Although the standard Windows FireWire bus driver works well with devices such as cameras and hard drives equipped with the IEEE 1394a interface, the driver has not been updated to take advantage of newer functions, especially higher data speeds, introduced with IEEE 1394b. Jens Hashagen, software product manager for Allied Vision Technologies, commented on how this affects engineers designing 1394b-compliant machine-vision systems running Windows, and he discussed the pros and cons of alternative 1394b bus drivers.

Q: What are the speed limitations that the original Microsoft FireWire bus driver places on 1394b-equipped cameras and other devices used in machine vision?

A: The native OHCI 1394 bus driver for Microsoft Windows XP, which was included in Microsoft’s SP2 (Service Pack 2) release, was designed to operate primarily with 1394a-compatible devices. If you connect a 1394a camera to a 1394b bus using this driver, the maximum data-transfer rate on the bus decreases to 100 Mbps. The same is true if you connect a 1394b device. So, even though the 1394a maximum speed is specified at 400 Mbps, you need to do some tricks to reach that speed on a 1394b bus. And 400 Mbps is the maximum transfer rate you can reach with this driver, even for devices with a 1394b interface.

Q: How have designers of machine-vision systems coped with this situation?

A: The original 1394 driver of Windows XP SP1 (Service Pack 1) allowed 800-Mbps data-transfer rates, so for XP systems, you can run 1394b cameras at that speed. However, there is no such option if you’re running Windows Vista.

The only other alternative is to use a proprietary bus driver from a camera vendor if it supports 800-Mbps data-transfer rates, as most of these drivers do, since that’s why they were written. But most of these drivers are also noncompliant with the Windows 1394 standard driver. This means that other FireWire devices connected to the PC, such as hard drives, may not operate correctly.

Q: What other issues associated with the original 1394 driver affect industrial imaging?

A: There are stability issues that are unacceptable for industrial applications with high reliability demands. For example, with the Microsoft 1394 driver, an invalid packet sent in asynchronous mode could lead to an interruption of the communication between the PC and the camera, which could cause problems such as corrupt data. There’s no mechanism in place to prevent that; you would have to restart the system.

Q: What has Allied Vision Technologies done to help improve this situation?

A: Besides fault-tolerant operation and low CPU load, the speed limit is the main reason we developed the AVT 1394 bus driver package. Since the driver conforms fully to the IEEE 1394 standard and complies with Microsoft’s OHCI 1394 standard driver, it works with 32-bit versions of Windows, including Vista, XP, and 2000. It lets our 1394b-compliant AVT cameras transfer image data at 800 Mbps. Our bus driver can be used with the CMU (Carnegie Mellon University) 1394 camera driver, and with 1394 camera drivers based on the Microsoft bus driver, which are provided in imaging software from A&B Software, Cognex, Matrox, and National Instruments.
Two bright spots in machine vision these days are the rise of solar-cell inspection, and the inspection of HDI (high-density interconnect) boards and their complex component packages.

As was evident at the Vision Show in Phoenix (March 31 to April 2), solar-cell manufacturers need machine vision in both front-end and back-end processes. And to produce higher volumes, drive down product costs, and increase yields, makers of photovoltaic solar cells based on silicon wafers are turning to the high-speed, high-volume manufacturing and inspection the semiconductor industry is known for, leveraging technologies and processes originally developed for semiconductors (p. 49).

Although the general economy is beginning to show signs of picking up, the machine-vision industry is still undergoing trying times, as indicated by shakeups among some manufacturers of AOI (automated optical inspection) and AXI (automated x-ray inspection) equipment. But as board interconnect and IC packages get denser and more features like passives are embedded in substrates, OEM and EMS customers need x-ray technology to see inside and under these complex structures. 3-D technology is becoming more important for electronic inspection to ensure that solder balls in ball-grid array components are shaped correctly, which can’t be determined using 2-D techniques (p. 50).

