Official Monthly Publication of the Society for Information Display

INFORMATION DISPLAY

September 1994
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MONITOR ISSUE

Microprocessor-controlled monitors
Where are monitors made?
European monitor market scene
The way to San Jose

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Cover: At SID '94 in San Jose in June, several LCD manufacturers were showing prototypes specifically designed for automotive applications. This photo of a mock-up reflects Sharp Microelectronics' enthusiasm for the concept. It also makes clear that LCD makers will have to work closely with automotive systems integrators. What happens, for example, when the driver spills his coffee – which he seems about to do? Or when 10,000 noontime footcandles are incident on the horizontal displays in this pretty convertible? Making sure these questions get the right answers will supply some of us with job security.

Sharp Microelectronics

Next Month in Information Display

Flat-Panel Issue
- Active addressing
- Color plasma displays
- Computex Taipai '94

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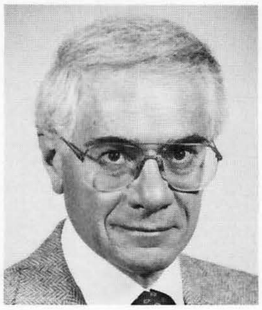
president's message



SID: Ready for Robust Growth

by Andras I. Lakatos

The past 12 months have been an outstanding period of growth and development for the Society for Information Display (SID). The society's membership stands at an all-time high. The 1993 International Symposium, Seminar, and Exhibition held in Seattle broke the previous attendance record, and included an outstanding technical program and a record-breaking number of exhibitors. In 1994 the Symposium was held in San Jose and attendance records were once again surpassed. SID '94 boasted the largest display exhibit ever held in North America. It included not only the larger, well-established companies, but also smaller and start-up firms, many of them based in Silicon Valley.

The 13th International Display Research Conference (Eurodisplay '93) was held in September in Strasbourg, France. It also drew an attendance that exceeded all prior figures. In addition to its stimulating technical program of research papers, Eurodisplay offered for the first time a half-dozen tutorial seminars. These seminars were first-rate and provided their attendees with textbook-quality lecture notes. The small but well-attended exhibit was another innovation at Strasbourg in 1993.

SID also organized two new international meetings: the Display Manufacturing Technology Conference (first held in January 1994) and the Color Imaging Conference (co-sponsored by the Society for Image Science and Technology and first held in November 1993). Based on their initial success, we are making both of these meetings annual events. Two new SID chapters were formed: the Beijing Chapter in the Asian region and the Mid-Europe Chapter in the European region.

SID rejuvenated the *Journal of the Society for Information Display*, its archival publication, with a more pleasing external and internal appearance and a new editorial policy that emphasizes timeliness and quality. *Information Display*, our magazine, is on its way to becoming the monthly news organ for the global display industry.

This growth could not have taken place without the tremendous worldwide growth of the electronic-display business. But these favorable economic conditions did not guarantee SID's growth by any means. The society grew because 4 years ago the Board of Directors began to recast SID from a North American technical society with a few overseas chapters into a truly international organization.

At the end of the 1980s, SID had essentially zero membership growth. Display manufacturing was steadily declining in North America and Europe and growing in Asia. But the society had an underlying strength. From its inception, SID had brought together three kinds of technical professionals:

- Research scientists working on new concepts and materials.
- Technologists developing display prototypes and new manufacturing processes.
- Manufacturing engineers responsible for the effective mass production of electronic displays.

continued on page 37

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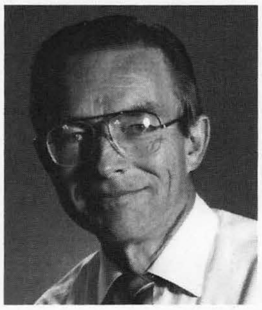


You Can't Do It All with Electronics

by Aris Silzars

As I watched, the brush moved swiftly, first from the water cup to the palette, then to one of the small globs of watercolor pigment around its periphery, then back again, but this time to a different color. As the process continued, the puddle took on a complex blend of blues, reds, and oranges. Not only were the colors blending in a multiplicity of hues, but the intensity was varying from place to place in what had originally been just a clear puddle of water.

On the white sheet of "cold-pressed" watercolor paper, one could see the faint pencil outline of a tree and some surrounding scenery – a Banyan tree in a tropical setting. As the small group of us sat watching, the brush began to create the trunk and branches of this tree. Some areas took on a dark bluish tint. Others had a strong hint of orange. Yet others were in blends of reds and greens. I looked at the real tree in front of me, then at the one beginning to take form on the paper, then back again at the real tree. To my eye, the trunk and branches on the real tree all looked a uniform dirty grey. Where did this person, wielding the brush with such self-assurance, see the oranges, blues, reds and other seemingly invisible hues. What would she end up with – some bizarre rendering of a fantasy tree? No, in actual fact, I had to admit that what I was seeing was a beautiful and quite realistic tree taking shape.

My engineering mind struggled to reconcile what I was seeing by attempting to analyze it all in terms of color pixels and how blues, greens, and reds make color images in displays. But I could clearly see that that was a most inadequate explanation. This tree had PERSONALITY! And it was the personality of the artist, combined with years of training and practice that allowed her to anticipate just what the final effect would be.

I had arrived at this tropical location a few days before with not the slightest intention of watching someone create works of art. I had agreed to join my wife on this trip with the proviso that I could bring along some business-plan review work and a laptop computer. The idea was that I would do my work while she participated in this skilled-artists workshop. However, by the second day I had become a fascinated and enthusiastic observer. I was learning and experiencing things that I would never see in a lab or at a technical conference.

Can you guess what happened next? After asking one too many questions, I ended up with a brush in my hand and a blank sheet of paper in front of me. Now, I would have the opportunity to try first-hand to see how the colors and intensities blend to produce a spectacular work of art. Or at least that was my fantasy.

Doing the starting pencil sketch wasn't too difficult, with my science training and some past drawing experience, and understanding how colors blend to produce other colors was not too much of a problem either. Who would have guessed that my career in display technology and my many years of photographic work would prove so handy. I had also already absorbed and understood why watercolor artists typically need at least 10 or 12 colors instead of just the three primaries to create all of the desired blends. (It has to do with the fact that real-life pigments are not truly pure colors, so one needs, for example, a red that is somewhat towards the orange, one that is a bit towards the blue, and

continued on page 39

Society for Information Display
1526 Brookhollow Drive
Suite 82
Santa Ana, CA 92705-5421
714/545-1526
Fax: 714/545-1547

Where Are CRT Monitors Made?

The geographical breakdown of monitor production changes slowly – but it does change.

by Rhoda Alexander

DESPITE CONTINUING CLAIMS of its imminent demise, the CRT monitor industry remains alive and well, exhibiting strong growth and continuing product innovation. Flat panels – the upstart rival waiting in the wings to unseat CRT monitors as the desktop display of choice – remain overpriced for most end users in today's cost-competitive PC market. With manufacturing exceeding 46 million units in 1993 (see Table 1), much of the CRT monitor's continued growth can be attributed to manufacturers' ongoing efforts to reduce manufacturing costs while incorporating product improvements.

As profit margins have steadily decreased in the CRT monitor industry over the past decade, manufacturers have been constantly forced to adapt – or fall behind more innovative competitors. Although the CRT monitor is a relatively mature display technology, room for innovation remains. Since product cost is such a huge part of today's monitor industry, much of the innovation is targeted at reducing component requirements, increasing mechanization, and making other improvements to reduce manufacturing costs. To date, companies have achieved many of their cost reductions by shifting manufacturing locations to take advantage of lower labor costs in developing regions, duty-free status, and proximity to markets. Many large manufacturers have production facilities in several different regions.

Rhoda Alexander is a Senior Analyst for Electronic Display Market Research at Stanford Resources, Inc., 3150 Almaden Expressway, Suite 255, San Jose, CA 95118; telephone 415/324-4553; fax 415/324-8150.

Table 1: Regional Monitor Production in 1993 (thousands of units).

	Color	Monochrome
Taiwan	14,089	3,013
Korea	8,381	2,769
Japan	3,116	199
Europe	1,961	527
North America	2,034	358
All Other Regions	5,959	3,903
Total	35,540	10,793

Table 2: Color/Monochrome Breakdown by Region in 1993.

	Color (%)	Monochrome (%)
Taiwan	82	18
Korea	75	25
Japan	94	6
Europe	79	21
North America	85	15
All Other Regions	60	40

The Big Three on a Rising Tide

Although labor costs in Taiwan, Korea, and Japan continue to climb, more than 68% of the world's monitors were still produced in these three regions in 1993 (Fig. 1). Taiwan remains the dominant manufacturing region, with almost 37% of the world's monitors manufactured in this region in 1993. Color displays represented approximately 82% of the total Taiwanese production in 1993 (see Table 2), up from 74% in 1992. The combination of component availability, historically inexpensive labor, local design expertise, and strong

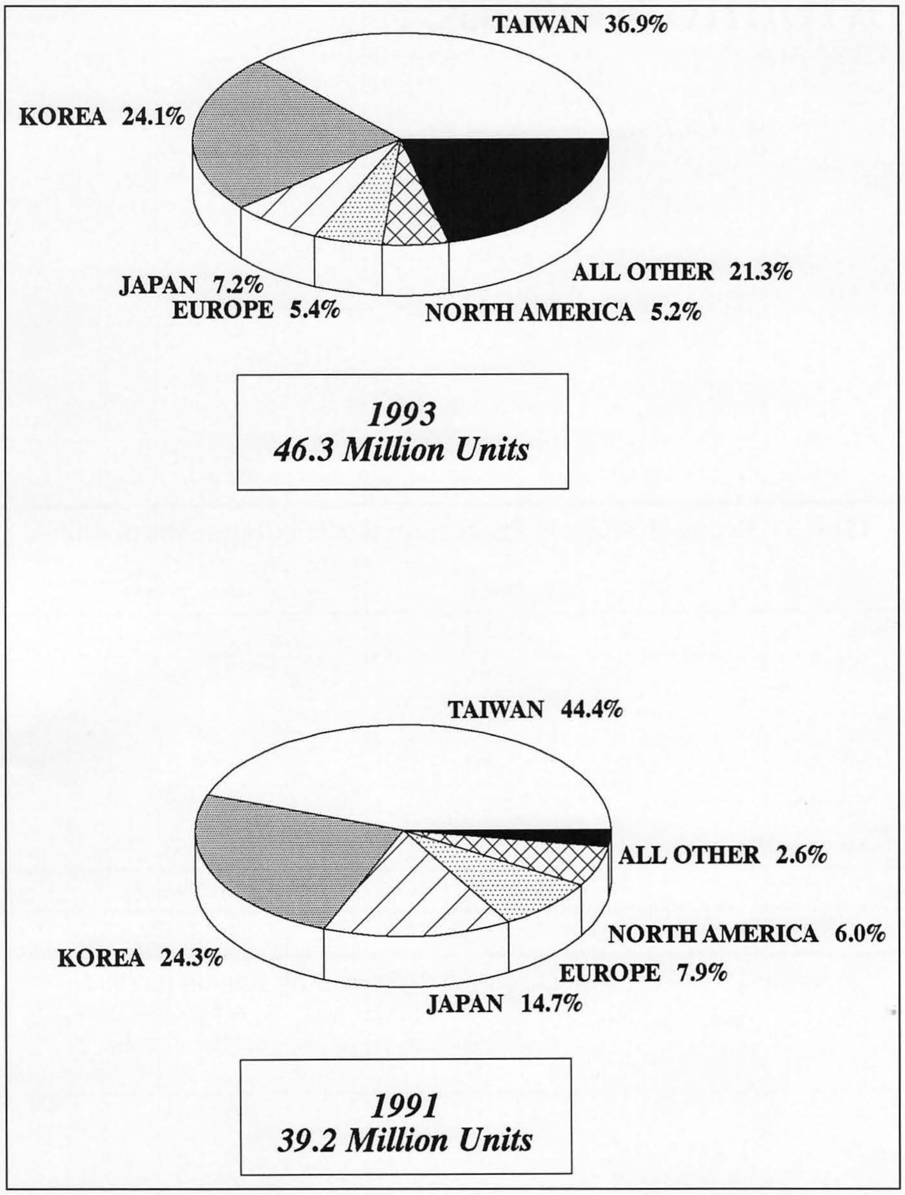


***Fig. 1:** A pie chart of the share of worldwide monitor production by region (monochrome and color) in 1991 and 1993 shows a growing pie with the biggest growth in share going to new manufacturing regions ("other").*

support from the Taiwanese Government has helped to establish Taiwan as a leading manufacturing region. However, as wages and benefit demands have steadily increased in Taiwan and the available labor pool has shrunk, manufacturers have been forced to seek cheaper manufacturing sites. Many Taiwanese manufacturers now produce monitors in China, Thailand, and Malaysia, which has reduced Taiwan's production share in recent years (Fig. 1). Although many of the world's top monitor manufacturers are based in Taiwan, an increasing share of their production is based in other regions of the world.

Korea, boasting some of the largest monitor producers in the world, is the second largest monitor-manufacturing region, representing approximately 26% of the world's production in 1993. Approximately 75% of the 1993 production was color (Table 2), up from 69% in 1992. Unlike their Taiwanese competitors, Korean manufacturers have been slow to shift manufacturing outside Korea.

Several of the manufacturers in this region offer branded product, but most of the production is targeted at OEMs. Samsung, Goldstar, and Samtron – three of the world's leading monitor suppliers – manufacture all of their displays in Korea. Specialists in large-volume production, most Korean manufacturers target the already established 14-in. market and the booming 15-in. market. Several of the Korean manufacturers produce CRTs in addition to monitors. Most of the CRT production is limited to 14-in. tubes, but Samsung has reportedly been producing 15- and 17-in. CRTs for internal consumption since early 1993.

With a well-established reputation for producing high-quality color displays, Japanese manufacturers still control most of the large-screen color market. As prices of 14-in. displays plummeted in recent years, most of the Japanese vendors abandoned the small-screen markets and focused on 15-in. and larger markets. These markets offer higher profit margins and more discriminating customers who are willing to pay a premium for a quality display.

The largest Japanese manufacturers have all established production facilities in other regions and have dedicated most of their Japanese production facilities to large-screen production. While only 7% of the world's monitors were produced in Japan in 1993, total Japanese production was significantly higher because 32% of the Japanese manufacturers' displays were produced off-shore. With a virtual lock on large-screen markets, Japanese manufacturers still control a large portion of the overall market by value. Although several Taiwanese vendors are gaining market share in the 15- and 17-in. monitor markets, Japanese manufacturers still control the tube market for these displays. Japanese vendors continue to supply almost all of the monitors for the workstation market, where quality and performance requirements are more critical than price.

Europe: Still an Ebbing Tide?

European manufacturing has dwindled in recent years and now represents less than

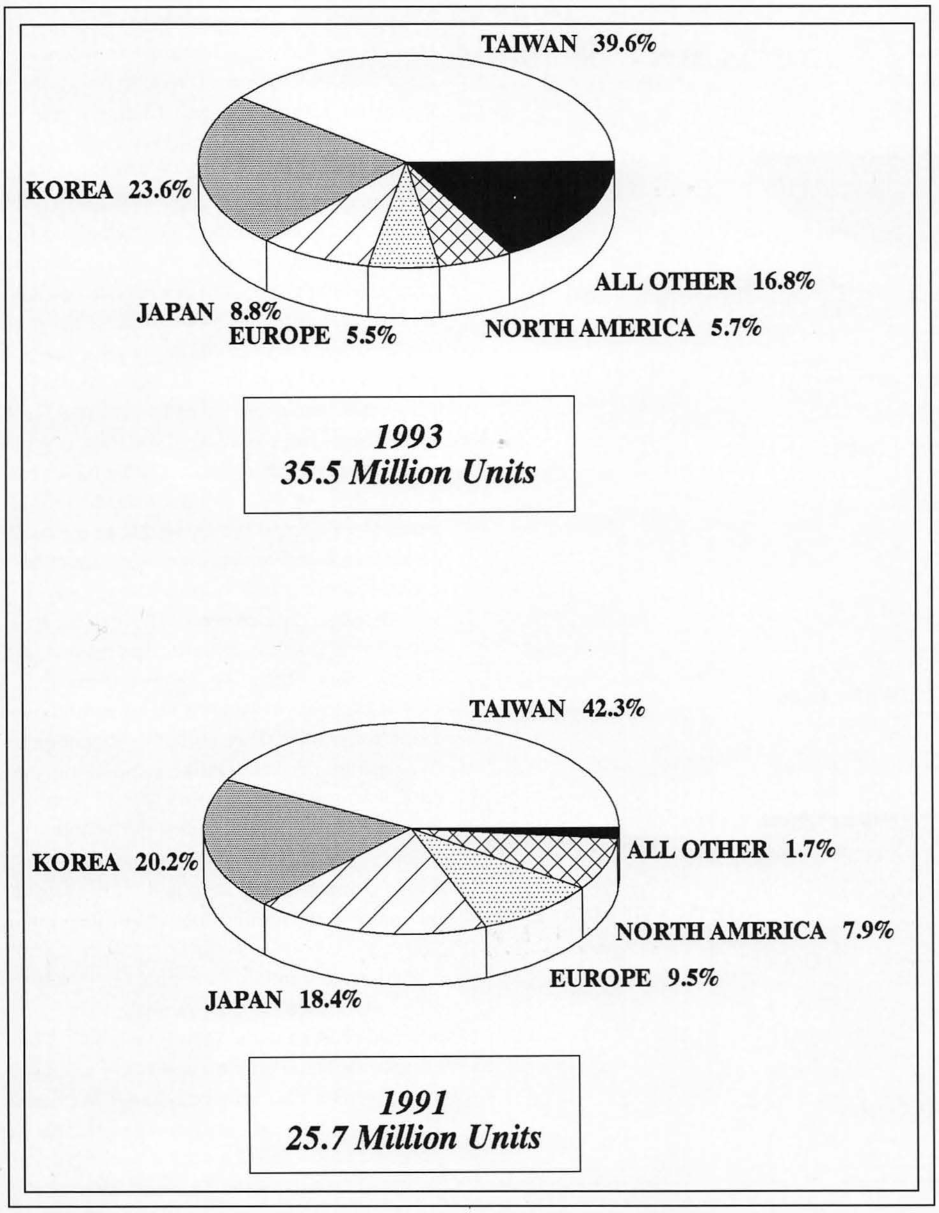


Fig. 2: *Share of worldwide monitor production by region (color only).*

5.5% of worldwide production. Color displays represented 79% of the total monitor production in the region in 1993. Several Far Eastern manufacturers who had prepared to expand production into Europe in anticipation of the closing of the European market to outside manufacturing have abandoned their efforts in recent years as too costly and impractical.

