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Motorola Makes Chip Breakthrough

By BARNABY J. FEDER

Motorola (news/quote) plans to announce today a breakthrough in the manufacture of semiconductors that allows high-performance materials like gallium arsenide to reside on top of standard silicon, a decades-old dream for microchip designers.

Motorola said that it hopes to license its discovery to other manufacturers widely and quickly. The technology, which takes advantage of equipment already in use, will make it possible to make specialty chips like power amplifiers in cell phones more cheaply as early as next year, the company said.

"It's a monumental change in the constraints on the construction of semiconductor systems," said Dennis Roberson, chief technology officer of Motorola. "We've opened the door on a whole new world."

Over the long term, Motorola expects the breakthrough to lead to speedier alternatives for a range of chips that now rely on silicon alloys. In addition, chip designers should be able to invent new integrated circuits that combine the low-cost robustness of silicon with characteristics of higher-performance semiconductors, like the ability to emit and absorb useful quantities of light in wavelengths widely used in communications equipment.

Such integrated circuits could sharply reduce the price of connecting high-speed optical networks for Internet and data communications to the home. They might also spur the development of new wireless devices, like radar systems that would help automobiles avoid collisions, and new semiconductor-based lighting systems, according to Motorola.

A handful of analysts briefed by Motorola in advance of the announcement were cautiously enthusiastic.

"This is beyond fascinating research," said Jeremy Donovan, a semiconductor industry analyst for Gartner Group (news/quote) Dataquest. The company has already demonstrated in its internal research that chips made with the process work in cell phones and has gotten well down the path of developing the data needed for mass manufacturing, he said.

Motorola, based in Schaumburg, Ill., is struggling to regain investors' confidence after being hard hit by downturns in its cell phone and semiconductor operations. In July, the company said it lost $232 million from operations, and $759 million including one-time expenses, in the second quarter on revenue of $7.52 billion. The company's stock, which peaked at

$61.54 in 1999, ended last week at $17.40. The shares fell as low as $10.50 in April. The company recently announced a shift in strategy toward making the fruits of its research available to outsiders, even potential competitors. Such is the plan with its chip-manufacturing technology. Motorola hopes that it can reap profits more quickly from its innovations and that the successes of others might stimulate growth throughout the wireless industry.

Motorola made the underlying discovery behind the technology in 1999. The company said that it had been granted basic patents covering the technology and had been filing related patent applications at a rapid rate this year. Motorola typically files for about 1,000 patents annually. Applications related to today's announcement account for over 20 percent of this year's total, Mr. Roberson said.

The discovery resulted from an experimental failure. The company had been trying to create extremely thin transistors - in essence, gates for electrons - on top of crystalized silicon out of a material called strontium titanate, or STO. The process involved bathing the crystal of the strontium compound in oxygen as it grew on top of the silicon. As the STO crystal thickened, however, oxygen slipped through to the silicon below and combined with it to form a glass- like layer between the two crystals.

The irregular arrangement of atoms in the middle layer impaired the performance of the STO transistors. Motorola, like others who had been doing similar work, initially tried to get rid of it. Eventually though, the researchers noticed that the spacing between the atoms in the STO, which had been squeezed to align the STO with the silicon crystal, relaxed as the middle layer formed. The spacing became wide enough for crystals of gallium arsenide and related materials to be grown on the STO.

The excited researchers soon realized that they had stumbled on to a possible solution to a constraint that had stumped Government, academic and industry semiconductor experts for some 30 years.

Silicon, which is basically purified sand, had become the workhorse of the semiconductor industry because it was plentiful, cheap and relatively easy to work with. The main method for improving silicon chip performance had been to shrink components to boost speeds and cut power consumption. In the 1990's, chip designers also improved performance by growing related alloys like silicon germanium on top of pure silicon.

What no one had been able to do, though, was deposit materials like gallium arsenide and indium phosphide, much more efficient semiconductors, on silicon. As a result, when the performance characteristics of such materials and their chemical relatives have been needed, users like the builders of radar equipment, power amplifiers and optical components like lasers have been unable to take advantage of the economies of scale of the vast silicon-based semiconductor business. Nor can such chips be easily integrated with silicon devices.

The barrier, which Motorola says it has solved, was the difficulty of bridging the difference between the spacing of the silicon atoms and the spacing in the other materials.

In addition to demonstrating that working gallium arsenide cell phone amplifiers can be made, Motorola says it has done computer studies leading it to believe that the process could work with many materials. Some of them have been virtually ignored, despite reasons to believe they could be valuable semiconductors, because there seemed to be no prospect of making them at a reasonable price, Motorola said.

"They turned lemons into lemonade," said Darrell G. Schlom, an associate professor of materials science and engineering at Pennsylvania State University who was shown the technology while working as a consultant this summer.

Looking back, Mr. Schlom said, the pieces of the puzzle had been lying around for about 10 years. I.B.M. (news/quote) came close in the mid-1990's when it demonstrated a much more complicated approach to growing crystals on non-crystalline forms of silicon, he said. "What was brilliant was how Motorola put things together," Mr. Schlom said.