KPMG ANALYSIS

Semiconductor Firms Searching for Silicon Replacements

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By Dave Pelland, Managing Editor, Digital Insider

Semiconductor chipmakers concerned about shrinking components and improving performance have launched collaborative research efforts to find the next generation of materials and production methods.

The seemingly endless advances in chip performance characterized by "Moore's Law" are reaching their limits as firms bump against the physical limits of their ability to reduce component size further. (Intel co-founder Gordon Moore predicted in 1965 that the number of transistors within a microprocessor would double about every two years.)

"When the gate [within a transistor] is three atoms thick, it's very hard to shrink it much further," said Jeff Welser, director of the Nanoelectronics Research Initiative (NRI) for the Semiconductor Research Corp., a nonprofit effort between chipmakers, universities and government that sponsors research into future chip design and fabrication.

According to Welser, who spoke at the Nanobusiness 2008 conference organized by the Nanobusiness Alliance, chipmakers are searching for alternatives because the current generation of chip materials, such as the complementary metal-oxide-semiconductor (CMOS) technology that has dominated chip production since the late 1980s, may not be sustainable for much longer.

"Someday CMOS will end," Welser said. "What do we do next? What do we use for the transistor or the chip beyond what we're going to get from silicon CMOS?"

Looking for Replacements

Semiconductor firms searching for replacements for silicon-based processors and memory chips are exploring several alternatives such as graphene, a material made from a single layer of carbon atoms arranged in a honeycomb pattern to conduct electricity.

"We're [also] looking at molecular devices that can change shape or have some other effects as it does computations, and would be completely different than just moving electrons around," Welser said.

The commercialization of such technologies is likely to take about 10 years. In the meantime, semiconductor firms are rolling out design improvements such as a multi-core chip that divides and shares computations, and three-dimensional packaging that

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arranges components in vertical layers to improve microprocessor performance and cooling requirements.

"Is there something out there that we can jump to?" asked Welser. "The answer is no, but that's what were going to search for."

Semiconductor companies are also facing other issues in atomic-scale design and manufacturing. For instance, the tiny wires connecting transistors are prone to electrical leakage, and the density of billions of tiny components within a single microprocessor makes it difficult for chipmakers to maintain a safe operating temperature.

"If we just scale transistors smaller, even if we can package and connect them, the issue is still that they're going to run slower and run hotter, and nobody would buy them," said Jia Chen, program director in the office of the chief technology officer and strategic alliances for IBM's systems and technology group.

"The key is we have to introduce new materials, processes and structures to [provide] the kind of improvement we need."

The search for alternative materials and processes is marked by industry collaboration. NRI, for instance, includes chipmakers AMD, Freescale, IBM, Intel, Micron Technology and Texas Instruments. The companies are working with the Semiconductor Industry Association, the National Institute of Standards and Technology, the Defense Advanced Research Projects Agency (DARPA), the National Science Foundation, and the states of California, New York and Texas.

The NRI effort is one of at least a dozen collaborative research efforts exploring topics such as replacing CMOS technology or development production methods for 32-nanometer components.

Cooperation Not Uncommon Anymore

Ron Steger, partner in charge of KPMG's semiconductor practice, says such collaborations have become more popular among chipmakers in the past couple of years as the cost of basic research increases.

"The concept of companies joining together to set the next level is not uncommon in the industry," Steger says.

The fact that semiconductor firms are collaborating in the lab isn't likely to diminish their ability to compete in the marketplace. Under the terms of most research collaborations, the parties receive a royalty-free license to use jointly developed technology.

"The resulting technology is generally shared equally by both parties, and how that is commercialized is up to each participant," Steger says.

Not all areas of semiconductor research involve shrinking components or exploring new materials. A sector known as "printable electronics" involves embedding silver particles into ink, which gives the ink the ability to conduct electricity. That ink can then be printed with commercial-grade equipment to form three-dimensional patterns that act like basic circuits or sensors.

The initial uses for printed electronics, which don't require the precision of microprocessors or memory chips, are expected to come from supply-chain and inventory applications such as advanced labels or RFID chips.

Vik Pavate, vice president of business development for chip designer Kovio, said using printed circuits can lead to applications that aren't practical or cost-effective using silicon chips. For instance, he cited the potential to print simple sensors, such as glucose or cholesterol meters, directly on medication-bottle labels.

"[Printed] sensors that can read temperature or humidity aren't that exciting, but the combination of biomolecules with printed electronics can be an exciting [sector,]" Pavate said.

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