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Machine vision aids solar-cell inspection

By Ann R. Thryft, Contributing Technical Editor

As manufacturers of solar cells face pressure to drive down costs, they are turning to higher-volume automated manufacturing, accompanied by high-speed inspection to increase yields and improve the quality of their products.

Inspection of photovoltaic solar wafers and cells is required throughout the solar-cell production process. For example, KLA-Tencor equipment inspects at several steps in the solar-cell production line, from incoming wafers to finished cells, said Jeff Donnelly, group VP of the growth and emerging markets group for KLA-Tencor. “We examine incoming bare wafers to determine their dimensions and inspect them for various defects, such as stains and microcracks,” he said. “We also conduct in-line cell inspection at different process steps for excursion monitoring and to enable immediate interventions in case there are production problems, such as a defective print screen. Finally, our systems are used in the cell classifiers for final sorting and binning of completed cells.”

The two basic kinds of photovoltaic solar-cell technologies are crystalline silicon and thin-film photovoltaic. About 86% of the industry’s photovoltaic solar-cell capacity is based on crystalline silicon, in either polycrystalline or monocrystalline forms, said Donnelly. “This technology creates solar cells on top of silicon substrates, not unlike a semiconductor manufacturing process,” he said. The finished active devices are then placed in a panel.

Efficiencies of silicon-based photovoltaic solar cells, typically 15 to 20% for polycrystalline and 18 to 25% for monocrystalline, are higher than efficiencies of thin-film photovoltaic cells, Donnelly said. “Developers of thin-film technologies are still using different types of substrate materials, such as plastic, glass, or very thin stainless steel, and are therefore inventing their own process equipment.” Although some believe that thin film has cost advantages, KLA-Tencor has only just started to look at that technology because volumes have been so low, he said.

By leveraging industry knowledge and the technology for dealing with silicon, manufacturers can produce photovoltaic solar cells in high volumes with automated manufacturing and handling equipment. For example, KLA-Tencor’s P-6 stylus surface profiler is commonly used offline in surface topology measurements, including measurements of solar cells. In March, the company’s ICOS division debuted the PVI-6 system, which performs in-line optical inspection of photovoltaic solar wafers and cells, said Donnelly. The PVI-6 is a family of inspection modules combined with software, including analytical tools that increase the overall yield of the solar-cell production process.

Since polycrystalline solar cells are semiconductor devices, they have inspection and metrology requirements similar to those of non-solar semiconductors, and the basic inspection technologies are similar, said Donnelly. In both, the challenge is to combine high resolution with high throughput. “Typical semiconductor manufacturing throughput is 100 to 200 wafers per hour, but in solar cells, it’s 2000 to 3000 wafers per hour,” he said. “On the other hand, the typical scale of semiconductor inspection is in nanometers to microns, whereas for solar inspection it’s in microns to millimeters. In both cases, the data sets are huge and require fairly sophisticated data processing.”

In general, the solar-cell industry is moving from the research stage into the production stage, and aiming at lower costs and maximized yields, said Dave Cochrane, Dalsa’s director of product management. “The market is tending toward larger [solar] panel sizes, produced for a lower cost, and with somewhat less power per square inch,” he said.

In March, Dalsa announced its entrance into solar inspection with a new 22-Mpixel camera and the application of existing capabilities, such as its TDI (time delay integration) technology. “We are taking the standard technologies used in wafer inspection and other applications such as flat-panel display inspection, and tailoring them a little for the needs of solar-cell inspection,” said Philip Colet, Dalsa’s VP of sales and marketing. “Right now, the degree of customization is somewhat small, but as we learn more, that will increase. The main differences are in the areas of speed, sensitivity, and spectral response.”

Since a solar panel can measure up to 2x2 m, the inspection equipment has to scan that surface very quickly to be efficient, said Colet. “For example, our area-scan Pantera 22-Mpixel camera takes fewer snapshots to look for gross surface defects because of its very large array,” he said. “For higher volumes and higher speeds, our TDI line-scan camera is used for large, thin-film solar cells.”