Concerns regarding the closing of this market have largely dissipated. Even Philips, the leading European manufacturer, produces most of its displays in the Far East. Hantarex, one of the region's large suppliers in the past, has reportedly suffered financial difficulties in recent years and may be exiting the monitor business. IBM, while instituting major product changes, scaled back production at its Greenock, Scotland, facility in 1993, but is expected to increase production in 1994. (For more details on the European market, see the accompanying article by Bryan Norris.)

North America: A Turning Tide?

Only 5.2% of the world's monitors were produced in North America in 1993, but production in this region is expected to expand in the next few years as several vendors consider Mexico as a possible production site. Mexico has always offered a large inexpensive labor force, but manufacturers have been frustrated by the lack of locally produced CRTs. Reportedly, several CRT vendors are considering the option of establishing production facilities in Mexico, which would allow monitor manufacturers in the region to take advantage of the trade benefits offered through NAFTA. With over 50% of the world's monitors consumed in North America, this could offer a substantial benefit to monitor manufacturers able to make the production shift. Japanese manufacturers Sony and NEC produced 43% of the monitors manufactured in North America in 1993. In addition to this large Japanese presence, Philips recently established monitor production facilities in Mexico.

The Big Other

Among the fastest-growing production regions is the one entitled "other" – which includes Malaysia, Thailand, Hong Kong, India, and China. Over 21% of the world's monitors were produced in these regions during 1993, up substantially from the 2.6% reported in 1991. Almost all of the production in this region is 14-in. displays.

China, with 49.1% of the production reported for this region, is the fastest-growing production area. As production of monitors and other goods in this region has increased, wages have escalated. The Chinese Government has recently imposed wage freezes in hopes of curbing inflation. Much of the development in China has been tied to Taiwanese firms. The few Chinese firms in the region have generally evolved from older television production companies. They lack the capital, as well as the design and marketing expertise, to be truly competitive in global markets. The larger Taiwanese firms are better positioned to develop and market display products.

Much of the remaining monochrome production has been shifted into the "other" region. Production in Malaysia, Thailand, and Hong Kong is predominantly color, with most of the monochrome production centering in

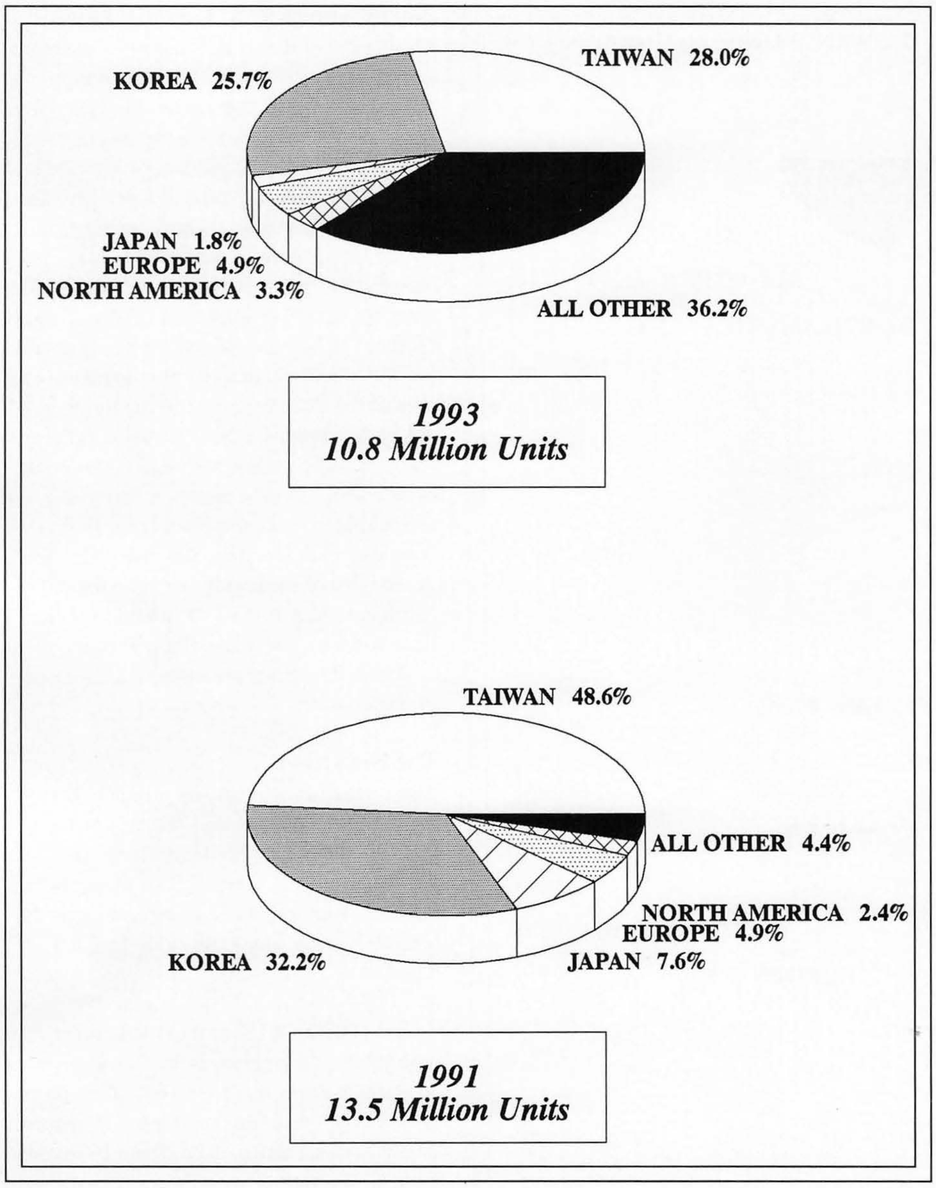


Fig. 3: *Share of worldwide monitor production by region (monochrome only).*

China and India. India, with locally produced monochrome CRTs and a large domestic market for monochrome displays, has focused almost exclusively on monochrome production. Some of the larger Indian firms have recently introduced color displays – most of which are purchased in kit form from Taiwanese manufacturers.

Although color production is expected to increase in India in the future, the lack of locally produced color CRTs and small production volumes are expected to hinder the output of color monitors. In 1993, 60% of the monitors produced in the "other" region were color displays.

CPU Sale vs. System Sale

Most of these shifts in manufacturing are invisible to the end user. Customers are not nearly as concerned about where the display is manufactured as they are with the identity of the manufacturer. Japanese displays are still generally considered superior regardless of their manufacturing site. Manufacturers tend to establish similar quality-control standards throughout their manufacturing facilities regardless of location. Thus, the key decision for most OEM customers is finding a manufacturer that has sufficient production capacity and the ability to meet the OEM's price/performance criteria.

Systems manufacturers have benefited from continual price erosion in color monitor markets in recent years. The abundance of qualified manufacturers in 14-in. markets has given OEMs tremendous flexibility in price shopping. As CPU costs have fallen in recent years, the display has come to represent an increasingly large portion of the total system cost. Systems manufacturers, who have seen a large share of their monitor sales lost to stand-alone competitors in recent years, have begun to expand marketing efforts aimed at retaining the monitor sale. These efforts include expanding monitor offerings beyond basic 14-in. displays and offering rebates on display sales. Reducing the cost of the display is essential to systems manufacturers vying for market share in the highly competitive desktop market. Unlike stand-alone vendors, who sell their monitors for use with other manufacturers' systems, the system manufacturer rarely sells a monitor for use with a competitor's system and relies instead on retaining the monitor portion of the system sale.

While many monitor manufacturers sell only to OEMs, a growing number offer branded product under their own label as well. Capetronic is the only manufacturer among the top ten to sell exclusively to OEM clients. Thus, a system manufacturer may find that its strongest competition for the monitor portion of the sale are the same manufacturers who supplied the display on an OEM basis. The products may appear to be virtually identical, with price and logo the only substantial differences to the end user.

The Shape of Today's Market

Approximately 100 manufacturers worldwide offer a wide array of products, leaving today's end user facing a dizzying abundance of monitor choices. With growing interest in larger displays, a multitude of manufacturers have introduced 15- and 17-in. units in the past year, which has fueled price wars in these developing markets. Following a slow start in 1991 and 1992, the 15- and 17-in. markets grew dramatically in 1993. With average street prices of 15-in. displays falling below $500, demand has escalated. Prices of 17-in. displays, previously priced between $1000 and $1500 have fallen below $1000, with some vendors offering units street-priced at $700 or less. Sales of these units are expected to double in 1994 as prices drop even lower.

Despite skyrocketing growth in the 15- and 17-in. markets, 14-in. color displays remain the dominant screen size. Although sales of 14-in. stand-alone displays have started to decline in the United States, sales of integrated systems featuring 14-in. displays have increased. Integrated systems such as the Compaq Presario, the IBM PS/1, and the Apple Performa are sold as bundled units with an integrated display and are not open to stand-alone monitor sales. By bundling a display with the CPU, vendors are frequently able to reduce the cost of the total system by eliminating redundant functions in the CPU and display, thereby reducing the component count.

However, sales of 15-in. monitors are expected to displace 14-in. stand-alone displays as the display of choice by 1995 in the U.S. marketplace. Worldwide, 14-in. color units are expected to remain the dominant display choice for several years to come.

With sales of 1024 × 768-pixel and higher-format non-interlaced color displays rapidly displacing lower-pixel-count color and monochrome units, it is interesting to reflect upon just how far monitor technology has progressed in the past 6 years.

In 1988 the VGA market was just starting to explode and almost half of the units were still monochrome; 14-in. displays had only recently displaced 12-in. units as the dominant screen size. By 1993 color-display sales had grown to 76% of the market, and 22% of the units featured screen sizes of 15 in. or larger.

Attributes such as MPR-II, tilt-and-swivel bases, color control, LCD readouts, multi-frequency capability, and power management have become standard on many units. At the same time, prices have fallen so that the $550 that would buy a 0.31-mm fixed-frequency VGA unit for the desktop in 1988 now purchases a 0.28-mm 15-in. flat-faceplate digitally controlled 1024 × 768-pixel non-interlaced multi-frequency display with MPR-II, power management, and on-screen display.

Design Trends

As the number of monitor providers continues to increase, vendors struggle with finding ways to differentiate products. Consumers, overwhelmed with the array of comparable displays, rely increasingly on magazine product reviews and assistance from salespeople to help them make a monitor selection. Two similar displays with seemingly identical specifications may offer widely different performance, depending on the underlying engineering, components, and construction. The casual shopper is ill-prepared to distinguish the differences in the two displays based on a surface inspection.

In the highly cost-competitive 14-in. market, product differentiation is especially difficult. Vendors must walk a careful line between providing sufficient features to make the display attractive and not weighing it down with added costs that the user is unwilling to absorb. Although prices have stabilized somewhat in the 14-in. color market in the past year, manufacturers are not expected to devote much effort to additional product features in such a low-margin market. Vendors remaining in this market are expected to focus on reducing component count and manufacturing costs.

Originally introduced in late 1991 at prices in excess of $750, the first 15-in. displays were already laden with features. Much of the development effort in the intervening years has focused on determining user requirements for various features. By eliminating such features as color matching, MPR-II, and wide horizontal scanning ranges, vendors can significantly reduce the price to the end user. As the price-conscious attitude that pervades the 14-in. market spills into 15-in. purchases, vendors are expected to offer a variety of 15-in. units ranging from feature-laden high-end models to more budget-priced displays. The budget-priced 15-in. models will probably utilize the newly developed lower-priced iron-mask flat-square tubes, and narrower scanning ranges or multiple-frequency options rather than true auto-scanning. While these new displays will not offer the performance of earlier 15-in. displays, the pricing is expected to lure buyers away from the 14-in. market. The other new development in the 15-in. market is Sony's recent introduction of its first 15-in. Trinitron® display. Sales of these units are expected to increase rapidly, especially in the Macintosh market, where users have shown a distinct preference for Trinitron® tubes in the past.

The 17-in. market – which includes displays featuring flat-square tubes, Trinitron® tubes, and Mitsubishi's new Diamondtron™ aperture-grille tube – is split into two distinct categories. The lower end of the market includes displays with horizontal scanning ranges from 30 to 57 or 64 kHz. The higher end of the market features units with scanning ranges of up to 82 kHz or higher. End users in the workstation and high-performance markets will generally opt for the high-end display, while the 64-kHz version is sufficient for the average Windows™ user. As additional vendors enter this market, end users must look beyond the basic specifications to determine the wide range of quality differences in the various displays. A 17-in. purchase represents a significant capital investment and deserves careful research.

The market for 20-in. and larger displays remains relatively small, largely limited to workstation and high-end graphics and specialty markets. This segment is expected to grow, but much more slowly than the 15- and 17-in. markets. Performance demands are constantly increasing in this market, where users are willing to pay for quality improvements. While sales of 20-in. units currently eclipse 21-in. sales, the recent introduction of Mitsubishi's Diamondtron™ 21-in. unit and continuing growth in 21-in. flat-square markets is expected to contribute to growing 21-in. sales.

Beyond Just Staying Afloat

So, what effect do all of these changes have on today's monitor manufacturers? This is not a market for amateurs. Manufacturers hoping to navigate safely through the treacherous waters of declining prices and increasing performance requirements will need to run lean ships, paying close attention to shifts in customer requirements, innovations in manufacturing, reducing components, and savvy marketing. Quality is key in large-screen markets, and poorly designed product releases can damage even well-established vendors. There is plenty of profit still to be made for those vendors willing to adapt, but manufacturers hoping to rest on past accomplishments can expect to lose ground as more innovative competitors seize the day. ■

Microprocessor Control for Monochrome CRT Monitors

Digitally controlled monitors provide the seemingly impossible – lower cost with better performance.

by Ken Compton

FOR EVERY ACTION there is a reaction, particularly when setting up a CRT monitor. Adjust one trim pot and the change you've made will require you to adjust at least one other – and the sequence goes on and on.

High-resolution monochrome monitors that use analog circuits for a single frequency – a type that still represents the majority of monochrome monitors on the market – often have 20 adjustment pots for internal factory settings, which are in addition to the user controls. For a multi-frequency display, that count can easily double.

Now, a monitor architecture has been developed that places a microprocessor at the heart of the system. One advantage is that the pot count can be reduced virtually to zero for both single-frequency and multi-frequency monitors. Advanced microprocessor control can provide other benefits to the customer and manufacturer. The customer benefits by receiving a consistent product that is factory set to specific values – not subjective and/or arbitrary pot settings. Manufacturing no longer requires diddle sticks and pocket protectors; the tools are PC keyboards and software/firmware that are far less prone to mistakes regarding proper system functionality. Even geometric alignment – another operator-dependent set-up procedure – can be automated.

Ken Compton is Director of Marketing at Clinton Electronics Corp., 6701 Clinton, Rockford, IL 61111; telephone 815/633-1444, fax 815/633-8712. He is a Contributing Editor to Information Display.

The use of an embedded microprocessor provides the display with real-time calculated performance and tangible benefits. Four specific areas illustrate the microprocessor's potential to coordinate and improve display control functions:

Trim-pot profusion and interaction. The interactions among the trim-pot adjustments, bad enough in single-frequency displays, become an even bigger problem with multi-frequency displays. However, when the monitor is under the control of a microprocessor and an application-specific integrated circuit (Micro/ASIC), there is automatic compensation for even the most basic interactions between parameters such as vertical size and linearity. The same compensation is applied to the horizontal sweep to maintain linearity and size at the proper values when one of them is adjusted. The automatic compensation is calculated in real time and scaled to the horizontal and vertical synchronization for the display format being used.

Control of shape. The microprocessor can calculate the best fit for the "horizontal shape" – making sure the active area is rectangular instead of trapezoidal – along with control of size. For the horizontal, this process is carried out in blocks of lines, approximately 29 lines per block. Each block represents a new calculation for pin, trap, center, and horizontal size. This permits the control of edge linearity (pincushion) from a dynamic digital-to-analog converter (DAC). Straightening the edge from a keyboard builds a set of final values for a look-up table that reflects the yoke's performance characteristics.

For monochrome displays, manual pincushion adjustments with magnets have always been a compromise with focus. The more magnets you use to correct pincushion, the more detrimental the effects on focus become. Setting pincushion dynamically with the Micro/ASIC permits the use of fewer and/or weaker magnets, and more yokes can be qualified in production. With the proper connections, customers themselves could fine-tune the edge geometry from the keyboard.

In addition, a closed-loop automated alignment system can be used to pin geometry – a process an embedded microprocessor makes practical for color as well as monochrome.

