Tek's 'giant' CCDs: producing 'unworldly images' of inner and outer space

The only similarity between Tek's CCD imaging devices and olives is that even the super-colossal giant sizes are relatively small.

But in the world of CCDs, Tek's new 2048 x 2048 CCD is truly a giant, not only in size, but for its unprecedented performance in helping medical and scientific people learn about both outer space and inner space. Or, as one customer said recently, "The pictures we're getting are beyond science."

Among the largest charge-coupled devices available, the TK2048E is designed to efficiently image scenes at low light levels from infrared to ultraviolet wavelengths. "We thought that since scientists want to see in more detail, we'd take CCD fabrication to its limit and make it as big as physically possible," says Larry Riley (design manager for the CCD product line).

The highest initial demand for the TK2048E is from astronomers. When the product was first announced five years ago, orders began arriving immediately. Those same orders were then placed in backlog while manufacturing processes were refined to produce large CCDs with the highest possible quantum efficiency. "That these customers were willing to wait so long indicates how rare and useful they are," says Todd Yuzuriha, (Marcom mgr.)

"In astronomy," adds Art Luthi (product line mgr.), "objects that were too faint to be seen are now visible. Astronomers think they're going to be able to see the Big Bang instead of just theorizing about it. This is why Tek is trying to place a thin TK2048E in every observatory in the world."

The TK2048E is expected to have an equally important impact in medical imaging. By using a large CCD in place of X-ray film, patients do not need to be exposed to radiation for as long, and since the CCD is so much more sensitive to light, it's able to dramatically aid diagnoses by showing internal structures in considerably more detail. In addition, since CCDs record images digitally, these images can be enhanced through signal processing to further illuminate anatomical details, as well as be stored and transmitted as standard computer files. A doctor unsure of a diagnosis can simply transmit the image in digital form over a phone line to a specialist, who can then generate the same image and, if necessary, further enhance areas of interest from surrounding tissue.

A number of doctors have already written about the advantages of CCDs in medical imaging. One physician says he uses the TK2048E for body-width medical X-ray imaging, which allows him to "view data in real time, enhance the image, and archive the data, thus offering a superior alternative to film."

Physicians initially thought they would need grade 1 TK2048Es, particularly since they wanted to avoid any pixel defects that could throw off their diagnoses. But they've since learned from astronomers that they can remove aberrations through signal processing, and are now saving money by using alternate grade TK2048Es.

Other markets expected to show interest in the TK2048E include machine vision and chemical analysis. In machine vision, television cameras are used in place of the human eye, especially in non-destructive testing, where cameras fitted with CCDs search for structural defects. Since the TK2048E's resolution is so great that the fine print of a newspaper shows exceptional clarity from across a football field, it can see in much greater detail than human inspectors.

In chemical analysis applications, ranging from drug-testing to DNA analysis —where samples absorb different wave lengths of light and give themselves an identifying fingerprint — the TK2048E makes an excellent sensor since it can see across a wider light spectrum than any other imaging device.

What's next?

Since Tek has successfully pushed CCD size to the limit, the next challenge is to increase the speed at which data leaves the device. "When a CCD is used to look at the heavens, the heavens appear stationary, so there's plenty of time to get the information out of the CCD," says Larry Riley. "In medical applications, though, there's concern about the motion caused by heartbeats, digestion, and nervousness, so data transfer becomes an issue. We need to get our CCDs to read out faster."

Despite the down-to-earth issues of manufacturing and marketing, the TK2048E team is still able to appreciate the Buck Rogers aspects of its device: "We still get pumped up when customers tell us about the unworldly images they're getting," says Art Luthi. "We get especially excited knowing we're going to save a lot of lives with our contribution to medical imaging." ■

PAULINE MARRIOTT has been involved in processing the TK2048E CCD's since their inception. At left is a (reject) sample wafer. At right is the shipping package designed to protect the delicate, costly and technically significant product. The package is an aluminum block with a plate glass window, and the TK2048E—when inserted, locked in and grounded—looks like a holy relic on display. The package is shock proof, and levers (instead of screws) are used to hold the glass in place as screws would throw off particles that would get onto the device.

What is a CCD (charge coupled device)?

Think of a CCD as an electronic sensing device that resides where film used to, and, when coupled with digital electronics and a computer, yields exceptionally sharp images. When exposed to light, its pixels (image points) transform impinging photons to electrons, which are then shifted — pixel by pixel via the charge-coupling process — to the edge of the device where they are amplified, read-out, digitized, and processed through a computer to produce pictures. Their most familiar use is in video camcorders.

As CCDs go, the Model TK2048E is physically imposing. Measuring about two inches square and containing over 4 million pixels, it is constructed using the same process that Tek's CCD product group employs to build its smaller TK512 and TK1024 model CCDs. But since the TK2048E is so much larger, the risk of defects — or pixels that fail to operate — becomes that much greater. Depending upon its intended use, a single defect can brand one as unacceptable.

This search for performance has necessitated two versions of the TK2048E: "front illuminated" and "thin," each with multiple quality grades. The principal difference between the two is one of quantum efficiency, or the ability of the device to detect all that it sees. For a front illuminated device, quantum efficiency is about 30 percent, as compared to 70 percent for thin. In contrast, the human eye is approximately 7 percent efficient, and film 1 percent.

A front device has all its pixels on the front of a wafer approximately 500 microns thick, or about the width of five human hairs.

Thin devices are marked by having the wafer thinned on the back to about 20 microns. They are then reversed in use so photons are able to penetrate bare silicon with none of the obstructing gate structures located on the front.

Only one competitor makes front-style devices as big as the TK2048E, and none has yet been able to build large thin versions, which means the TK2048E has the highest quantum efficiency in the industry, and is so popular that this year's sales plan is expected to be exceeded.

Since the TK2048E is essentially a component, marketing consists mainly of forming strategic partnerships with original equipment manufacturers who make entire viewing systems.

TK2048Es are priced according to version grade with a top-of-the-line thin grade costing $110,000 and engineering grade priced as little as $15,000. Front side grades are about half that of thin.

Process is real challenge

Though CCDs have been in use for over 15 years, never before have such large ones been possible, even though the processes to fabricate both large and small are similar. With large CCDs, the bigger active area means more chance for defects, accounting for the weeks it takes to painstakingly complete the hundreds of steps needed to manufacture one. When Tek's proprietary thinning processes are used, the time further increases.

"The way you make money in this business is to work on the process, since the cost for making a bad wafer is the same as for a good one," says Larry Riley. "The five year period from product development to shipment was essentially one of refining the process." But those five years weren't a void. What they learned along the way was applied to processing the smaller CCD's, producing dramatic increases in yields.