

Advances in CMOS Chips Help Sales of Digital Cameras

By Laura Johannes Staff Reporter of *The Wall Street Journal*

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For years, toy designers at Nintendo Co. dreamed of creating a digital camera.

But digital cameras cost hundreds of dollars, too much for a toy. Then this year came new technology that sharply cut the cost of making one of the digital camera's most critical and expensive parts: the light sensor, its equivalent of film. Now Nintendo has a new hit, a \$49.95 filmless camera that fits into its Game Boy toy and has sold more than 800,000 units in the U.S. and Japan since April.

Nintendo's leap was made possible by advances in devices known as complementary metal-oxide semiconductors, or CMOS chips. These thumbnail-sized wafers of silicon (pronounced SEA-moss) have long been used in the innards of personal computers and digital cameras. But until recently, no one had figured out how to adapt them to the light-gathering sensor, or "eye," in consumer cameras.

CMOS sensor chips are the 'eyes' of Mattel's Barbie digital camera. By tinkering with the microscopic circuitry embedded in CMOS chips, researchers have scored the breakthrough that has long been a Holy Grail of digital imaging. They've built CMOS light sensors that can be cheaply mass-produced in the same giant factories that turn out chips used in personal computers. The advances already are transforming the economics of filmless cameras, driving down prices within reach of the mass market.

Production Race

Some in the digital-imaging industry are betting CMOS sensors will become ubiquitous, finding a host of new applications in toys -- such as dolls that recognize and greet their owners -- as well as cars, security devices and cellular phones. The potential opportunities have touched off a race among at least a dozen companies, including

Eastman Kodak Co., Motorola Inc., Intel Corp. and Japan's Toshiba Corp., to produce the cheapest and best chips.

So far, CMOS sensors have appeared mainly in low-end items, such as the Game Boy accessory and a filmless Barbie camera, due this fall from Mattel Inc. for about \$69. But high-end cameras are also converting to CMOS. Last year, Sound Vision Inc. brought out the first super-high-resolution digital camera priced under \$400. Like the Barbie camera, it contains CMOS sensors made by early market leader Vision PLC, a Scottish company started with technology from the University of Edinburgh.

Other companies are placing big bets on CMOS. Motorola hopes to put CMOS chips in cellular phones that could transmit graphics or a caller's image. Several companies are looking at automotive applications, including tiny cameras that recognize -- and sound an alarm -- when a car veers over the median line.

Polaroid Corp. and Atmel Corp., its San Jose, Calif., partner, are in early talks about selling a CMOS chip for use in automatic-teller machines to verify identity by examining images of a user's face or fingerprints.

Two CMOS sensor chips. Here's how the chips work. As light passes through the lens of a digital camera, it activates thousands of tiny light-sensing cells, or pixels, on the sensor chip. Each cell generates a minute electric charge that carries the information needed to generate a picture made up of black, red, green and blue dots. After this image is relayed to processing and memory chips inside the camera, the sensor chip is wiped clean to record the next picture.

Up to now, the light-sensing task has been performed by a microchip known as a charge-coupled device, or CCD sensor. CCDs are made in a relatively few specialized factories, where their silicon layers are arranged to maximize sensitivity to light and sharpness of image.

Silicon layers in ordinary CMOS chips, by contrast, are organized for optimum versatility and ease of manufacture. To convert them to camera-quality light sensors, developers have grafted tiny lenses or amplifiers onto CMOS circuitry. The new CMOS sensors offer a huge advantage: They can be manufactured on the same assembly lines that stamp out ordinary PC chips.

Another plus: Because CMOS technology is used elsewhere in digital cameras, designers can cram multiple functions on the sensor chip, potentially cutting costs and size further. Finally, CMOS chips use less battery power than CCD sensors.

But there is a big downside as well. CMOS sensors have a way to go before they can match the CCD's sharp pictures. Nor have early prototypes always delivered promised cost savings.

Bulkier Camera

Intel's first CMOS sensor, announced last year, actually was bigger than the average CCD. Though its size boosted light sensitivity and image clarity, it made the camera 30% to 40% bulkier, "offsetting any savings in silicon with more expensive lenses and more plastic," says Don Whiteside, general manager of Intel's digital-imaging and video division.

Meanwhile, makers of CCDs, such as Sony Corp., are responding to better CMOS sensors by slashing prices. A high-end CCD that cost \$100 a year ago now goes for \$30, according to Bob Caspe, chairman of Sound Vision, a Framingham, Mass., maker of digital cameras. "The pricing is very aggressive, almost predatory," he says. "It's great for consumers."

A Sony spokesman declines to comment on its pricing, but stresses that CCDs still offer the best picture quality.

Nintendo's Game Boy uses CMOS sensor chips.	CMOS sensors cost an average of less than \$14, about 15% to 20% cheaper than CCDs, says Mark Kirstein, of Cahners In-Stat Group, a market researcher in Newton, Mass. If additional image-processing functions are crammed onto the chip, the savings can reach 50%, he says. The chip Nintendo used, Mitsubishi Electric Corp.'s new "artificial retina," incorporates both light-sensing and image-processing functions. It costs only \$10, or half what traditional CCD technology would have cost, Mitsubishi says.
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Mr. Kirstein estimates that sales of products made with CMOS sensors, including toys, cameras and fax machines, will reach \$110 million this year. He predicts growth in cameras and toys will help push that to \$3 billion by 2000.

First, CMOS designers must work out the kinks, including "noise," the industry's term for annoying little dots or scratches on photos. "These chips have to work in low light and deliver the same vivid colors your eye sees. They have to do that running off a watch battery, for a price that everybody can afford," says Don Lake, general manager of Vision's

U.S. unit. "There are a lot of smart people in the world, but no one's completely figured it out yet."

Work on CMOS sensors began two decades ago for military and aerospace applications. In 1995, some NASA scientists saw commercial potential and formed Photobit Corp., a closely held company in Pasadena, Calif., that now licenses technology to Kodak and others. During the past couple of years, many others have entered the fray.

Get a Scorecard

It is hard to follow the alliances without a scorecard. Kodak disclosed last year it was working with Motorola, but in April inked a deal with Intel. The reason for Kodak's shift away from Motorola is unclear, though at least some of the partnership survives, both companies say. Willy Shih, who heads digital imaging at Kodak, promises "a CMOS consumer digital camera as soon as we can get image quality where we want it." He declines to speculate when that might be.

Intel has 250 engineers working mainly on the chip at a lab in Chandler, Ariz., 15 miles from Motorola's CMOS lab. Kevin Christensen, strategic marketing manager at Motorola, won't disclose the size of its research team, but says "we have it from market intelligence" that it is ahead of Intel.

Intel concedes that Motorola likely will beat it to market with a product providing low-resolution images. Indeed, Motorola already has announced a chip designed with Kodak. But Intel says it is focusing on higher-quality chips that can win a "leadership" position in the market.

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