Bias compensation with changing line count. When the pixel format is changed on a multi-frequency monitor, the electron-gun bias – which determines the pixel size – typically remains the same. As a result, if the line count is reduced from 1280 to 768, for instance, the space between the lines opens up. With microprocessor control, the voltage bias on G1 and G2 can be adjusted to change the pixel size automatically.

Dynamic focus. An analog implementation of dynamic focus generally uses a parabolic waveform capacitively coupled to the static dc focus component. Some very-high-resolution displays also incorporate a second variable axis of focus to deal with the corners. But such solutions do not differentiate between the top and bottom corners very well, nor do they go far enough in compensating for the differences between tubes and yokes.

Fortunately, the Micro/ASIC approach provides a dynamic solution that can differentiate

Clinton Electronics Corp.

Fig. 1: *Microprocessor-controlled monitors provide better performance with fewer components at lower cost. Clinton's family of smart monochrome monitors, the company's first, was introduced in June at SID '94 in San Jose.*

between the top and bottom corners, the edges, and the center. Since the waveform is constructed in small segments, it can be tailored to the specific CRT/yoke combination on each chassis with keystrokes on a keyboard. The end result is improved and consistent screen focus rather than a compromise between the screen regions.

A Hidden Benefit

Handpicking parts and selecting resistors to bias devices are not compatible with automated production, but the horizontal base drive, in particular, benefits from customized selection of values. Since power-output devices vary within every lot, it follows that not all displays are running at optimum gain and efficiency with preset drive values. This can result in premature failure of the horizontal output – a known failure mode in some commercial displays. During the production of microprocessor-controlled monitors, the base-drive bias level can be adjusted from a keyboard to match the device's characteristics for optimized operation and better life.

The Microprocessor's Heritage

At SID '94, held last June in San Jose, California, Clinton Electronics Corp. introduced a family of microprocessor-based monitors (Fig. 1). This raised some eyebrows because for 30 years Clinton has been known as a manufacturer of monochrome cathode-ray tubes (CRTs). But it was our long experience manufacturing monochrome CRTs and matching tubes to yokes that made us realize how impressive the strengths of microprocessor monitor technology are. Even in manufacturing our first family of monitors, a basic Clinton tradition continues: the monitors are monochrome.

This first family of products utilizes a Motorola 68HC11 series 8-bit microcontroller, a high-density CMOS unit with sophisticated on-chip peripheral capabilities, and a nominal bus speed of 2 MHz (Fig. 2). The 68HC11 is available in many application-specific configurations.[1] We selected the following architecture:

- A ROM of 12 kilobytes (kB) for system bootstrap and operating parameters.
- A 512-kB EEPROM containing the factory settings and optional user memory.
- A static RAM of 512 kB for the CPU core and temporary user formats, which are used primarily during factory set-up.

The 68HC11 also has an enhanced 16-bit timer system, along with counters and comparators to measure frequency and time intervals within the analog circuits for assessing the monitor's status and control loops. Five ports (A–E) round out the microcontroller's major features.

An RS-232 serial communications interface allows the microprocessor to be linked to manufacturing. Internally, a serial peripheral interface forms the link to the ASIC. The two serial interfaces reside on the same port (D).

Three multi-function ports (A, B, and C), with eight serial lines each, complete the link to the ASIC. Various port configurations – in/out, in only, or out only – are possible for these ports, but the remaining port (E) is a dedicated analog-to-digital converter (ADC).

Linking Digital to Analog

When all is said and done, the CRT is an analog device, and a microprocessor can not control the analog circuits of a monitor by itself. The bridge between the digital and analog environments is provided by an ASIC.[2] The one exception, however, is the microcontroller's ADC 8-line port (E) used to monitor critical analog functions applicable to both monochrome and color displays.

Through the other 8-line ports – A, B, and C – 8-bit digital values are passed to the ASIC to control the analog circuits. A few examples of these circuits will provide a glimpse of the dynamic solutions possible with a Micro/ASIC approach.

The control voltages that fan out from the ASIC into the analog world are 0–5 V, allowing circuit paths to be close together. This permits the overall board set to be small, with very few cables. Low voltages are the rule throughout the system until analog power is delivered to the deflection system and the CRT. Static voltages that control dc focus, dc vertical and horizontal centering, and the G2 cutoff voltage for the CRT are themselves

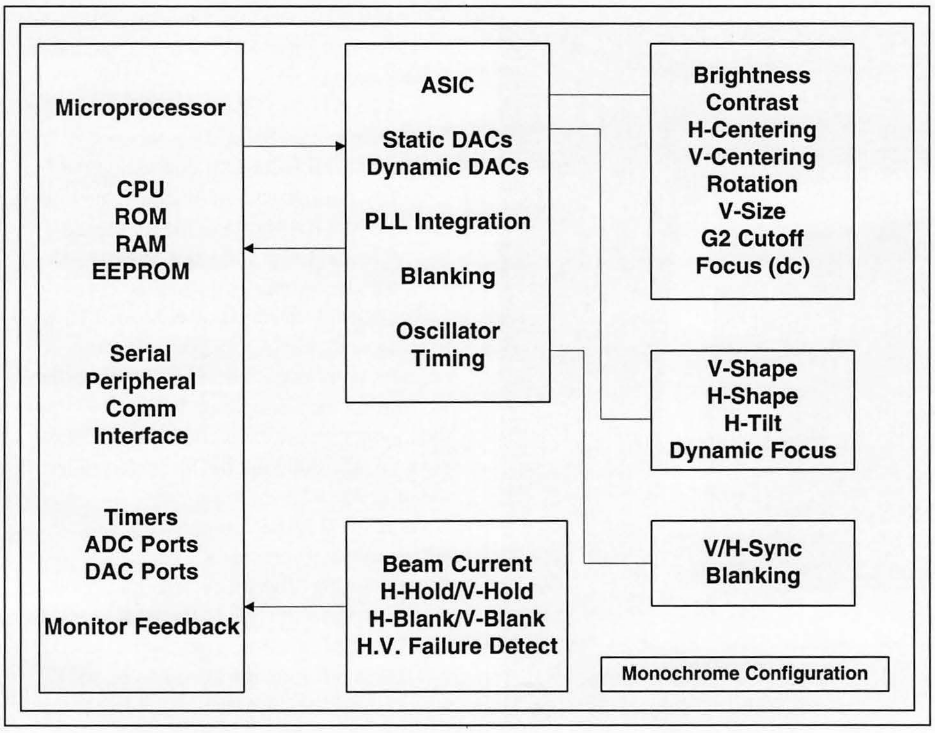


Fig. 2: *Clinton's first family of microprocessor-controlled monitors utilizes a Motorola 68HC11 series 8-bit microcontroller, a high-density CMOS unit with sophisticated on-chip peripheral capabilities, and a nominal bus speed of 2 MHz.*

controlled by static DACs on the ASIC. The user's brightness and contrast settings are also controlled by static DACs.

But static solutions alone do not make for a good display, so the ASIC design also provides dynamic DACs that function like hardware segment generators, which build complex waveforms in small increments scaled to the vertical and horizontal frequency. Focus, shape, and edge linearity are just three of the areas that benefit when these waveforms are applied to the deflection and focusing system.

Making the Factory Connection

Despite the many preset values recorded in the EEPROM, factory adjustments must be input via the keyboard. The main reason is that CRTs and yokes – quintessential analog devices – vary substantially even within the same lots. Randomly combining CRTs and yokes produces units with varying characteristics – not at all what Eli Whitney had in mind when he laid out the principles of mass production via interchangeable parts in 1798.

Fortunately, this variability can now be addressed by feeding the appropriate data to the microprocessor's RS-232 port. The port is connected to a PC with a menu-driven program that provides direct access to the microprocessor. The program displays over 80 fields of information on the current status of the system. This includes actual voltages, relative settings subject to adjustment, and status-only values.

Changing values is simply a matter of direct input. With a conventional monitor, adjusting one trim pot can require the subsequent adjustment of several others because the adjustments interact. The Micro/ASIC takes care of this automatically by re-calculating the required reference voltages. The final adjustments are then saved over the initial settings in EEPROM as factory default values. Customer-specific formats can be installed in EEPROM per OEM specifications. This data can provide, for example, the proper sync-timing delay to position the video within the raster.

The final settings become a record, both in the display and the manufacturer's production log, which is tied to the specific display by an ID number. This also provides an immediate quality feedback loop. If values being modified by an operator are outside of established limits, the information is immediately available and the reason can be evaluated. More importantly, the limits are in software, so the settings cannot leave the established range without being noticed.

Combined with a modular approach to system design, the microprocessor allows convenient upgrading to new performance requirements. Hardware changes for specific applications will require some software reconfiguration, but the hardware that is modified will still be controlled by the same 0–5-V control signal at 8 bits of resolution.

The programmable nature of the system also permits a greater degree of flexibility in addressing various standards, such as display power management, and how they are implemented. A typical approach is to include the RS-232 line in the video cable so that the microprocessor can be accessed directly from within the videographics driver software. Customer-specific adjustments, including brightness and contrast, can then be manipulated from a program manager, perhaps in a pull-down window.

Another part of the microprocessor's internal capability is the watchdog feature that monitors software execution and system operation – and will shut the system down if a fault is sensed. A set of system status lines, closely coupled to the watchdog, can monitor predetermined values and set a corresponding bit if a failure occurs. This bit can be read from a PC, making service easier.

For the OEM and ultimately the end user, the microprocessor-based display can be used across various platforms and display formats. This flexibility is achieved by putting all those calculations into software that the design engineer evaluates in designing monitors for various application platforms and frequencies.

Notes

[1]Motorola *Semiconductor Technical Data Manual.*

[2]ASIC chip DLAB520A, monitor interface microchip (MIMiC™) by Display Laboratories, Inc. ■

The European Monitor Market Scene

Sales are up and screen sizes are growing, but 14-in. monitors still dominate.

by Bryan Norris

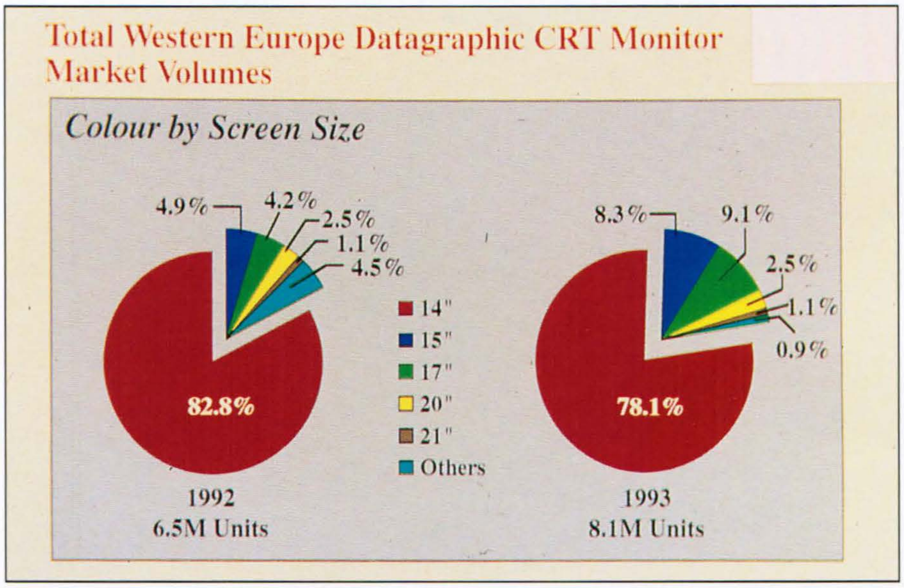
THE TOTAL Western European datagraphic monitor market increased to 8.6 million units in 1993, up over 16% compared to the 7.4 million in 1992. (This was broadly in line with the growth in PCs and PC-associated products.) Of this total, the percentage of monochrome monitors declined to 6.5%, down from 13% in 1992 as the swing from monochrome to color continued. Nevertheless, the few remaining monochrome suppliers, such as Philips and Tatung, had a very rewarding year in terms of the number of units they sold!

Within the color segment, the movement to large screen sizes and higher resolutions also progressed. Of the 6.5 million color monitors sold in Western Europe in 1992, nearly 83% employed color display tubes (CDTs) with a 14-in. screen size (Fig. 1). Sales of 14-in. monitors actually increased overall in Western Europe from '92 to '93, with the result that the 14-in. sector still represented a surprising 78% of the 1993 color total of 8.1 million units – the total itself up nearly 25% on 1992.

The main reason for the continuing success of 14-in. sales was the slowness of the changeover to 15-in. FST screen-size monitors in Europe. The sales of 15-in. monitors did grow from 4.9% of total color sales in 1992 to 8.3% in 1993. But most of the movement was towards the year's end, and this swing is still quite a lot less than most of the pundits – myself included – were predicting at the end of 1992. Why was this? In my opinion, there are two major reasons.

First, unlike the situation in the United States of America, there is still no United States of Europe – despite the EC and EFTA. In Western Europe, with its monitor market not too different in size from that of the USA, we have to contend with 16 *individual* countries – each with its own preferences, expectations, parameters, and foibles. When it comes to buying 15-in. monitors, end users in most of the Southern European countries such as Italy and Spain generally asked first, "How much?" And, on finding that a 14-in. monitor was still much cheaper, all still voted with their purchasing orders for the 14-in. monitors – and paid for them 3 months later, if the supplier was lucky.

***Bryan Norris** is Monitor Program Manager at BIS Strategic Decisions, Ltd., 40-44 Rothesay Road, Luton, Bedfordshire, LU1 1QZ UK; telephone 44-582-405-678, fax 44-582-454-828. He is a Contributing Editor to* Information Display.



BIS Strategic Decisions, Ltd.

***Fig. 1:** The Western European market for color monitors grew nearly 25% between 1992 and 1993. The movement toward larger screen sizes and higher resolutions was clearly under way, but was progressing more slowly than many analysts had predicted. Although 14-in. monitors lost share, they actually gained in gross sales.*

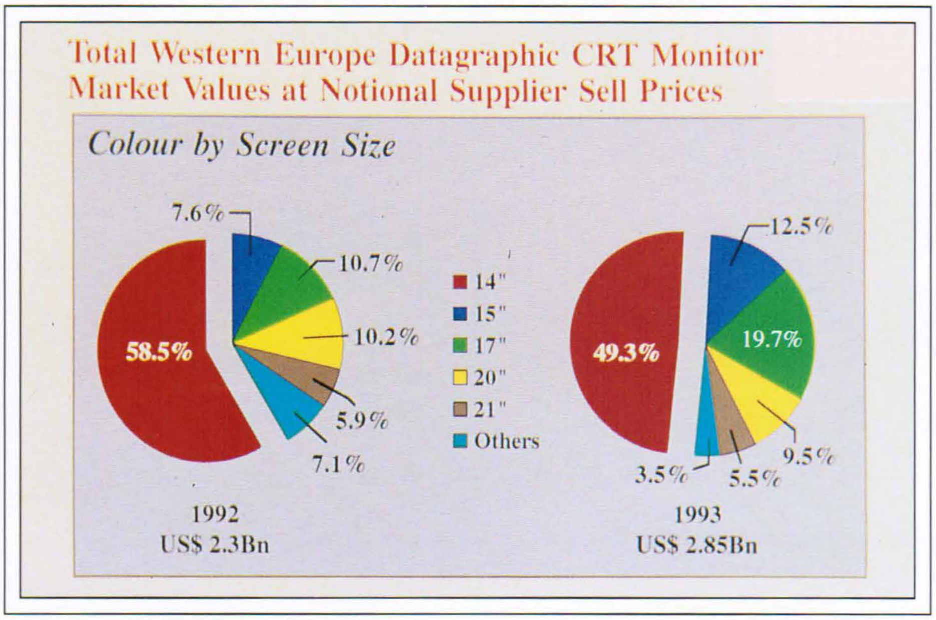


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Fig. 2: When we look at sales value instead of sales volume, the 14-in. segment does not fare as well. The value dropped below 50% of the market in 1993, while the value of the 17-in. screen-size segment nearly doubled to take almost 20% of the market.

Fig. 3: The substantial R&D investment of European monitor manufacturers has produced a number of product innovations. Among them is Philips (Italy) Cyberscreen® technology, which digitally controls the beam at each point on the screen to achieve all-over optimum convergence, color, and brightness.