For more information:
After Agilent Technologies announced in February that it would leave the AOI (automated optical inspection) and AXI (automated x-ray inspection) equipment markets, other manufacturers made related announcements. Orbotech said in its fourth quarter statement that it had signed an agreement to sell its assembled PCB (printed-circuit board) business in Europe and the Americas, but planned to continue supporting and servicing its assembled PCB installed base in the Asia-Pacific region. The company continues to make AOI equipment for bare-board PCBs, flat-panel displays, and IC substrates. Meanwhile, Machine Vision Products and Viscom each issued press releases stating that their respective AOI businesses were healthy and that each was committed to its product roadmap.

Whether Agilent’s and Orbotech’s actions represent the start of a wave of AOI industry contraction and consolidation remains to be seen. Omron Electronics’ AOI business unit manager Chris Speck said his company hasn’t seen any consolidation yet, since each equipment manufacturer has a different, proprietary technology for AOI or AXI, and they don’t cross over well from one manufacturer to another. “Companies that aren’t as well capitalized as others might exit the market, as well as those for whom AOI is not a key product,” he said. “AOI is one of Omron’s key global product lines, and we have been investing heavily in this technology.”

Other large companies might also sell off their AOI capabilities, especially if it’s in a small division, said Jean-Yves Gomez, CEO of ViTechnology. “Since everyone has a different AOI technology, I don’t believe there will be consolidation by technology,” he said. “But there might be consolidation for the purpose of buying market share, that is, buying another company’s customers.”

Whether consolidation occurs will depend in part on how long a recovery takes, as well as other factors, said Carsten Salewski, CEO of Viscom. “For example, Viscom is one of the few AOI/AXI companies that is not part of a large group, [and] we are dedicated to test and inspection, most of it in electronics,” he said. “As one of the market leaders, we are in a strong position, both technologically and financially, to continue with our long-term strategy.” Salewski said he would expect to see more consolidation, and that “there will be fewer companies at the end of all this. The transformation of the market on the supplier side is not over yet.”

When Agilent made its announcement, the company cited commoditization in optical inspection products and the consequent lower ASPs (average selling prices), along with the large number of players, as major challenges affecting its decision. Not only is the market fragmented, but engineers use AOI technology for a variety of purposes, said Gomez. Some use AOI simply to make a “go/no-go” decision, labeling a board either OK or not OK. “They want more automation to avoid a lot of time programming, so they log known-good board information into the machine,” he said.

Others use AOI to improve productivity and fine-tune production. Explained Gomez, “These customers need a high level of programmability to program parameters so they can find very small defects to improve the process. These machines are all called AOI, yet they are not the same product.”
Most manufacturers agree that system prices have come down over the past few years, but they have different takes on why that has occurred. “The basis for founding YESTech in 2002 was the recognition that the inspection market and the technology—meaning, digital camera technology, and the processing power in the PC—is maturing and becoming more commoditized, and hence bringing down ASPs,” said Don Miller, YESTech’s CEO and president. There will still be IP (intellectual property) involved and differences among competitors, he said. “But in general, the market is offering more value and there are pricing pressures evident more so now than ever, especially in today’s market. This is a natural evolution.”

The key is to offer technology that addresses the ever-changing requirements of the market, said Miller. “In other words, to evolve and adapt and upgrade your product offering in response to the advancements in the technology that you are trying to inspect. This is the reason for adopting the commoditization instead of hiding from it. In this industry, if you are locked into IP from even just five years ago, you’re not moving fast enough to keep up. For customers, the benefit is they are getting more capability for a lower price, and a quicker return on investment.”

