Moore's Law: No End In Sight

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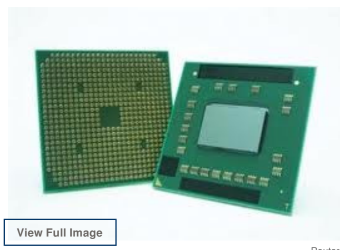
By Jesse Emspak | October 9, 2010 8:07 AM EDT

Computers have grown so powerful, so fast, it almost seems a given that it will go on forever. But lately chip makers have had to find more ingenious ways to cram more circuits on computer chips, and some have started to ask whether we might be reaching limits.



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Microprocessors are still getting smaller, despite the physical limits of silicon.

The trend of increasing computer power with time is called Moore's Law, after Gordon Moore, one of the founders of Intel. It says that the number of transistors per integrated circuit that can be put there for the minimum cost will double about every two years.

Thus far Moore's law has proven remarkably accurate. But the number of transistors that can fit on a microchip is limited by some brute laws of physics.

First is the fact that to do calculations, electrons have to move from one place to another. The faster the clock speed of the chip, the more heat gets generated. Any wire that was only a single atom thick would break up, essentially melting, if the computer were operated at anything like an acceptable speed.

Another is that when you make memory circuits sufficiently small, the electrons that store the data start to leak out, in a process called quantum tunneling. Then there is the problem of power usage; a recurring challenge for chipmakers is how to keep the amount of electricity used to an acceptable level, especially when designing chips for phones and mobile devices.

Mike Mayberry, director of components research at Intel, notes that extreme ultraviolet lithography, or EUV, has been able to push the limits and keep Moore's law operative. Lithography is the way in which semiconductor chips have been manufactured for decades; it uses light, passed through a mask, to etch a pattern on a substrate. The pattern determines where the material making up the circuits is laid down.

Ordinary lithography uses ultraviolet light, at a wavelength of about 193 nanometers. EUV uses wavelengths of about 14 nanometers. That means the pattern that can be etched is that much smaller, Mayberry said.

"The technology [of lithography] has changed about every 10 years or so," he said. Those changes often mean big advances in the technology of making integrated circuits.

Mayberry says there are several ways that engineers could continue to pack more power into smaller spaces. One is going vertical. Instead of building integrated circuits as flat planes, they could be built like skyscrapers, with layers put on top of one another.

Raj Jammy, vice president of materials and emerging technologies at SEMATECH, agrees that EUV is a promising method. He says the limits of Moore's law haven't been reached yet. "We've quite a distance to go before we can't go anymore," he said.

One way to get around the limits of size is to change the way processors operate. Robert Yung, chief technology officer at Tessera, says the physical limits are at least another three to four generations worth of doubling using current lithography techniques. "In terms of physical limits, we have another 10-15 years," he said.

Yung notes there have been many advances in separating out processing to several cores, or "scaling out" as opposed to scaling down. That alone could keep Moore's law in effect by altering the way processors operate. He adds that there has also been a lot of research at Tessera and other companies in the use of other materials besides silicon, which could push the limits out further still.

That technique would also address the fact that clock speeds have not moved as fast as the number of processors on the chip. While the number of processors in a given space has increased exponentially, the clock rates have not; back inthe 1980s they were measured at a few million cycles per second, but anything faster than about 3.5 billion cycles per second (GHz) generates too much heat. The fastest processor sold to date (in an IBM mainframe) has a clock speed of about 5.2 GHz.

There are also the more exotic technologies on the horizon. One is spintronics, which uses a property called spin to store the information on a chip, rather than the charge, which is what conventional electronics do. Mayberry said he doesn't see that becoming commercially viable for a few years yet. But spintronics solves many of the problems -- notably waste heat -- of electronics, because they use much less power.

Another method might be using a whole different kind of logic. "Maybe non-binary computation will be the way," Mayberry said. "But we are good for at least another 10 years."

Every technology, he said, has limits, but he notes that just as often those limits have been breached. "For years they talked about the limits of lithography," he said. "Every time it was pushed further."

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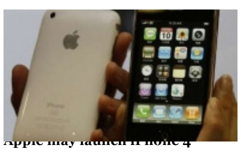

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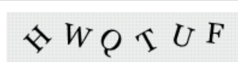

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