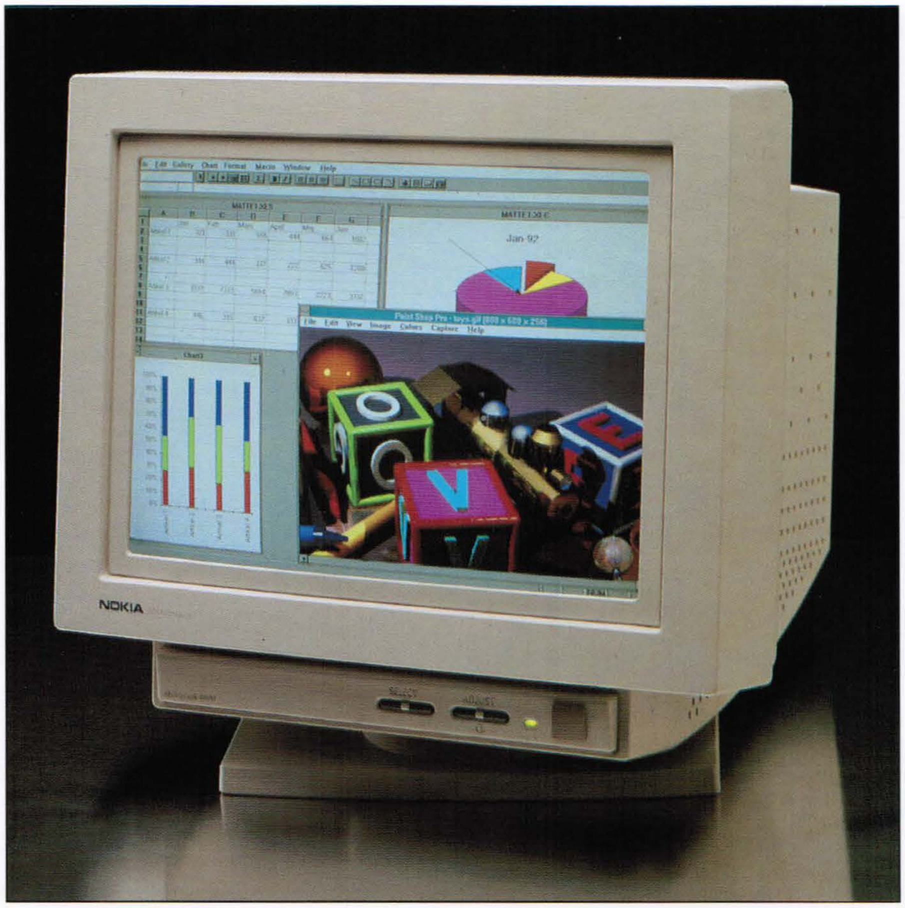
In Northern Europe – Germany and Sweden being particularly good examples – the first questions were likely to have been about better specifications, such as increased display area, higher resolution, or low-radiation certificate. And after some serious consideration, many purchasers then bought 15-in. monitors for the better specifications – despite the price.

However, 1993 was a recessionary year in most of the European countries, which explains the second major reason why 15-in. sales were sluggish. End users opted primarily for the cheaper 14-in. monitors to go with their new PCs – even in Germany! But 1994 has seen the introduction of (relatively) low-cost 15-in. monitors, so maybe the start of the real metamorphosis from 14- to 15-in. screen sizes in Europe is about to take place.

We saw the end of 16-in. screen-size monitors in Europe in 1993. Never a success in Europe, the last of the stock of Eizo (Nanao) 16-in. units were sold off in various countries by the maker's offices or distributors. The most successful outlet was undoubtedly Raab Larcher (formerly Rein Elektronik) in Germany. Raab transferred its success to 17-in. sales.

This success in selling 17-in. monitors also applies to many other European suppliers. As can be seen in Fig. 1, sales of 17-in. color monitors grew from 4.2% of the total in 1992 to a staggering 9.1% in 1993 – more than that of 15-in. units – as the "professional" end users of Europe adopted this screen size as their new working model. No doubt this was primarily due to the success of Windows™-based software packages, and for the ease of moving spreadsheets around the screen that the 17-in. units offer.

Sellers of 20-in. models in Europe also had a rewarding year. Although they remained at 2.5% of the total color market, this represented an increase of over 25% in units sold. In a year of financial restraint, the end user opted for the much cheaper 20-in. rather than the newer 21-in. models. Thus, although 21-



Nokia

Fig. 4: Finland's Nokia has introduced the world's first monitor containing Sony's new 15-in. Trinitron® aperture-grill tube.

in. models maintained their share at 1.1%, much more had been expected for them. Again, the advantages of the FST – a flatter screen with more corner area and that extra inch on the diagonal – do not command an unlimited premium from the end user. And in 1993 the extra charge of around $500 was too much for most purchasers.

When we look at volume, 14-in. monitors continue to be important. When we redraw the sales charts to show value (by using our estimates of the prices suppliers charge their sales outlets for monitors), we obtain a different perspective (Fig. 2). The value of the 14-in. segment dropped below 50% of the US$2.85 billion Western European color market in 1993. On the other hand, the value of the 17-in. screen-size segment nearly doubled to take almost 20% of the market, and the 15-in. segment grew to take another 12.5%.

The total Western European monitor market can be subdivided into three segments. First, there is a total Europe overlay consisting of a "closed-to-local-country-suppliers" section made up, primarily, of large PC OEMs such as Apple, Compaq, and IBM. The remaining "addressable" market can be broken down into two further segments: (1) the local country OEMs, which include prominent examples such as Elonex in the UK, HP in France, ICL in Finland, Olivetti in Italy, Tulip in the Netherlands, and Vobis in Germany, and (2) the local country "branded" market, which includes well-known suppliers such as Eizo (Nanao), Goldstar, Hitachi, Mitsubishi, NEC, Panasonic, Philips, Samsung, Sony, Tatung, and Taxan, plus some local European makers such as Hantarex, Microvitec, and Nokia. Each of the three segments constituted approximately one-third of the total market in 1993. Within the addressable (two-thirds) segment of the market, 31% of sales were made in Germany, approximately 16% each in Italy and the UK, 12.5% in France, and nearly 11% in the four Nordic countries combined – Denmark, Finland, Norway, and Sweden.

The Product

Over 60% of the color monitors sold in Western Europe in 1993 were Super-VGA 14-in. models, 12% of these operating flicker-free (800 × 600 at 72 Hz). Another 12% were capable of running 1024 × 768 non-interlaced at a flicker-free refresh rate. Most of these 14-in. models, and nearly all of the larger screen sizes, meet the MPR-II low-radiation recommendation. Generally, only in southern Europe were end users prepared to forego low radiation for a cost saving. In Sweden and, more recently, Germany, some institutional and governmental bodies demanded – and got – monitors meeting the even more stringent TCO low-radiation recommendation.

Sweden and Germany were also in the forefront of the "green revolution," embracing both "power-down" to below the 8-W (NUTEK) level and the use of "pure and recoverable" materials during the monitor production process. There is no doubt that "ergonomically sound" products are high on the list of desirable features for the 1994 monitor.

The Suppliers

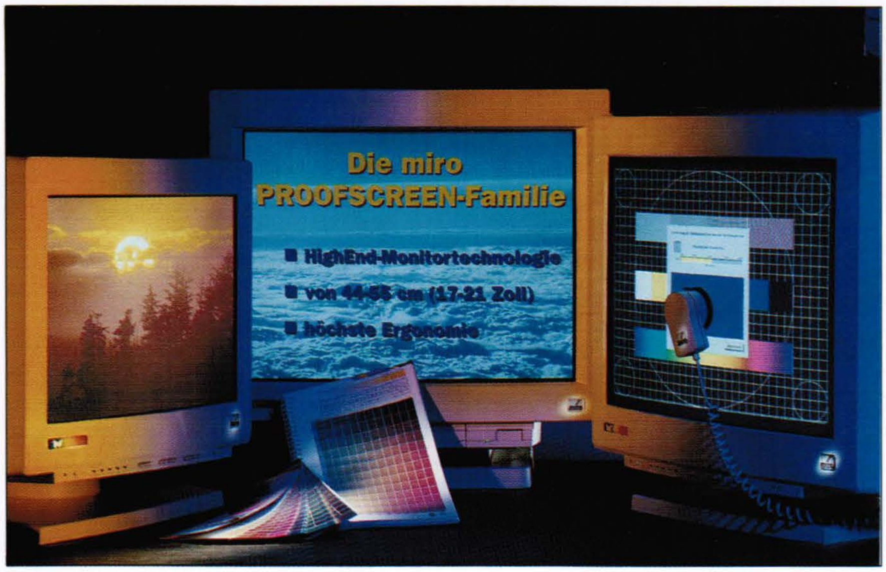
Approximately 5.5 million of the monitors sold in the West come from Taiwan or Taiwanese manufacturing plants elsewhere in the Far East. This is not surprising when it is realized that Philips, the number one supplier in Europe, makes most of its monitors in Taiwan. In addition, there is Tatung and a long list of Taiwanese companies that were also active in Europe, including Acer, ADI, AOC, Capetronic, CTX, Lite-on, MAG, Sampo, and TVM. Other Far Eastern monitor sources included, of course, the South Koreans – Samsung and sister company Samtron, Goldstar, Daewoo, and Hyundai.

With this powerful Asian presence, it is not often appreciated outside Europe how important are local manufacturers and suppliers.

The Manufacturers

Hantarex of Italy produced over one million monitors in 1992. Primarily because of its

(a)



(b)

miro

Fig. 5: *European companies excel in the development of high-specification monitors equipped with sophisticated graphics boards. The offerings of one of these companies – Germany's miro – are representative.*

deeply troubled financial state, the company's 1993 production was well down, and a forecast for 1994 is impossible to make. On the other hand, Finnish Nokia goes from strength to strength, and its 1993 production was not too far short of the magic million monitors a year. In addition, there are the Greenock, Scotland, operations of "Big Blue" IBM. Although in 1993 IBM sourced much of its European monitor requirement from the Far East, and Greenock ran very light, in 1994 Greenock production is back up and will easily exceed one million units.

There are also the production plants of European Monitors in Scotland, NEC and Tatung in Telford, England (all with over 200,000 units a year capability), plus numerous smaller operations, such as Microvitec, serving specialist markets. Philips, too, has a monitor production unit near Milan, Italy, which makes its top-end 20-in. Trinitron® and 21-in. FST monitors.

Product Development

All these European operations spend a great deal on R&D. This produces a number of product innovations, many of which were described in detail in the CeBIT '94 show review in the July/August issue of *ID*. For example, Philips in Italy developed the revolutionary Cyberscreen® technology, which digitally controls the beam at each point on the screen to achieve all-over optimum convergence, color, and brightness (Fig. 3). Nokia, as well as being in the forefront of low-radiation development, introduced the world's first 15-in. monitor containing Sony's new 15-in. Trinitron® aperture-grill tube (Fig. 4). ICL announced a module (AutoBRITE) that attaches to its monitor and sets the brightness and contrast to suit local lighting conditions. And Tandberg Data of Norway brought out a monitor that contains a 486 PC.

An area where European companies are really in the vanguard of development and presentation is high-specification monitors equipped with sophisticated graphics boards (Fig. 5). Notably, four German companies offer top-quality monitor/graphic-card products – Elsa, Kontron, miro, and SPEA.

Miro introduced the first monitor fitted with the exciting new 21-in. Diamontron® aperture-grille tube from Mitsubishi at the CeBIT show in March 1993, and the monitor was on the market by May. By the end of the year, the new tube had appeared in monitors from IBM, HP, and Mitsubishi itself. Since then, IDEK has also announced monitors with this tube.

The Future

In spite of continuing economic difficulties in many European countries, further growth of well over 10% in 1994 can confidently be predicted for the total Western European datagraphic monitor market. The bulk of the monitors sold in 1994 are again likely to be SVGA 14-in. models, albeit now capable of operating at a non-interlaced resolution of 800 × 600 with a flicker-free refresh rate meeting the MPR-II low-radiation recommendation. These monitors are increasingly likely to be microprocessor-controlled and to boast a "power-down" facility.

Sales of 15-in. models in Europe should now grow at a faster pace as the price premium over the 14-in. models reduces considerably. Certain of the local PC makers, such as Viglen in the UK, now promote 15-in. screens as standard, although there is still a 14-in. alternative that saves £60 (US$90). If some of the major PC houses start similar heavy promotions of 15-in. models, then the swing to 15-in. units will be accelerated. (It is forecast that 7.5 million 15-in. CDTs will be produced worldwide in 1994! This could lead to a glut in tubes and in 15-in. monitors, and consequently to an even greater swing.)

The 17-in. monitor seems assured of a very bright future in the European environment. And 20-in. models are still expected to sell well for some while before falling prices allow the 21-in. models to seriously erode their market share.

The exceedingly high prices of stand-alone monitors incorporating new-technology flat-panel displays (FPDs) is impeding their sales in Europe. In 1994 we have seen the odd 1000-plus order in Europe for FPD monitors for a niche application. But the era of the economically priced flat-panel unit challenging the CRT-based monitor is not likely to occur until 1995 at the earliest – unless the FPD manufacturers lower their prices dramatically. ■

Circle no. 9

Circle no. 10

conference/show report

The Way to San Jose

SID '94 found lots of friends in San Jose – more than ever before.

by Ken Werner

THE DISPLAY INDUSTRY is bubbling with excitement these days, and the bubbles tickled noses everywhere in San Jose during the week of June 12th. That's when the Society for Information Display's International Symposium, Seminar, and Exhibition (SID '94) occupied a large section of San Jose's McEnery Convention Center.

Overall, conference, show, and seminar attendance was up to approximately 4000, compared to 2500–3000 in 1993. (The numbers are approximate because it's difficult to track exhibit-floor attendance precisely.) There were 1480 full conference registrations, compared to 1192 in 1993; 580 registrants for the Monday and Friday Seminars, compared to 422 in 1993; and 330 registrants for the How-to Seminars, compared to 293 in 1993. The number of exhibit booths was up to 220 from 1993's 180.

Trends

Active-matrix LCDs (AMLCDs) are becoming a mature technology. There is no question that the leading manufacturers can routinely make high-quality color displays, and are doing so with continually improving yields and (in some cases) profitability. For high-information-content (HIC) displays generally – color and monochrome, active matrix and passive matrix – increasing capacity is coming on line in Japan and Korea. The focus is on cost, availability, product refinements, developing new technology variations, and filling every conceivable market niche. But that's not to say that the new technology variations aren't significant.

Motif displayed its active-addressing LCD (AALCD) prototypes based on Motorola-supplied ASIC chips, as did Motif licensee Optrex. Several manufacturers were showing reflective LCDs – some of which were active-matrix units based on thin-film diodes (TFDs) – for use in personal digital assistants (PDAs) and other battery-operated devices. Contrast ratios generally left something to be desired in the exhibit-hall ambient, but everybody was predicting substantial improvements soon.

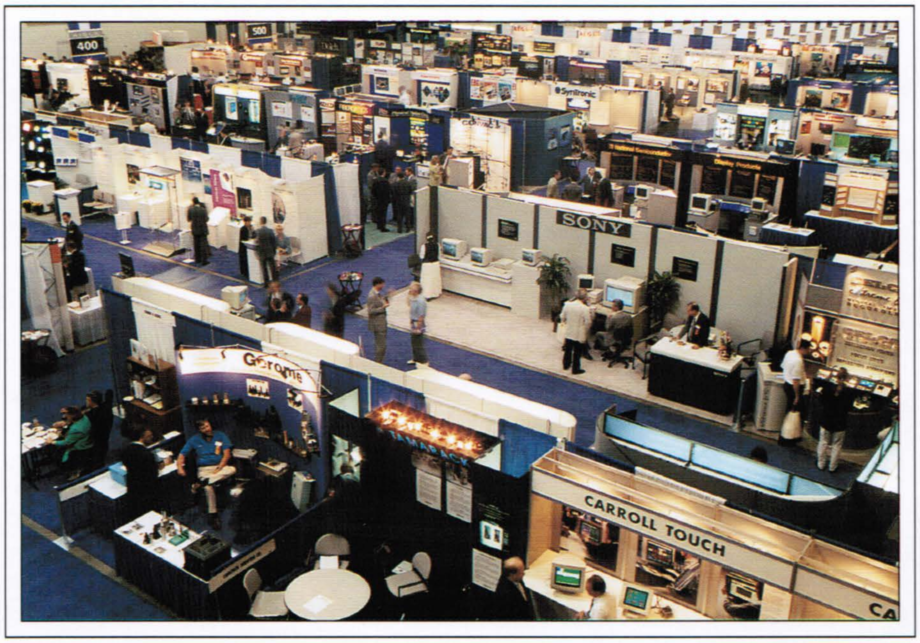
Everyone is showing more colors on their LCDs. **Sharp** claimed bragging rights to the largest color LCD at 21 in. on the diagonal – a panel that was announced but not exhibited – but the company seemed more excited about having fit a 10.4-in. LCD in the same sized package that had previously held an 8.4-in. LCD, thus providing notebook-computer makers with a relatively inexpensive way to upgrade their products.

One of the more interesting variations on standard LCD technology has been **Tektronix's** plasma-addressed liquid-crystal (PALC) technology. Unfortunately, as heard

Aktham Jarrar, Silver Image, San Jose, California

SID '94 was held at San Jose's McEnery Convention Center, June 12-17.

Ken Werner is the editor of Information Display Magazine.



Aktham Jarrar, Silver Image, San Jose, California

The SID '94 exhibition was the largest display show ever held in North America. The manufacturing-equipment segment grew dramatically.

in the aisles at SID and subsequently confirmed by Tom Buzak, former head of Tek's $3-million Display Research Laboratory, PALC got caught in a Tek corporate decision to divest the company of all component operations: ICs, hybrids, circuit boards – and displays. However, Tek regards PALC technology as a valuable asset and wants to license the technology and encourage applications for it. Three of the principal scientists at the Display Research Laboratory, including Buzak, have formed **Technical Visions, Inc.** They are continuing to develop PALC technology under contract to Tek, and will also support Tek licensees. Buzak continues to occupy his old office at Tek and can be reached at the same old number.

The only commercially available full-color plasma display panel (Fujitsu's) stayed home in Japan, but **NHK** showed their 40-in. HDTV DC-PDP, as well as a new and quite bright 18-in. panel with a 4:3 aspect ratio. **Photonics** showed their 30-in. full-color ac panel and **Plasmaco** got their just-completed color AC-PDP prototype into the booth about noon on the last day of the show. (Some of the solder joints were still warm.) **Thomson** is developing a 512-color panel for introduction early next year, and **Electro Plasma** is developing a full-color panel, also for next year.

Electroluminescent displays continued to advance. **Sharp** showed a high-bright VGA-resolution display with double the luminance of last year's model and an interface that is much like an LCD's. **Planar Systems** introduced its premium ICE+ sunlight-readable contrast-enhancement and anti-glare architecture, and showed a brighter full-color EL prototype.