Salewski said it’s important to differentiate between lower-end image-comparison AOI systems versus higher-end algorithm-based AOI systems. The first type “learn” from known-good samples and traditionally are simpler to program. But over time, it becomes less easy to change the program because the database of known-good samples originating in normal process variations continues to increase. In addition, since there’s a greater variation of good images, the probability of missing real defects becomes higher.

The second type of AOI system consists of high-end machines commonly used for a zero-defect strategy in medical, military, automotive, and industrial applications, and consequently, they require more sophisticated programming. “Algorithm-based AOI systems are perceived as requiring a longer learning curve to program and operate,” said Salewski. “But the long-term results are that you always know not just whether an item has been classified good or bad, but why.” At the high end, Viscom looks at the cost of its product and reduces it where possible, “but we don’t compromise on the results,” he said. “For us, it doesn’t matter whether the technology used is optical or x-ray because we combine them. In our combined AOI/AXI approach, we have been very price sensitive.”

Not everyone in the industry agrees that products are becoming more commoditized. “I don’t think AOI equipment is becoming a commodity product,” said Speck of Omron. “Companies are not manufacturing these products any cheaper than they were a year or two ago. However, the ASPs of the base equipment have clearly come down as a result of AOI companies attempting to gain market share by reducing their profit margins.”

“We do not feel a $100,000 [US] AOI system is a commodity, much less a $500,000 x-ray machine,” said Jim Lin, VP of sales and marketing for TRI. “These are major invest-
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A0I systems such as ViTechnology’s 5K series are increasingly interfacing with SPC software. Courtesy of ViTechnology.

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A0I systems such as ViTechnology’s 5K series are increasingly interfacing with SPC software. Courtesy of ViTechnology.

MACHINE-VISION & INSPECTION

These customers were looking for alternatives to the premium prices that some other AOI manufacturers were charging. Therefore, Lin said, TRI’s business model from the beginning was to be very cost-effective. “ASPs do come down on the same model, perhaps 5% per year. But we get that back by introducing new models with more advanced features. From the customer’s point of view, they keep paying the same price and get better value.”

AOI is becoming very commoditized only for those who want a go/no-go machine, where there’s a lot of price pressure and competition on specifications, said Gomez. But other customers want to improve their processes, fine-tune parameters, understand what’s wrong in the production line, and get warnings when a process has drifted so they can react before a process’s limits are reached. “To meet these customers’ needs, give them higher ROI [return on investment], and create added value,” said Gomez, “vendors need to continually create new hardware and new algorithms, so these vendors suffer somewhat less from price pressure.”

Several manufacturers agree that, given the current business climate, it’s likely more vendors will leave the business and some consolidation may occur. Others, such as Viscom’s Salewski, believe that some recovery in the PCB assembly business could come as early as next year. “Meanwhile, if a smaller EMS goes out of business, there will likely be products that must be produced anyway, so that piece of business may get picked up by someone else,” he said.

AOI and AXI machines continue to improve, driven in part by changes in the technologies they inspect. Gomez said that 3-D is becoming important in AOI for both semiconductor and PCB inspection. “With BGA [ball-grid array] components, you need to be sure that all solder balls have the right shape for correct solder reflow, and 3-D inspection can give good information on that shape.”

Salewski added that interfacing with SPC (statistical process control), which is enabled by software, is a growing requirement.

“Agilent was the king of x-ray inspection technology, and now that...”
In-line AXI systems like TRI’s TR7600 use x-ray technology to penetrate PCBs and components and capture test images, during pre- and post-reflow. Courtesy of TRI.

they have left the market, it’s not clear where this technology is headed,” said Lin of TRI. “X-ray technology is pushed forward by customer requirements, such as the increase in dense IC packages like system-in-package, ball-grid array, and quad flat pack.”

Lin said that, in the future, high-density interconnect boards and embedded passive components will become more popular, and equipment manufacturers will have to adjust to these new technologies. “3-D in-line x-ray inspection systems will be a big part of the answer to these challenges for our customers in the data communications, telecommunications, and automotive industries.”

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