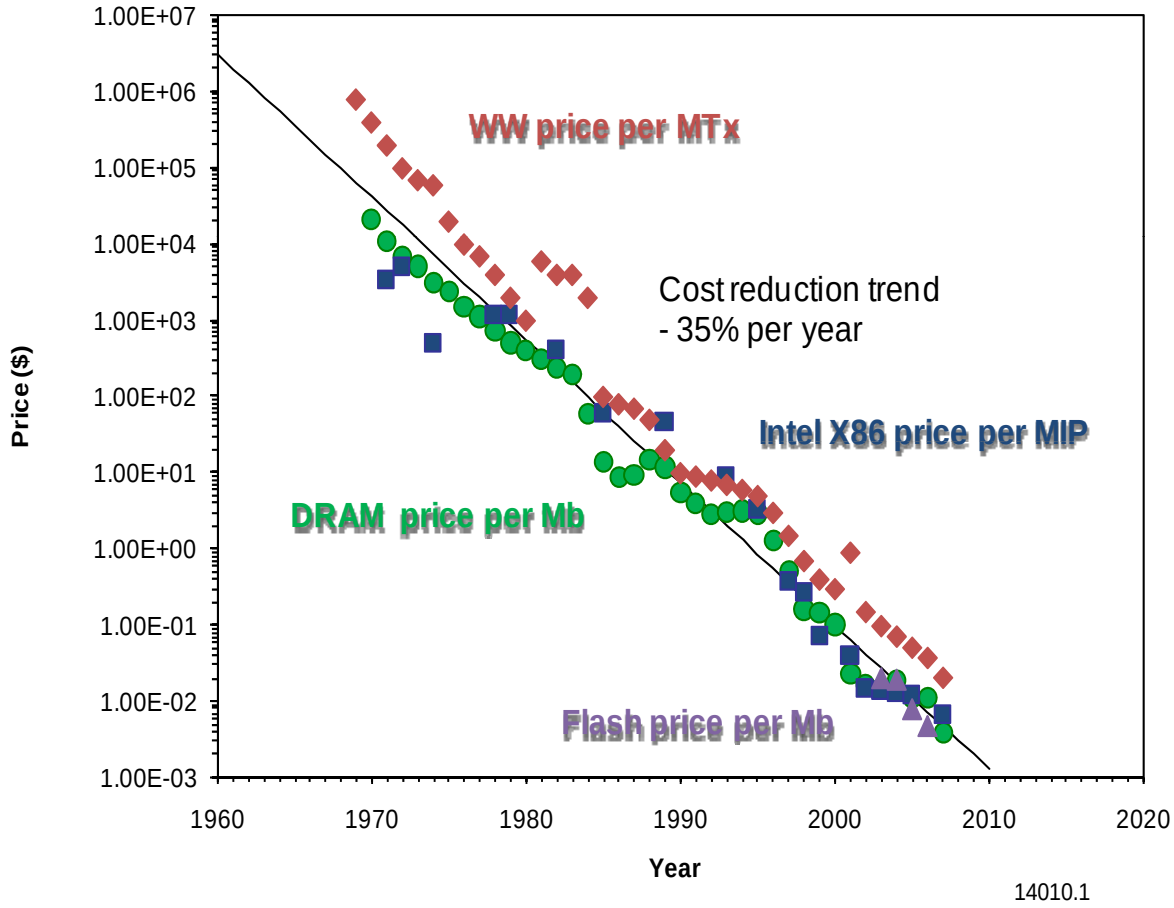
Product pricing

The exponential increase in transistors per die while shrinking linewidths and die sizes while simultaneously improving yields and factory productivity have all enabled product pricing to decline 35% per year while maintaining gross margins!



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