Mass-production CRTs are undergoing continuous refinement, with much of this year's news involving anti-reflection and anti-emission screen coatings. New monitors are relying more and more on microprocessor control, with the most advanced of them eliminating trim pots completely and incorporating extensive dynamic control. 16:9 tubes for HDTV and data display were shown, but not in greater numbers than last year. That may be because terrestrial HDTV in the U.S. is still 2 years away – just like last year.

Over the last few years, the manufacturing component of the SID show has been increasing, but this year the increase in manufacturing-oriented exhibitors was particularly dramatic. Purveyors of photolithography equipment, coating equipment, environmentally secure chemical-delivery systems, materials, components, supplies, and production-line test and alignment equipment were all at SID '94 in profusion – and most were expressing enthusiasm with the contacts they made. Given the commitment of government and industry to build a North American flat-panel-display manufacturing industry, and the many shoppers from elsewhere in the world, this trend is likely to continue at future SID meetings. My guess is that the initiation of exhibits at this coming January's Display Manufacturing Technology Conference (DMTC '95) will do nothing to slow this trend. Many of the exhibitors I spoke with seemed anxious to attend both conferences if they continued to deliver the high-quality attendees the exhibitors were seeing in San Jose.

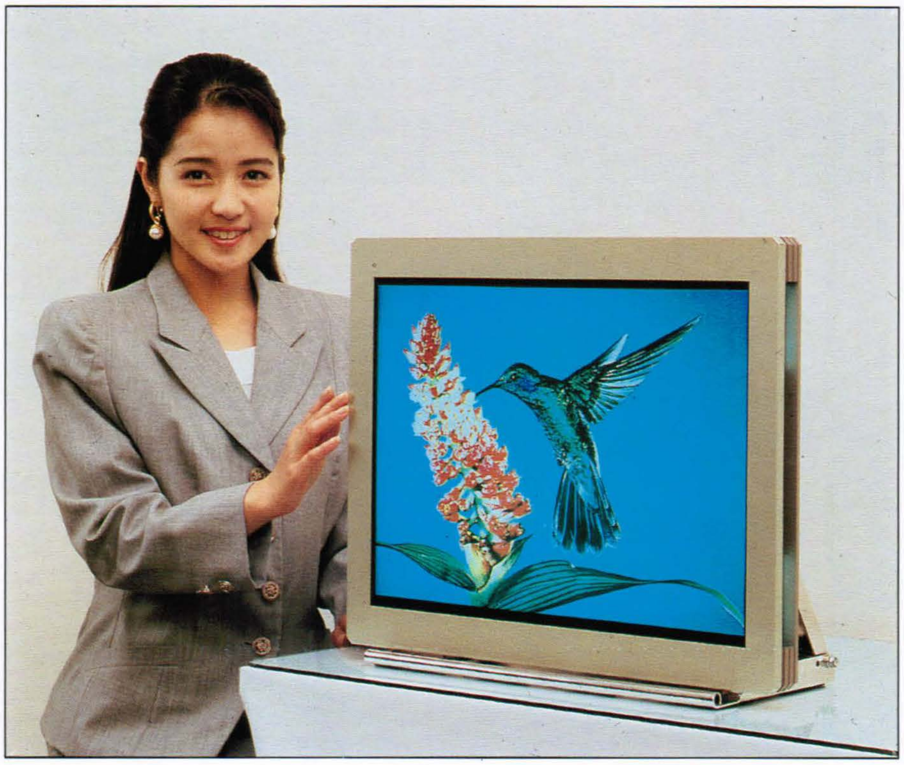
Now, let's take a walk down the show aisles as they were at the San Jose Convention Center in mid-June. Because the show has grown so much, this report is necessarily less complete than the SID show reviews of years past – another trend that is likely to continue well into the future.

LCDs

Motif had several AALCD units on display. Limited quantities of engineering evaluation units will be available in Q4. The availability of active-addressing ASICs will determine when Motif makes the transition from pilot to quantity production.

Color is not the only direction for AALCDs. There's interest in AA monochrome for some industrial applications. Motif was showing a 6.9-in.-diagonal monochrome transmissive AALCD with 64 × 480 pixels, 0.22-mm dot pitch, 65-ms speed, 35:1 contrast ratio (CR), and 14% transmissivity.

Color transmissive versions in 9.4-in. VGA format with 0.30-mm dot pitch, 65-ms speed, 20:1 CR, and 5.5% transmissivity looked good, although not the equal of the 60:1 Sharp active-matrix panel sitting next to it for comparison. However, there's more contrast to come on the next-generation panel from strategic partner **Sanyo**, Motif says. The Motif panel is definitely video-rate, although to my eye there was a little more motion blurring than on the comparison TFT. Nonetheless, the panel is eminently usable and has a good viewing angle.



Sharp Microelectronics

Sharp announced, but did not exhibit, the world's largest AMLCD to date: this 21-in. display with 640 × 480 pixels and 8-bit color.

There were also reflective monochrome AALCDs with 5.5- and 6.9-in. diagonals and a 10:1 CR (and more to come) for PDAs and similar applications. Promising.

Optrex, the **Mitsubishi-Asahi Glass** joint venture that is the world's second-largest manufacturer of LCDs, showed a wide variety of LCDs – from small to 10.4 in. – and some of the OEM products in which they are used. Optrex's strength has been in smaller displays for applications such as auto instrument panels and copying machines, but this year the company exhibited VGA LCDs for the first time.

The star of Optrex's large exhibit was the new active-addressed display (Optrex is one of Motif's strategic partners.) The display is 9.4 in. and has 640(×3) × 480 pixels, 1/240 duty cycle, and 0.10 × 0.30-mm pitch. Response time $(T_r + T_d)/2$ is 50 ms and CR = 50:1. Nice colors and good viewing angle.

There was a nice passive monochrome 640 × 480 with 1/240 duty cycle, 0.30 × 0.30-mm pitch, greater than 18:1 CR, and your choice of 70 or 100 cd/m^2. A related 9.4-in. passive color 640(×3) × 480 dual-scan FSTN 90 cd/m^2 from a dual cold-cathode fluorescent-lamp backlight also looked good. Also on display was a mini-VGA and a 10-in. monochrome 1024 × 768 1/384 duty-ratio 0.20 × 0.20-mm-pitch display in a Mitsubishi Amity pen computer.

Zvi Yaniv, who formerly held forth at OIS, is now president of **Kent Display Systems**, a company formed within the last year to commercialize some of the technology developed at the Kent State University Liquid Crystal Institute. The technology in question is the polymer-stabilized cholesteric-texture LCD (PSCT-LCD), a cousin of the polymer-encapsulated LC technology that was being developed by Taliq and Raychem a few years ago. The active material is mostly cholesteric liquid crystal, with a fraction of 1% polymer, which provides bi-stability. With proper glass treatment, polymer might not be needed at all, Yaniv said. Pixel size is limited by interconnect technology and glass etching.

Kent was showing large display pixels suitable for replacing electomechanical flip-dot displays for bus destination signs, for example, and a page-size monochrome display with approximately 100 pixels/in. Pluses for this technology are a response time of 10 ms/line, a 15:1 CR in bright ambient, no emissions, no flicker, and no polarizers (so there's no problem with birefringence, making it easier to use plastic substrates and think about roll-to-roll processing). The structure is simple and should be inexpensive to make, said Yaniv. Limitations are – at least for now – the lack of gray scale, video, and full color.

Epson America showed a "super-MIM" 4.4-in. full-VGA monochrome reflective display, which looked very good for PDAs and similar applications. There was also a 1.1-in. full-VGA poly-Si LCD, and a rear-projection monochrome VGA monitor with about a 10-in. diagonal.

Sharp has 43% of the overall worldwide LCD market (in dollar sales) – excluding watches and other very-low-margin displays – and 54% of the active-matrix market (based on end-of-1993 numbers), said Sharp's Joel Pollack. Befitting its leadership position, Sharp rolled out a substantial variety of LCDs and announced (but did not show) the world's largest color LCD: 21 in. on the diagonal.

There was an enhanced 14.2-in. TFT. Its viewing angle was 40° vertically (V) and horizontally (H), up from 20° H and +10°/–20° V (or +20°/–10°) through the use of multidomain pixels. There were 10.4- and 11.8-in. TFT displays in 1024 × 768 format – the highest-resolution TFTs currently available from Sharp.

The LM3200 family of 1/4-VGA monochrome LCDs were shown in various flavors: 4.7- and 5.6-in. reflective, transflective, transmissive high contrast, and transmissive high brightness (with one less layer of compensating film). Sharp hopes that customers will use these displays to replace small CRTs. Although not yet products, passive-color versions of these displays were also being shown. These displays are used in Pachinko parlors in Japan, and they might see use in the future in videophones and similar devices.

Sharp was also showing a range of small TFT displays with an LC mixture optimized for an extended temperature range (–30°C to +85°C) for automotive applications. A black-chrome matrix and special polarizers enhance contrast under direct sunlight, and chip-on-glass (COG) packaging is used. Versions

Clinton Electronics

Clinton Electronics' new line of microprocessor-controlled monochrome monitors is based on Display Laboratories' MIMiC® chip set and design structure. This is the 20-in. monitor with flat profile.

were shown with the color subpixels in standard stripe and delta dot patterns. (Sharp studies indicated that on small-format displays, video looks better in delta format.) The displays come in 4-, 5-, and 5.5-in. versions – the 5-in. is for the new 2-DIN format. The displays have slots for custom backlights, which are often high-brightness.

Sharp was showing an interesting technology demo: a small subtractive reflective guest-host TFT display using filters but no polarizers. The device boasts low power, good brightness, and good color and contrast. A possible application would be a PDA for outdoor use – perhaps for an express rent-a-car return system.

There was a 2-in. poly-Si TFT-LCD, as well as a 6.4-in. color TFT that will be a product this year. The 6.4-in. TFT on the stand had 2-bit color, but 4-bit color exists. It uses a stripe graphics configuration and produces a luminance of 100 nits while consuming only 1.5 W of power. The display is 8–10 mm thick and is light in weight.

Sharp is among the manufacturers producing display modules with one-tube backlights designed to replace models with two-tube backlights. It seems that the one-tube backlights are cheaper and easier to dim, and can be less power-consuming. Sharp's LM64C15P is a 9.5-in. dual-scan passive-color display with a single-tube backlight that is form-factor compatible with the 8.4-in. product line (LQ9D021, etc.). $T_{on} + T_{off} =$ 300 ms and the color is pleasing. The LQ9D021, by the way, is the 8.4-in. TFT with a single CCFT designed for low power consumption (3.3 W) that replaced the LQ9D011 with its two tubes.

Sharp's 10.X – "ten dot ex" – program was a large effort that succeeded in fitting a 10.4-in. VGA color TFT display – the LQ10D131, for instance – into the same form factor as a current 8.4-in. display such as the LQ9D021. The fill factor increased from 55% to 70% while even the screw holes were kept in the same place. This will allow laptop-computer manufacturers a relatively inexpensive way to upgrade their products or extend their product lines. The folks at Sharp who actually have to move product are far more excited about 10.X than they are about having a developmental 21-in. LCD in the family stable.

Toshiba showed a 13.8-in. TFT-LCD technology demo with dual-domain cell technology for a very wide viewing angle. (The panel is otherwise the same as the regular 13.8-in. display, which has been shipping since May '93.)

There were new monochrome AMLCDs using thin-film diodes (TFDs) as the active elements: 7.8-in. panels (both reflective and transmissive) and a 4-in. reflective technology demo. These panels exhibit a 50-ms turn-on, and their prices should be between those for standard passive monochrome and dual-scan. There was a nice CR of 15:1 in reflective mode. Toshiba is looking for applications in PDAs, GPS devices, and possibly automotive displays.

Responding to a question following his (remarkably short) seminar, "Integration of Flat-Panel Displays into Portable Computers," on Friday, June 17th, Eugen Munteanu of **Apple Computer** commented that TFD-LCDs look good optically and that the black-and-white displays look crisp. He said that Apple "is looking at the technology on a continuing basis," with the understanding that "reliable mass production has not yet been established."

There were also color displays on the **Toshiba** stand. The mechanical package of the 9.5-in. TFT has been shrunk and its power consumption lowered from 3.6 to 2.8 W. This is part of a generational improvement: Toshiba, too, is moving from two- to one-tube backlighting. Also on the stand were a 10-in. TFT VGA panel capable of 6 bits per primary color (that's 262,000 colors – enough for most pie charts) and a 10-in. dual-scan color with single-tube backlighting. Not exhibited was a dual-scan 7.8-in. passive color display that supersedes the previous single-scan 7.8-in. display. All of Toshiba's 7.8-in. displays are mechanically compatible.

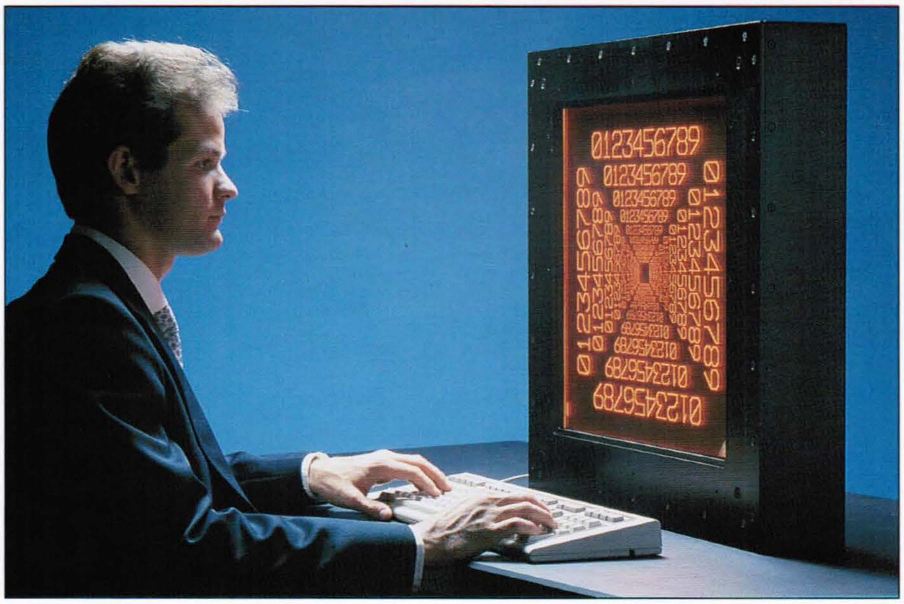
Hitachi's stand is always interesting because of the company's solid technology, as well as for sage comments on LCD markets and products from Tim Patton, Hitachi's Business Planning Manager. The company showed an interesting new family of 10.4-in. displays that have nearly the same outside dimensions as its current 9.4-in. units. The first is a TFT display with a new backlight that produces 70 nits from an overall power consumption of 3 W. Hitachi claims improved color saturation and white background compared with previous models. This display will be the flagship for Hitachi's new plant that officially opens in September. Full production is scheduled for October. And the plant is geared to produce these displays 4-up – four on each glass substrate. Since 6-up production of 9.4-in. displays is not in the cards, and since 4-up production of 10.4-in. displays costs little more than 4-up production of 9.4-in. displays, Hitachi's Patton expects the price of 10.4s to equal the price of 9.4s by mid-'95.

There's also a color STN with the same form factor, a new filter arrangement, and a 35:1 CR. Luminance and power consumption is the same as for the TFT panel. $T_{on} + T_{off} =$ 270 ms, which Patton says has become the industry standard for passive-color displays. Incidentally, Hitachi has invested heavily in a plant for making their own color filters, and they will continue to purchase from the outside as well.

There is also an SVGA (800 × 600) version of the TFT display at only about a 15% price premium over the VGA version. Power consumption is 3.5–4.0 W – available Q2 '95. At present, says Patton, XGA displays cost about twice what VGA displays cost to produce and will, at least through 1995, so SVGA could be the next hot laptop upgrade.

Hitachi is making a substantial investment in polysilicon. The company showed a 1.4-in. color poly-Si display and talked about a 1-in. monochrome. Initial applications are virtual reality and head-mounted displays for medical and other applications. Subsequently, Hitachi will be looking at projection displays for business applications. Consumer poly-Si projection displays are a ways off as far as Hitachi is concerned.

Kyocera was showing its 640 × 480 passive dual-scan color 9.5-in. 150-ms display with 60% color saturation and a low power consumption of 2.5 W with a single-tube backlight. (A two-tube backlight is available.) This display is used in an NEC laptop, and Kyocera says it has the highest color saturation on the market. Kyocera is yet another of Motif's strategic partners. Says Kyocera's Joe Maurer: "We are excited about the opportunity to add active addressing. We believe it will allow us to maintain our technology lead in passive color."



Photonics Systems, Inc./Photonics Imaging, Inc.

The familiar red-orange glow of a monochrome plasma display could be seen in several booths at SID '94. This particular glow is from the Photonics 1024 × 1024 PDP.

NEC's Omid Milani was energetically promoting the company's use of high-speed analog ICs to supply LCDs with "natural color that is as close as possible to a CRT's." No analog-to-digital converters (ADCs) for NEC in their "natural-color" line. These full-color displays included a 9.4-in. VGA, a 14-in. 1280 × 1024 workstation display, a new 13-in. 1280 × 1024 workstation display exhibiting a larger vertical viewing angle than the standard product. This display had a 0.201-mm pixel pitch, a typical luminance of 100 cd/m^2, and a power consumption of 28 W.

The non-"natural-color" section of NEC's stand included a very nice-looking 6.5-in. 4096-color (4-bit) VGA display for instrumentation, network analyzers, and perhaps back-of-the-seat entertainment applications for trains and planes. Luminance was 120 cd/m^2 at 5 W, with lower-luminance (and power) versions available. There was also a 10.4-in. XGA (1024 × 768) display.

