



Ten O'Clock Tech

Moore's Law Due For Retirement

Arik Hesseldahl, 04.15.05, 10:00 AM ET

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Forty years ago next week, an obscure trade magazine called Electronics published an article by one of the electronics industry's leading thinkers, the director of research and development for the semiconductor division of the Fairchild Camera and Instrument Corp. It was entitled "Cramming More Components Onto Integrated Circuits."

The author was Gordon Moore. Three years after the article was published he, Robert Noyce and Arthur Rock would settle on a contraction of the phrase "integrated electronics" as the name for their new company: Intel (nasdaq: INTC - news - people).

His forward-looking article has for years been widely acknowledged as Moore's Law, one of the great benchmarks of faith in technological innovation as an engine of economic growth. It's also widely misunderstood.

The key section of Moore's piece doesn't exactly sing. "The complexity for minimum component costs has increased at a rate of roughly a factor of two per year," he wrote. "Over the longer term, the rate of increase is a bit more uncertain, although there is no reason to believe it will not remain nearly constant for at least ten years."

Loosely translated, Moore was arguing that the number of transistors which could be economically built on a chip tended to double every year. In those days, the most advanced chips had about 50 transistors, but he argued it would be economical to build chips with 65,000 transistors by 1975. On the whole Moore's Law has shown to be prescient, but by the time of its 50th anniversary in 2015, it will probably no longer be true.

The complexities and expense involved with keeping it on track are enormous. At the same time, the most advanced chips may not be needed to handle computing tasks for which there is the most demand.

The most advanced chips currently being manufactured have elements 90 nanometers in size, and by the end of the year, smaller chips with 65-nanometer elements will come to market. Chip manufacturers tend to upgrade their manufacturing technology to allow for the smaller transistors every two years or so. Smaller transistors can be crowded in greater numbers onto ever-small slices of silicon, increasing the amount of work a chip can do.

You can expect Intel, Advanced Micro Devices (nyse: AMD - news - people), IBM (nyse: IBM - news - people) and others to further shrink their manufacturing capabilities to 45 nanometers by 2008 and 32 nanometers by 2010. How they'll get to that point is generally well understood, but looking beyond 32 nanometers is hazy, says Kevin Krewell, a chip technology analyst with Instat/MDR in San Jose, Calif.

"There are a lot of materials science advances that have to happen to get us beyond 32," he says. Shrinking those transistors helps get computing work done, but it brings its own sets of hazards, like power leakage. Chips with smaller transistors tend to lose individual electrons more easily, meaning more power has to be routed through the chip to replace the power that "leaks" away. Recent advances in chip manufacturing have slowed that effect, but the problem becomes more complex and expensive at the smaller sizes, Krewell says.

"That two-year cycle for process technologies is going to have to start slipping," he says. "Some people are starting to talk about a three-year cycle."

And designing chips with elements smaller than 32 nanometers will require some radical changes in how chips are built. Today lasers etch circuitry directly on wafers of silicon through a series of lenses and masks that act a little like a stencil in a process called "deep ultraviolet lithography." Making chips with smaller elements will require a massive shift to a new manufacturing method called "extreme ultraviolet lithography," in which the laser is reflected off a series of mirrors to create wavelengths of light so fine they can only be produced in a vacuum.

If it sounds complex and expensive, it will be. Moving to EUVL technology will require substantial changes to such things as work flow, and it's not going to be cheap. Neither the chip-making equipment nor the manufacturing facilities exist today to produce chips made with EUVL. It already costs about \$3 billion to build a modern chip factory.

And is all that computing power going to be needed anyway? It will be, but only at the very high end. There is always an insatiable thirst for faster number-crunching on supercomputers and servers. It may be where the power is, but not where the sales volume is.

For all its perceived importance, the most advanced chips account for the smallest number of chips sold by volume. Semico Research, a Scottsdale, Ariz., research firm says that 78% of chips sold last year were manufactured on three-year old process technologies of 180 nanometers or higher. Barely 11% of the chips sold in 2005 will be of the 90-nanometer variety.

And by 2015, typical consumers may find by their personal computers won't need the very best chips that money can buy. PCs already have more than enough smarts to handle standard tasks like e-mail and word processing. New applications like video will require more power, but that may be addressed through wider spread use of high-speed broadband Internet connections.

And much of the computing tasks handled by PCs are increasingly handled by other devices like wireless phones. Chips used in handheld devices usually lag the leading edge by a generation or two, and they don't necessarily need to be shrunk every year to two to remain cost-effective.

Many have predicted this before only to regret it later. But I'm willing to bet that by the time Moore's Law turns 50, it will be nothing but a memory. It's due for retirement.