Dimension Technologies, Inc., of Rochester, New York (DTI – not to be confused with the *other* DTI, the IBM-Toshiba joint venture in Japan) showed its autostereoscopic (no glasses) field-sequential-color LCD-based display. The display is effective, its one drawback being that half the basic horizontal resolution of the LCD is traded for the stereo effect. Price at the moment is $26,900 for an evaluation unit and $17,500 each in lots of 20. The field-sequential color is also applicable to 2-D displays, and DTI is working on a demonstrator.

Of course, there were lots of interesting goings on at SID '94 off the show floor. Two interesting papers (12.3 and 12.4) by Culter and Kongslie of Tektronix and Bos of Kent State's Liquid Crystal Institute described two methods for increasing the response of STN-LCDs while retaining good contrast. The first synchronously scans the backlight with the display's vertical scan. The second uses a "travelling-wave compensator" with a dual-cell STN (D-STN) LCD. In conversation, Keith Kongslie carefully acknowledged that the synchronous illumination technique is a variation on an idea by Terry Nelson of Bellcore – coincidentally, the SID '94 Program Chair.

In a suite, **Xerox** showed their 6.3-million-pixel display and mentioned that the next-highest pixel count was 3.9 million in the Sharp workstation display. (This Xerox display won the award for the best Poster Paper delivered at SID '93.) For 1994, the display is repackaged with separate poly-Si drivers for an overall package that is much smaller. Engineering prototypes for selected customers will be available by Q1 '95. DoD money is helping establish the manufacturing facility.

CRTs

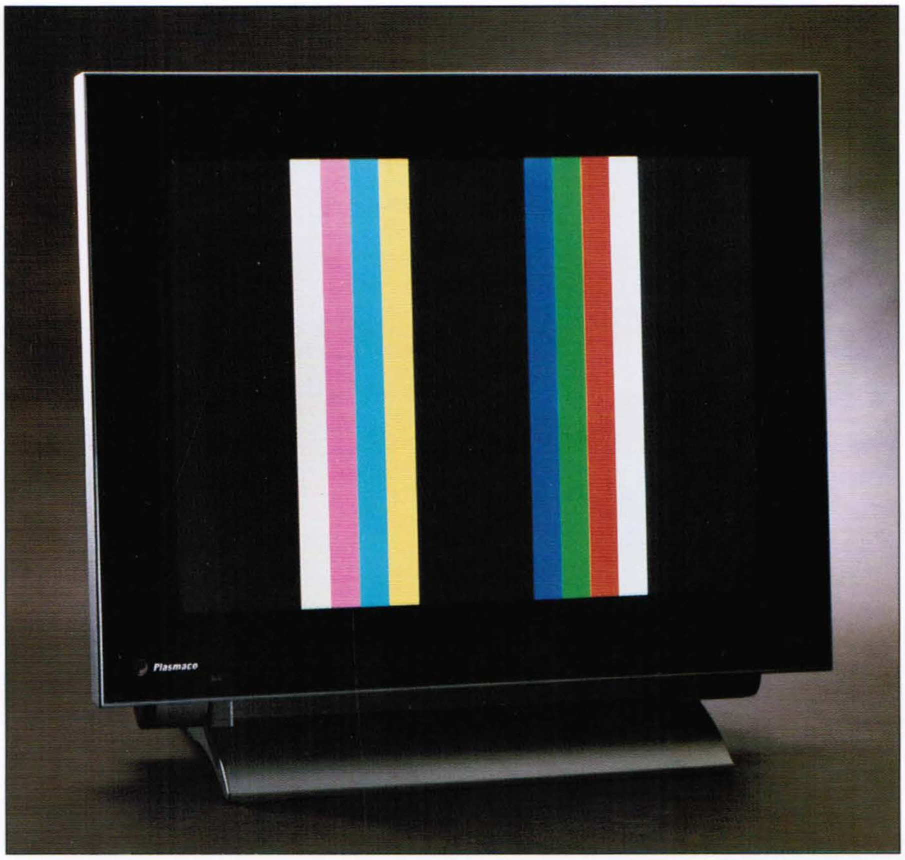
Tektronix was showing its Colorgard™ field-sequential color CRT system that uses liquid-crystal-based pi-cells to coordinate the three separate color images. The displays come in sizes from 1 to 19 in. The color purity of such a system is not sensitive to external magnetic fields, which makes it one possible solution to a problem the U.S. (and other) navies are wrestling with. Modern naval vessels carry large degaussing coils between their double hulls to prevent the detonation of magnetic mines and make the ships invisible to magnetic sensors. These coils can produce fields of 5 G or more inside the ships – enough to completely disrupt the color images on uncompensated shadow-mask CRTs. This has become a serious issue now that the U.S. Navy is contemplating a general upgrade of on-board systems from monochrome to color, which may explain why the Colorgard™ is now being sold by Tek Federal Systems/Avionics.

Tek was showing a 6-in. version for cockpit displays, and a 19-in. version for the Navy and for the back of aircraft. Current Air Force CRTs are 19 in. and they don't want to change sizes. The cockpit version produces 3000 fL from the monochrome source CRT and 200 fL to the viewer after going through the color shutter. The CR is 7.4:1 at 10,000-fC diffuse illumination. A two-color version is flying in the F-18.

After SID '94 closed, it was announced that Planar had acquired Tek's avionics unit – basically the people, equipment, and components relating to Tek's flat-tensioned shadow-mask CRTs – and also acquired a license for the liquid-crystal shutter, but did not buy the LC shutter business itself.

Rank Brimar was emphasizing commercial CRTs, high-resolution "hi-brite" CRTs, and new helmet-mounted displays with Reynolds connectors.

Sony showed its GWM-3000 prototype of a 16:9 computer display. The 28-in. (V) Trinitron™ CRT displays 1920 × 1080 pixels at a refresh rate of 72 Hz non-interlaced. The pixel pitch is 0.35 mm, and the glass is the same as that used in the professional HDVS display. This display will be introduced as a commercial product and will be available in the fall. Target price is $33,500 for a single unit. Target markets are digital post-production, high-end pre-press, and previewing of CAD drawings. (One of these displays can show a full-size B drawing.) "Pre-prototypes" were used in the post-production of the movies *Line of Fire* and *Last Action Hero*. Sony has received estimates of doubled productivity in heating, ventilating, and air conditioning (HVAC) system design when one of these monitors is used for Autocad and an HVAC graphical add-in.



Plasmaco

With this color ac-plasma display panel prototype, Plasmaco joined the color-PDP club.

Sony was also showing its new line of digital multiscan computer monitors that use silica-coated Trinitron™ CRTs in 15-, 17-, and 20-in. sizes. The monitors comply with Energy Star standards, come with a 3-year parts-and-labor warranty, and a 2-year warranty on the CRT. Major user adjustments, including color temperature, are made with front-panel pushbuttons. All three monitors are made in San Diego.

Tei Iki, Sony Senior Vice President, Display Systems, who lives in San Diego, said that the 15-in., in particular, represents a serious Sony initiative to make a fully competitive mainline PC monitor in North America. Dr. Teruaki Aoki, Sony Director and Executive V.P. for the Consumer A&V Products Company, told me, "Sony covers many areas, but displays are the center of our interest. In the developing multimedia environment, displays combined with digital control and software expertise should prepare Sony for full participation."

Toshiba has decided to concentrate on CRTs and discontinue its efforts on CRT-based monitors. The news with those CRTs is coatings, says Toshiba's Steve Vrablik. The new tubes have a new anti-static anti-reflective coating with a surface resistance of

Planar Systems

Planar will begin customer sampling of the world's first commercial full-color electroluminescent (EL) display late this year. The 320 × 256 16-color display is intended to replace a 5-in. CRT.

10^{-4} Ω/□, which compares to 10^{-9} Ω/□ for Toshiba's older coating. The tubes themselves are second-generation 15- and 17-in. flat square designs with new guns and coatings. The 17-in. tubes have impregnated cathodes standard.

Clinton Electronics was showing its 14- and 15-in. ITCs – integrated tube components – integrated pairs of tubes and yokes that are factory matched and set up. In addition to its range of monochrome CRTs, Clinton also showed its new microprocessor-based multi-frequency monochrome monitors. This is a new direction for Clinton, which has not made complete monitors in the past. Clinton's Ken Compton reported a very positive response to the monitors at the show and noted that Clinton is not being selfish with its recently developed expertise: the company is offering that expertise in the form of contract building services.

Matsushita showed its Flatvision™ flat-CRT television set at the author interviews, a session at which authors of technical papers speak with interested citizens – and a large crowd of citizens were interested, including senior CRT design people who had been involved in prior flat-CRT efforts. Among the comments:

- The picture quality is good, and the visible structure resulting from the focusing grids is not overly intrusive.
- The Flatvision's 14-in.-diagonal flat tube is probably the largest flat tube you can make without incorporating an internal reinforcing structure to keep the tube from collapsing under atmospheric pressure. Such a structure would almost certainly be visible to the viewer.
- Matsushita is working to enhance the display from the present NTSC level to VGA level.
- Present price in Japan for the TV set is the equivalent of \$2500, comparable to the price of a 14-in. color LCD.

Philips was showing its 16:9 32-in. XGA data-grade CRT that weighs 34 kg. The CR is 100:1 and the luminance is 150 cd/m^2. You can buy one of these good-looking tubes right now for \$3500. Also on display was a 4:3 Brilliance™ 2120 FS color monitor with impregnated cathode, refresh up to 160 Hz, 1600 × 1280 pixels, power management, and low emission with ARAS coating.

Also on the Philips stand was a TV add-in card (Model DTV 1000) for ISA personal computers that works with a variety of video sources. Many economical TV cards can only provide smooth motion video at 1/4-VGA size. The DTV 1000 provides smooth motion at a full-VGA-screen 640 × 480 pixels with only a little blurring, and scales down to any size without having to maintain aspect ratio. Although a very nice item in its own right, the card was at the SID show mainly to show off Philips' FI1236 video tuner chip.

Emissive Flat Panels

Unlike LCDs, which control the light that reflects off them or passes through them, emissive flat panels generate light as part of their display mechanism. The classic emissive technologies are plasma display panels (PDPs), electroluminescent (EL) displays, and (for low-to-moderate information density) light-emitting diodes (LEDs). To these, we must now add field-emission displays (FEDs). There are no commercial FEDs yet, but development work is accelerating at several significant sites, and notable appeals are being made for investors' dollars. Pixel (France) promises to have an FED pilot line running by Q4 and Silicon Video is talking about samples in 1995. Texas Instruments and Raytheon are Pixel licensees and are pushing FED technology vigorously. Silicon Video has received significant support from heavy hitters in the computer industry.

Nippon Hoso Kyokai (NHK), the Japanese Broadcasting System – which has been heavily involved in the development of PDPs for nearly 20 years – demonstrated its 40-in. DC-PDP, the world's largest full-color plasma panel. DC-PDPs can be fabricated more economically than AC-PDPs – which is why NHK has pursued the technology for nearly two decades – but the ac architecture has inherent memory that has permitted greater luminance. This year, NHK was showing a redesigned version of the panel that incorporates cathode pulse memory – a technique for incorporating the advantages of memory in a DC-PDP. The resulting luminance is 93 cd/m^2, 40% better than previous large DC-PDPs and within 10% of some of the larger full-color ac displays.

The panel also features a simplified structure implemented by sand-blasting and phosphor dyes applied by thick-film printing. New high-voltage ASICs developed by Texas Instruments (Japan) implement a new low-power drive scheme. The panel exhibits 256 gray levels and a fast write-access time. The panel measures 874 × 520 mm, has 1344 × 800 display cells, is just 6 mm thick, and weighs 8 kg less than the previous version. The panel had no obvious defects and looked very nice indeed, although it had to be exhibited under an awning. More luminance is still

Texas Instruments

Although the graphic is labeled "Texas Instruments," this field-emission display (FED) demonstrator was shown in the Raytheon booth. Both TI and Raytheon are licensees for the Pixel/LETI FED technology developed in France.

needed before this display can be used in a consumer product, but NHK has made impressive steps forward.

NHK introduced their new 18-in. DC-PDP at SID '94. It has a 4:3 aspect ratio, 0.65-mm dot pitch, 576 × 432 cells with a GR/BG configuration, and a luminance of 150 cd/m^2. This is very impressive for a DC-PDP, and is within shooting distance of the (also impressive) 200 cd/m^2 of Fujitsu's 21-in. AC-PDP. This display was also exhibited under an awning – a smaller one – perhaps unnecessarily. The panel displays 16.8 million colors, and NHK is claiming a lifetime of over 10,000 hours. The entire unit (not just the glass) has a thickness of 50 mm. This display looks very good. Whites look *white* rather than gray. Drivers for this display, too, are made by TI Japan. NHK and Dai Nippon Printing Company are clearly proud of their sand-blasting panel-preparation method.

Some industry watchers, including yours truly, had convinced themselves NHK was painting itself into a corner with dc technology. On the strength of these displays, we have to do some serious rethinking.

Two hours before the show closed, **Plasmaco** completed the prototype of their single-substrate 640 × 480 20.8-in. color AC-PDP. The prototype was showing eight colors; the final product will have diagonal 24-bit color. Engineering evaluation units are expected by Q1 '95. Larry Weber, who is both Plasmaco's Acting CEO and head of the team that developed the panel in a short 5 months, said that Plasmaco plans to become a second source for the Fujitsu panel – the only full-color panel currently in commercial production.

Plasmaco was also showing their 1280 × 1024 monochrome 21.3-in. AC-PDP, which has been in commercial production for 2 years.

Photonics' 30-in. color prototype was producing an average luminance of 30 fL (about 100 cd/m^2) and showing 6-bit color (64 shades of gray in each primary). The company is working on increasing the luminance, reducing the power consumption, increasing the pixel density, and moving to 8-bit color. The 30-in. display has 1024 × 768 pixels – 43 pixels/in. Next on Photonics' agenda is a 21-in. 8-bit color display for workstations, with 1280 × 1024 pixels – 75 bits/in.

Electro Plasma's new offering was a landscape version of its 30-in. monochrome PDP for CAD applications. The company is known for making surface acoustic wave (SAW) touch control available on its displays. And CEO Michael Horner says the company is working on full color.

Thomson's new 26-in. eight-color PDP broke in transit from France. A 512-color panel is in development and should be available by Q1 '95.

Planar was vigorously demonstrating the internal contrast-enhancement (ICE) system incorporated in its current range of EL displays and the ICE+ system for its premium EL line.

Traditionally, ELDs have needed front contrast-enhancement filters, which absorbed some of the emitted light. ICE replaces the filter with a gradient index layer for more luminance and reduced cost, says Planar's Jerry Vieira. The ICE panels offer a luminance of 25 cd/m^2 and a 10:1 CR. ICE+ increases the scan rate from 60 to 70 Hz to 120 Hz (which approximately doubles the luminance), offers anti-blooming characteristic, and has good contrast in direct sunlight – which opens daylight-readable applications to Planar EL displays. The Planar folks were shining a Sunlight on an ICE+ display, which remained impressively readable. The display's scan rate can be made switchable to conserve energy when the enhanced luminance is not required.

Vieira was taking pains to counter EL's reputation as the high-cost display technology. One reason ELDs have cost more in the past is their need for relatively high-voltage drivers. Vieira observed that the actual cost for the new custom TI Japan IC drivers is now 3½¢ per line – down from nearly 6¢ in 1992. This compared to 2¢ per line for LCDs, Vieira said.

"Now that driver costs have come down significantly and yields in the U.S. and Finland are consistently at 85% and higher," Vieira said, "we project that for high-volume applications, VGA-resolution EL displays should cost no more than 20% more than LCDs in the next 4 years."

Photon Dynamics

The Photon Dynamics FIS Flex-P flat-panel inspection system.

Planar introduced a 640 × 480 multicolor (two primary colors) 10.4-in. display with 25 cd/m^2 luminance, a 320 × 256 16-color prototype with 10 cd/m^2, and a 640 × 480 full-color 10.4-in. ICE prototype. The blue phosphor looks better than it has, and Planar is getting more luminance in the blue by using a stacked structure for color: a full-size blue subpixel lying behind red and green subpixels (as used in the multicolor display). The structure takes advantage of the fact that thin-film EL phosphors are transparent, and compensates for the blue phosphor's lower luminous efficacy by giving the blue subpixel the same area as the red and green subpixels together and driving it at a higher refresh rate.

Sharp was showing its high-brightness VGA-resolution monochrome EL display with a luminance of 100 cd/m^2 – double last year's value. Sharp does this with a dual-scan architecture for higher refresh rate. The display's interface is much like an LCD's and a very similar controller can be used.

FED technology was represented by **Texas Instruments** and **Raytheon**. Both companies are licensees of Pixel (France) which has the rights to the LETI patents. (LETI is the French Government research lab that has long been a developer of FED technology.) One of LETI's innovations, said TI's Tom Petrovich, was adding a resistive layer under the electron-emitting microtips to balance the I-V curves of the tips. This eliminated current runaway and the explosive self-destruction of runaway tips. Prior to this development, tip explosions would typically short the tip to its gate and the whole display would go bad. However, even after the resistive layer was added, pinholes in the layer produced a failure mode.

This was solved by LETI's design of a mesh cathode, which created lateral resistors from the mesh to the microtip cones located in the spaces within the mesh.

Color is now being implemented with a field-sequential technique that uses three color cones in sequence. This eliminated the need for two-thirds of the column drivers and makes critical alignment of the anode and gate/cathode plates unnecessary because a group of pixels is associated with each phosphor stripe. Good color is obtained even if alignment is off by two stripes – vs. half a stripe in conventional approaches. TI says lifetime with the switched-anode configuration is 20,000 hours without significant degradation.

The FED demonstrator – apparently the same one exhibited by Pixel at Eurodisplay last fall – was in Raytheon's booth. It has 360 × 288 pixels, uses rare-earth phosphors, and has a luminance of 62 cd/m^2 despite a 50% neutral-density filter (used because the demonstrator has no AR coating). The demonstrator uses an anode voltage of 360 V, limited by the power supply. As much as 1000 V can be applied to the anode before there is arcing to the cones. TI expects that a working anode voltage between 500 and 1000 V can produce a luminance of over 100 cd/m^2.

The image on the demo unit seemed adequately bright but exhibited defects and was unimpressive to some observers. TI's Bob Taylor said that the 10-in. VGA-compatible evaluation units anticipated in Q4 from Pixel's new pilot line in Montpelier, France, should exhibit images with dramatically improved quality.

Raytheon's main interest in FEDs is high-performance flat-panel displays for aerospace and military systems. The company is talking about FEDs in sizes ranging from 1 × 1 in. to 10 × 10 in., and with luminances as high as 10,000 fL (34,000 cd/m^2).

Teledyne builds LED displays for aerospace applications from bare LED chips. Working at the bare die level allows the company to optimize the display optics, said Product Development Manager Ed Bernard. Teledyne is currently developing field-sequential LED arrays for white and polychromatic backlighting. Among the products shown were night-vision-compatible dual and triple vertical instrument displays with backlighted indicia for military cockpits.

The proliferation of bright and efficient LED chips opens many opportunities for replacing incandescent bulbs for lower power consumption and high reliability. In a typical cockpit, a light bulb needs to be replaced every 40 hours. LEDs last for the life of the aircraft. Teledyne is also developing automotive lighting applications using its bare-die design approach.

Projection

There was substantial excitement about polysilicon LCD light valves for projection displays in the technical sessions, but on the show floor most of the attention was directed to **Texas Instruments'** Digital Micromirror Device (DMD). TI's Gary Feather said the issue for DMD last year was demonstrating the feasibility of fabricating micromechanical structures on semiconductor switches. This year it's exploring the details that make the now-established technology fit for business applications.

This year, the hinges for the deflectable micromirrors are hidden, which creates a slightly larger aperture ratio and a smoother surface for reduced diffraction. The improvements permit a CR of 120:1 from the device itself and over 100:1 for the overall system. The device is defect-free, Feather said, and the smallest feature is the 1-μm gap between mirrors, which is easy for current technology. The new horizontal split reset allows one driver to drive 16 locations, which has permitted a reduction in the number of pins from 108 to 54.

The baseline configuration for products is 768 × 576 pixels, and TI is now soliciting final-configuration input from end equipment manufacturers. TI was also demonstrating a 2048 × 1152 DMD as a technology demo for future applications.

IBM Bromont

IBM Bromont (Quebec, Canada) knows how to sputter chrome, copper, aluminum, and ITO onto large glass substrates and pattern them. Now they're selling their expertise. This glass panel is being loaded into an in-line dc magnetron sputtering tool.

TI's plan is to sell projector engines rather than just chips. Lower-cost engines can be based on a single DMD chip and a color-wheel field-sequential system. Light utilization for such systems is a bit less than 10%, so a 6000-lumen source will produce 500-550 lumens on the screen. (The color-wheel approach throws away two-thirds of the incident light.) Higher-performance systems can be based on three DMDs – one for each primary color.

Lamp life is a challenge for high-output sources, and the color shift during lamp aging needs work. But developers, including phosphor guru Aron Vecht, see a path through this particular thicket. For now, lamp life in high-end professional systems is not a problem because the duty ratio is so low. Lamp life *will* have to be improved before the technology can be used broadly for consumer applications. TI is happy to share optical and illumination approaches with clients.

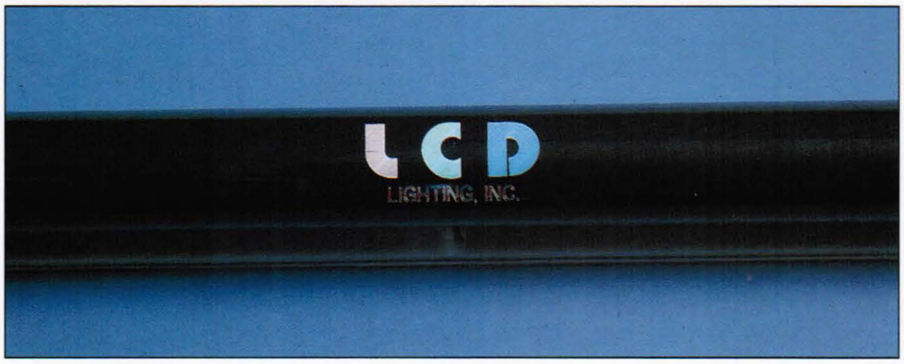
Manufacturing and Test Equipment

Here's a very small sample of the manufacturing and test-equipment makers exhibiting at SID '94.

TnP's LCD probe stations can now be integrated with a machine-vision system and LabView or Metric software. The basic system is fully programmable with control software running under Windows™. The company also has a new laser repair system. President Vu Tran said the company's strong business in Asia was continuing. In addition, the U.S. had suddenly become very hot and in North America, "Everybody wants delivery NOW!"

XMR was promoting its low-temperature laser-annealing process (and equipment) for polysilicon fabrication. The process permits polysilicon to be formed on low-cost glass substrates. XMR has a unit at Xerox for large substrates, and has worked with Japanese companies for 5 years.

Photon Dynamics was promoting its line of flat-panel inspection, test, and repair systems. Marketing programs manager Renee Mello-Robinett was clearly pleased to announce during the show that Kopin Corp. had accepted an FIS Mod-T100 front-panel



LCD Lighting

How do you apply different colored phosphors to different areas inside a fluorescent tube? LCD Lighting's sister company Light Sources isn't saying, but they've used the technique to create a product: Logo Lamp™.

inspection system to verify Kopin SmartSlide™ assembly and final-product quality at its new manufacturing facility.

Toronto-based **Image Processing Systems** (IPS) was showing its automated display inspection system (ADIS), which does test and alignment. The company makes its own CCD cameras for enhanced integration and customization. IPS was in the R&D mode for 4-5 years and expanded rapidly last year. Philips, Mitsubishi, and Sharp (Brazil) are customers.

IBM Bromont (Canada) was offering its deposition services for ITO and other thin metal films on glass. IBM Bromont, near Montreal, packages most of IBM's semiconductors for the North American market and is one of Canada's largest exporters. Staff engineer Dave Danovitch said that Bromont was not seeing "a lot of competition in high-quality thin-film services for glass in North America" – especially for large (up to 45-in. diagonals) substrates for information displays.

Viratec was promoting its conductive antireflective tube (CaRT™) process, which deposits a coating directly on CRTs after all tube-manufacturing steps – including the application of external dag, the aiming coil, and the implosion band – have been completed. The coating fulfills TCO ELF and ULF emission requirements. The company is working with European and Asian tube manufacturers.

Nikon Precision was featuring its FX-501D flat-panel-display stepper, which has a 100 × 100-mm field and accommodates substrates up to 550 × 650 mm. Nikon's Dave Kettering was proudly announcing the sale of Nikon's 120th FPD stepper since the company entered the market in 1986. Sales forecasts were up 70% over last year. Most sales are into Japan and Korea (10 projected in Korea), with interest in China.

Fabrication of four laptop-type panels on each substrate is typical now, and some customers are talking about six. Nikon is claiming 65% of the market worldwide and 72% in Japan. Sharp, NEC, and Toshiba are customers. Nikon wants to be more active in the North American market, is a member of SEMI, and is joining NAFPD.

MRS Technology is in volume production of the Model 5200G Panel Printer large-area microlithography system, which includes an improved lens from Tropel. President Grif Resor said that MRS's sales distribution is shifting from mainly Japan to an even spread between Asia and the U.S. – and the company has sold one to Pixel. MRS is delighted with Tropel's computer-aided lens design system, which was generously supported by Sematech. The result is fast turn-around of high-performance custom lenses – which are actually in spec. Resor said, "CAD lens design really works, and it's providing us with a new strategic tool." The company's second-generation graphical programming interface is proving attractive in the R&D environment, Resor said. Sarnoff and the University of Stuttgart are customers.

Semiconductor Systems Inc. was espousing the virtues of cluster architecture. According to marketing director Jim McKibben, these virtues are less use of floor space, ready accommodation of processes evolution, and flexibility. McKibben says that Semiconductor Systems is the first company to integrate the exposure station with a complete pre- and post-exposure process. Motif and Image Quest Technology (a Hyundai operation in Fremont, California) are customers.

EG&G Gamma Scientific was showing its line of radiometers and photometers. The company is developing a dual-detector ANVIS system for greater sensitivity and is rewriting software for the Windows™ environment. Customization will include a variety of detectors and light sources.

TEAM Systems introduced three new PC-based video generators. The company sold 200 of last year's model, which emphasized good performance at a relatively low price. This pleased TEAM president George Stoeppel. Now that PC instruments have been accepted by TEAM's customers, Stoeppel said, they are looking for more features and not just low price. Sony is the company's biggest customer for the PC-based generators.

Graseby Optronics introduced its SLS9400 hand-held colorimeter, which has four detector/filter combinations to capture CIE conditions. Graseby is proud of the unit's $4995 introductory price and striking ergonomic design.

Photo Research was showing its new Pritchard 880. It's like the 1980A but is fully automated with an on-board CPU and PC interface. Also new is the PR-940G CRT-geometry alignment system, which uses two cameras for stereoscopy. Using stereoscopy allows the tube face to be at any reasonable distance within the cameras' fields of view and at any angle within 15° of normal vertically and horizontally. The system therefore requires no fixtures or careful positioning of the CRT face. It measures to 0.1 mm. There's a digital interface to the popular computer bus of your choice and a graphical interface to the engineer or technician of your choice. The system can make optimal adjustments on monitors in relation to your specs rather than an ideal model.

Display Laboratories was showing its autoalignment systems for manufacturing, field service, and incoming inspection, and its Monitor Interface Micro Controller (MIMiC®) design structure for microprocessor control of monitors. The structure includes technical support and manufacturing

BARCO Chromatics

This installation of BARCO's Graph-X Wall uses six Reprographics 801 projectors and a BARCO X-Windows LAN interface. It is displaying AT&T Netminder software configured for BINOC, a European network operations center. The final BINOC installation will be two walls of 72 projectors each.

system analysis in addition to the chip sets. You can't just buy chips because the structure is support-intensive. President Jim Webb is speaking with IC manufacturers for further integration of the chip set. MIMiC is a hot ticket at the moment. Samsung is DL's largest client; Sony, Capetronix, and Clinton (with the new monochrome monitors) are also members of the club.

Display Systems and Pieces

Again, just a small sampling.

BriteView Technologies showed an interesting single-lamp backlight using total internal reflection. The Model MP-1 produces 3350 cd/m^2 from an input of 2.3 W, and the output angle can be varied with a controllable diffuser. This 9.7-in. demo unit was subjectively much brighter than a traditional two-tube backlight consuming 9 W. BriteView claims interest from IBM, Samsung, OIS, Interstate, Delco, Bell Labs, Motorola, and Kaiser Electronics. 3M will OEM the product for BriteView. Evaluation units are $100, and the price in large quantities will be "generally comparable" to that of conventional backlights.

Dolch Computer Systems was showing 24-bit color monitors based on 10.4- and 14.2-in. TFT-LCDs and accommodating NTSC or analog VGA input. Also on the stand were 1024 × 768 integrated systems and an active-matrix 256-gray-level monochrome LCD in your choice of industrial swivel mount or automotive package – the only AM monochrome display currently available, according to OEM products marketing director Carmen Piucci. Carmen also seemed proud of Dolch's 10.4-in. LCD monitor – in either color or monochrome – with a 486 computer integrated into the monitor. The diskless computer is bootable from ROM and Ethernet-compatible. It is being said more and more often that because the only thing in electronics you can't either shrink or replace is the display, increasingly, the display *will be* the product. Dolch is providing an early example. (Once chip-on-glass becomes a mainline technique, the display will also be the chassis.)

Physical Optics Corporation (POC) introduced an impressive line of Light Shaping Diffusers™ (LSDs) based on surface relief holography. A typical LSD – an unfortunate acronym – is a thin sheet of vinyl, acrylic, polycarbonate, or teflon embossed with a holographic pattern that emulates a random distribution of microlenses. The microstructures vary from less than 1 μm to more than 100 μm, with the size controlling the diffusion angle. Because the diffusion effect is based on refraction rather than scattering, transmittance can be as high as 92% (depending on the material used). The effect is essentially independent of wavelength over the visible spectrum. Although the most obvious application to displays would be a circular transmissive diffuser for backlights, it is the highly elliptical devices that diffuse through 0.2° in one direction and, say, 40° in the perpendicular direction that are initially most startling. These convert a small filament light source into a line source of light. A less extreme version of this elliptical diffusion can be used to make transmissive or reflective viewing screens that direct light toward the viewer, and could conceivably be used for backlight diffusers that match the viewing angles of passive LCDs for greater luminous efficacy in the directions where it counts.

LCD Lighting introduced its new family of 3.0-mm-diameter cold-cathode fluorescent tubes. The company thus becomes the sole U.S. manufacturer of such lamps, which are commonly used in LCD backlights, said marketing manager Al Hudson. Al was also showing the Logo Lamp™ from sister company Light Sources, Inc., a manufacturer of domestic and commercial lamps. Although not the sort of display usually covered in *ID*, this is worth a mention. The Logo Lamp is a standard-looking household fluorescent tube that works in standard fluorescent fixtures. It is blacked out except for a logo (or characters) that is clear so light shines through. What's tricky is that the light shining through is of up to four different colors from four different phosphors. According to Al, other people in the fluorescent lamp business can't figure out how Light Sources gets the different phosphors into different places in the same tube – and he didn't tell me, either.

The sign in the exhibit booth said "Penn-Tran," but the booth personnel were handing out yellow broadsides headed **WinTron**. The venerable producer of custom deflection yokes, flybacks, transformers, and high-voltage power supplies had just been sold by its former Oregon owner to an investor in the company's Bellefonte, Pennsylvania, neighborhood. The name is changed but the facilities and personnel aren't, except for a couple of management additions including new director of marketing Melissa Hein. The demise of the Penn-Tran name is the most recent of a bunch of changes in the once-predictable high-voltage business that have left some industry veterans shaking their heads.

Carroll Touch's Mark Austin seemed proud of the company's new CT-70 POS terminal with a personality card for quickly adapting to various displays. Carroll Touch is developing guided-acoustic-wave touch products, which will be demonstrated late in '94. The company's acquisition of Emerald Computer enhances Carroll Touch's integration capabilities, Austin said. Emerald's product line and logo will be retained.

CELCO was exhibiting its yokes for helmet-mounted displays and virtual-reality applications, and specialty yoke designs for monochrome and color CRTs. The company was also showing its Extreme fx digital image recorder that utilizes CELCO developments in yokes, deflection systems, and electro-optics. The Extreme fx achieves higher dynamic range than any other CRT-based image recorder, said CELCO vice president J. M. Constantine, Jr. In Hollywood shootouts, he said, CELCO has always come out on top, with 10–12 wins in the last few months. The machine was used to image the special effects in the current Arnold Schwarzenegger film *True Lies* and for the entire Disney feature *The Lion King*. A recent application is color-assigned electron microscopy, which was featured in a recent issue of *Life Magazine*.

In the Poster Session, **Live Works** (a Xerox company) featured its "Liveboard," a multimedia whiteboard for interactive conferencing. The board incorporates a very nice pen interface optimized for list editing, which Live Works has determined is what people do most on whiteboards. The interface operates under Pen Windows. Your scribbles can be recorded for posterity with a built-in floppy disk drive or an attached printer – or they can appear immediately on other, networked Liveboards. The display is a 67-in. rear-projection LCD showing 640 × 480 pixels and a more-than-reasonable number of colors. Liveboards will display 1280 × 768 pixels when the enhanced LCDs become available in Q3.

Also in the Poster Session, a group from Nippon Mektron were showing a developmental electrophoretic display (EPD) module for public-information applications. We haven't heard much about EPDs since major efforts from Exxon and others were abandoned 7 or 8 years ago, but there is some activity now. More on this next month.

RGB Spectrum was showing its broad line of scan converters, video windowing systems, and multiple screen controllers. The company says its MediaWall™ is the first multiple-screen controller to create wall-sized presentations with popular Mac or PC software. A MediaWall™ has been installed at the Smithsonian as part of the "Information Age" exhibition.

BARCO also has an impressive multiple-screen controller. The Graph-X Wall operates under X-Windows and is impressive with abutted rear-projection displays – even with the minimum configuration of 1 × 2 rear-projection displays exhibited at BARCO's stand. Atlanta is planning to use the system for highway traffic control for the 1996 Olympics.

National Semiconductor introduced its LM7503 64-gray-level 240-channel TFT color driver. The price is $8–9 per unit in 1000-piece quantities – less than 4¢ per line. Samples in November; production in April '95. National was also showing the just-released LMC6008 low-power octal buffer for TFT gray-scale displays.

In its first appearance at a SID show, **Advanced Backlighting** was "introducing innovative enabling technologies for advanced displays and imaging." There were ideas here for economical stereo displays and low-cost LCD color filters with improved color saturation. A particularly innovative idea is polarizing colored ink that makes direct stereoscopic printing and painting possible for the first time. The company claims this is revolutionary, and it may well be. What's clear is that there are more good ideas at Advanced Backlighting than one small company can support.

There was also more good stuff at SID '94 than one editor can adequately report, and I've left out a lot. We'll try to put together a tag team for SID '95 next May in Orlando.

Note

This article should be regarded as an extended editorial reflecting the author's observations and opinions. Those opinions are not necessarily those of *ID*'s publisher or the Society for Information Display. ■

president's message

continued from page 2

To maintain this balance in the society's membership and thereby ensure its future growth, SID took the next logical step: becoming a global professional society.

It was nearly 3 years ago that then SID president Walt Goede wrote in this column about the new bylaws that created for the first time the positions of regional vice-presidents for the Americas, Asia, and Europe. He urged the membership to vote for the new bylaws because the changes they incorporated represented health and growth for the society.

Even earlier, Howard Funk, then at IBM, Tei Iki at Sony North America, and Prof. Shunsuke Kobayashi at the Tokyo University of A&T were advocates of internationalization. These three individuals had the foresight and conviction to discuss at length the benefits that globalization of the society would bring. They urged the rest of the society's Board of Directors to make whatever changes were necessary. Aris Silzars, then chairman of the Long-Range Planning Committee, was instrumental in organizing the wide variety of suggestions into a few actionable proposals, the bulk of which were then incorporated into the new bylaws. Walt Goede subsequently guided the writing of the new bylaws and developed a strong consensus among the members of the Board in favor of the changes instituted by the new bylaws. The rest, as they say, is history.

This past June, the first group of regional vice-presidents – Peter Baron for the Americas, Prof. Shunsuke Kobayashi for Asia, and Tony Lowe for Europe – have stepped down after serving their elected 2-year terms. Their places were taken by newly elected vice-presidents Terry Nelson for the Americas, C. Suzuki for Asia, and Jean-Noel Perbet for Europe.

The last 12 months were an outstanding success because the globalization of SID has been an outstanding success. We have members and chapters throughout the world wherever there is significant display activity. The three regional vice-presidents see to it that their respective regions are well served by the society, and they also provide much-needed professional talent for the society's various technical activities through the generous support of the local chapters. It is to the credit of each and every member of SID that this professional organization today has 17 active chapters around the world, with nearly 100 events organized annually in the Americas, Asia, and Europe.

SID's increase in membership is due to its growth at the local level, and because local SID activities can occur just about anywhere on the globe. The society is growing because it renewed itself in order to remain true to its original mission: to serve the entire technical display community, from research through manufacturing to sales engineering.

It is time to tell our friends, our colleagues, and anyone who is interested in becoming a display professional that the networking of display professionals takes place at SID meetings. It is time to tell them that SID has grown because we prepared for the future, and we are ready to meet the needs of the expanding professional community with expanding services.

In the coming months, I will use this column to describe some of our new initiatives in the areas of membership development, academic relations, publications, publicity, display standards, and technical meetings. I will introduce some of the society's volunteers and the small but highly skilled professional staff who are working with dedication and imagination to further the aims of SID in each of these specific areas. It is my fervent hope that each of you is already benefiting from the activities of this society – or will be in the near future – and that many of you will become active contributors to some of our many technical activities. We want you as speakers, as members of the audience, as volunteers, and as leaders. ■

display continuum

continued from page 4

maybe one that is somewhere in between, and similarly for yellows and blues. And by the way, it's considered "tacky" to use greens out of a tube – you're supposed to mix them on the palette.)

However, putting all this understanding into practice to create my "work of art" proved to be a totally different program. As I struggled, I learned that a blue sky is not blue, a white building is not white, grass is not green, and nothing else is the way its "supposed to be" either. A "blue" sky may be somewhat red, or somewhat yellow, or whatever else, but never is it just blue. A white roof may be partly yellow, partly blue, with maybe a little orange blended in, but it's not white. My engineering-trained and technically-oriented mind was blowing fuses big time. Trying to blend the various colors, while controlling their intensity, while making sure that the paper was at the correct level of dampness, while not letting my brush get too wet or too dry was wearing me out much faster than if I had stuck to my original plan of working on the business plan.

After several hours of intense effort, I had created the rendering of a scene that, while not too terrible, would certainly not win any prizes at an art show. The consensus from the group of experienced artists was that I had "potential" and that if I diligently worked at it for a few years I might just be able to do something respectable. Still worn out from my efforts, I could easily appreciate how it could take that long to learn all the subtleties of controlling hues, intensities, wetness of the paper, and the many brush techniques for applying the pigments.

But wait a minute, why struggle with all that? After all, we display scientists have created computers that are getting pretty darn good at image manipulation. Maybe we technical types can show these artists a thing or two and just program all of this so it's fully under our control. We certainly know how to manipulate color, we know how to control intensity, and we know how to create images on our high-resolution screens. Not only that, with a keystroke we can undo whatever we don't like and change it to what we do like. So let's just write some software that simulates "watercolor." We can program any color palette we wish. Water can be simulated by a density function. We can even simulate the sizes and shapes of brushes. Color blending will be done on a "virtual" palette.

Please send new product releases or news items to Joan Gorman, Departments Editor, Information Display, c/o Palisades Institute for Research Services, Inc., 201 Varick Street, New York, NY 10014.

With this new technology, we should be able to do that Banyan tree trunk in all its beautiful blues and oranges and browns without having to worry about a messy medium we know little about. But there does seem to be just one little problem. Where should we put the oranges and blues and browns? And after we do it, will our tree have the same interesting personality as the one done by a truly skilled and talented artist? Somehow, I think not. It appears that the computer is just another medium to be used or misused by talented or not-so-talented people. And as with other art media, the results will be a strong reflection of the skill and personality of the one doing the work.

At the present stage of imaging technology, computers are especially well suited to artists or photographers who do advertizing layouts, retouching, photographic-image manipulation, and image transmission. In other words, we import images and then revise them or combine them with others. Depending on the need and application, this work will vary in its level of creativity.

In the near future, we can expect to see the evolution of a computer style of art different from anything we have seen before. I suspect that this new style will have a rather unusual blend of reality and fantasy. I will conclude with a second prediction: ***Computer imaging will not replace any of the traditional media such as oil, acrylic, watercolor, or even photography.*** Each medium has something special to offer, and in the hands of a skilled and talented artist, each becomes an expression of unique feelings, moods, and emotions. Since the field of computer imaging is so new, I don't think we know yet what special and unusual emotional messages it will be capable of conveying. It will be exciting to watch them develop.

Returning to the more comfortable world of technology and to some recent events, we find that the mood of the display industry continues to be upbeat. This column is being written after the SID Symposium in San Jose, which by any measure was a huge success. New records were set for attendance and for the number of exhibitors. You will, I am sure, read about all this in other *ID* articles and in other publications. I will, however, make just one observation. I will always remember the 1994 SID Symposium as the place and time where I looked at an AMLCD panel and had to admit that for computer display applications it was now ***better*** than a CRT. The demonstration of several 13-in. panels that were bright, with good color intensity, and with a wide angle of view confirms that this technology has finally arrived. It also means that new competing technologies will have to be very, very good before they are accepted for commercial use.

On Tuesday evening of "SID week," I had the pleasure and honor of attending a dinner hosted by **Heiji Uchiike**, Chairman of the **Japan** chapter. There were approximately 30 people there, roughly half from Japan and the rest from the U.S. and Europe. It is difficult to convey in words the warm feelings and spirit of cooperation and mutual support that were present during that dinner meeting. Over the last few years, SID has become a truly international organization. The 1994 Symposium was the best demonstration we have seen yet that the Society has accomplished its goal of representing display technologists from all parts of the world.

SID and the Symposium also achieved "newsworthy" status when **Malcolm Thomson** of Xerox and **Ken Werner**, editor of *Information Display* were interviewed by **CNN Television** for CNN's "Technology Week in Review." The show aired June 18 and 19. Malcolm spoke about **USDC** and the **Xerox** 6.3-million-pixel display. Ken spoke of the important catalytic role of the relatively small government investment in display manufacturing. I'm told that **Kathy Middo**, the new SID Communications Committee chair, was responsible for getting us this publicity.

Prior to the SID Symposium, the **U.S. Department of Defense**, through Deputy Secretary of Defense **John Deutch**, announced an inter-agency program to foster U.S. manufacturing capability in flat-panel displays. The department plans to spend a total of about $580 million on the National Flat-Panel Display Initiative over the next 5 years, with industry providing a like amount. The program will provide incentives for development of commercial production capability chiefly through matching research and development funds.

Michael Elta at the **University of Michigan** has provided additional information on the new **Center for Display Technology and Manufacturing.** The Center is engaged in independent and joint research projects in support of the U.S. flat-panel display industry and has chosen the following three thrusts for its initial focused research: (1) Manufacturing Process Methods, with the objective of developing control technology for the improvement of robustness, machine utilization, and yield of critical processes used in flat-panel display manufacturing, (2) Advanced Processes & Equipment, with the objective of investigating more radical processing approaches, and (3) Factory Optimization and Control, with the objective of addressing aspects of facility evaluation, management, and control for design, manufacture, and operation of FPDs. The leaders for these thrusts are **Prof. Pramod Khargonekar, Prof. Erdogan Gulari,** and **Prof. Yavuz Bozer,** respectively.

Photon Dynamics of Milpitas, California, has announced the appointment of **Jim Ellick** to the position of chief executive officer. Prior to joining Photon Dynamics, Ellick was president and CEO of Alameda Instruments, a company that manufactures chemical reprocessors. Photon Dynamics was founded in 1986 and currently has over 80 employees. PDI designs, manufactures, and supports a complete product line of advanced test, inspection, and repair systems for flat-panel displays.

Murielle Trenard of Infolex Corp., located in New York City, sends an announcement that Infolex was one of three manufacturers honored at the 1994 HIP Spirit Awards for Outstanding Customer Service, Staff Empowerment, and Community Involvement. Infolex produces a product that they call the Dynamic Marquee, which is an outdoor multicolor LED billboard/marquee. The proprietary design results in a super-bright display, readable in direct sunlight and providing considerable savings in both energy consumption and maintenance as compared to incandescent light bulbs. According to Murielle, the display shows live video, animations, and graphics, "utilizing explosions of 16 colors and hundreds of mesmerizing effects."

MRSI of Chelmsford, Massachusetts, a leading supplier of high-precision dispense, assembly, and testing equipment, **Samsung Display Devices,** and **Zymet, Inc.**, a material supplier of z-axis adhesives, have announced the development of a flip chip-on-glass flat-panel display. Samsung Display Devices provided the flat-panel display and appropriate chips. MRSI provided the flip chip bonding equipment used for assembling the display. Zymet provided the anisotropically conductive adhesives used to bond the devices. **Dan**

display continuum

Crowley, the MRSI sales manager, also tells me that they have opened a Flip Chip Applications Lab. Customers visiting the lab will have access to various equipment, along with MRSI's experienced flip chip applications specialists. And in keeping with all this, MRSI has appointed **Neal Calanni** as their worldwide customer service manager. Neal was recently at M/A-COM, where he provided process engineer support for microwave assembly.

A recent report by the investment firm of **Fechtor, Detwiler & Co., Inc.** of Boston, Massachusetts, authored by **Brian Kritzer** and co-authored by **Larry Tannas** (past SID president) suggests that the path to product commercialization is much more challenging than typically estimated by new technology start-ups. This report deals specifically with **Kopin Corporation** and its Smart Slide technology. The predictions made by the authors are that it will be several more years before a commercially viable product can be produced, instead of the quicker estimates made by Kopin. The report makes a comparison with a number of other display technologies and how long they took to become commercially viable. The patience of U.S. investors – or lack thereof – will certainly be tested over the next several years as attempts are made to establish a U.S. manufacturing capability in a number of new flat-panel display technologies.

On a final note, SID is searching for an editor to assemble a handbook of display technology. The person taking on this challenging task will be eligible for royalty income and, of course, the good feelings and prestige that come with having an industry standard reference work to ones credit. Please call me or send me a fax if you are interested or would like to discuss this opportunity further.

As always, I am pleased to hear from each and every one of you. I can be reached by phone at 609-734-2949 or by fax at 609-734-2127, or if by mail, send your information to Jay Morreale at Palisades Institute, 201 Varick Street, Suite 1006, New York, NY, 10014. ■

To participate as an exhibitor at DTMC '95 in Santa Clara, please call Erika Suresky, Exhibit Manager, Palisades Institute for Research Services, Inc., at 212/620-3375, fax -3379.

Compiled by HOWARD L. FUNK
H. L. Funk Consulting

U.S. Patent No. 5,327,001; Issued 7/5/94

Thin Film Transistor Array Having Single Light Shield Layer Over Transistors and Gate and Drain Lines

Inventors: Kanbara, Minoru; Sato, Syunichi; Wakai, Haruo; Yamamura, Nobuyuki
Assigned to: Casio Computer Co. Ltd., Japan

A TFT array has a plurality of gate lines and a plurality of drain lines formed on a transparent insulating substrate. The gate lines intersect with the drain lines. TFTs are formed at the intersections of the gate lines and the drain lines. An opaque film is formed above the gate lines, the drain lines, and the TFTs, allowing no passage of light through the gaps between the transparent electrode, on the one hand, and the gate and drain lines, on the other hand. Therefore, when the TFT array is incorporated into an LCD, the display will display high-contrast images.

U.S. Patent No. 5,327,273; Issued 7/5/94

Bistable Ferroelectric Liquid-Crystal-Display Cell

Inventors: Beresnev, Leonid A.; Buchecker, Richard; Chernova, Nina I.; Chigrinov, Vladimir G.; Funfschilling, Jurg; Loseva, Marina V.; Panarin, Yury P.; Pozhidaev, Fvgeniy P.; Schadt, Martin
Assigned to: Hoffmann-La Roche Inc., Switzerland

A bistable ferroelectric LCD cell utilizes two plates, a chiral ferroelectric smectic liquid-crystal sandwiched between the plates, and an electrode for applying an electrical field to the plates. The chiral ferroelectric smectic liquid crystal has a structure which is influenced by the action of an electric field so that its optical anisotropy changes. By using a first polarizer connected to one of the plates and a second polarizer connected to the other plate, the unique bistable ferroelectric display produces dark parallel stripes when the polarizers are in a cross position relative to each other.

U.S. Patent No. 5,327,268; Issued 7/5/94

Reflective-Type Liquid-Crystal Display with Reversely Staggered TFT Structures

Inventors: Mori, Yuji; Nagae, Yoshiharu; Takabatake, Masaru
Assigned to: Hitachi Ltd., Japan

An active-matrix reflective-type LCD is provided which is obtained by an easy alignment of the respective layers of the display, and the use of small TFTs and a reduced number of manufacturing steps. Each TFT comprises a drain electrode which comprises an area where a scanning conductor and a signal conductor concerned intersect, a source electrode which comprises an area where a short-circuiting conductor concerned parallel to the signal conductor and the associated scanning conductor concerned intersect, a gate electrode which comprises an area provided between the drain and source electrodes concerned on the scanning conductor and a reflective electrode concerned provided at an end of the short-circuiting conductor concerned.

U.S. Patent No. 5,333,073; Issued 7/26/94

Backlight Device and LCD Having Conductive Film on Electromagnetic Shield or Diffuser Between Fluorescent Tubes and Display

Assigned to: Suzuki, Mitsuhiro

LCD equipment comprised of a LCD panel for displaying therein characters or an image, a backlight device serving as an auxiliary device to finely display the characters or image on the display panel by irradiating a light from the back of the LCD panel, and a sheet of light diffusion plate mounted between the LCD panel and the backlight device and making a uniform illumination plane for the display panel by diffusing the light through itself. The backlight device comprises a transparent conductive film mounted in the vicinity of a plurality of fluorescent lamps arranged in parallel relationship to one another on the back side of the light diffusion plate so as to act as a backlight source of the backlight device.

U.S. Patent No. 5,333,072; Issued 7/26/94

Reflective Liquid-Crystal-Display Overhead Projection System Using a Reflective Linear Polarizer and a Fresnel Lens

Inventors: Willett, Stephen J.
Assigned to: Minnesota Mining & Manufacturing Co

A reflective LCD overhead projection system. The projection system includes a reflective polarizer, a phase-modulating LCD on the reflective polarizer, and a fresnel lens on the LCD. Unpolarized light rays are directed toward the fresnel lens, pass through the LCD, and are reflected and polarized by the reflective polarizer. The light rays then pass back through the LCD and the fresnel lens and on toward a projector head, where the light rays are analyzed by a polarizer and projected toward a screen.

U.S. Patent No. 5,333,099; Issued 7/26/94

Electrical Component Having a Sandwich-Like Subassembly

Inventors: Bauer, Karl-Heinz; Bruggemann, Ulrich
Assigned to: Preh Werke GmbH and Co., Germany

A simplified construction is suggested for an electrical construction assembly, or an assembled electrical component, having a circuit board, an LCD, a light conductor, and a sheet-metal screen. In this regard, a leg of the sheet-metal screen extends about one edge of the circuit board and effects, on the one hand, a secure contacting of the LCD and, on the other hand, in an uncomplicated manner, a releasable clamping together of the assembly.

U.S. Patent No. 5,332,946; Issued 7/26/94

Electroluminescent Lamp with Novel Edge Isolation

Inventors: Eckersley, Rodney T.; Hooke, Will M.; McGuigan, Ralph; Stocker, Sharlyn R.
Assigned: Durel Corp.

An electroluminescent sheet-form lamp with a main portion of a conductive layer isolated from an edge region susceptible to detrimental conductive pathways by isolation provided along at least a portion of the perimeter of the lamp as a result of removal of a preapplied conductive coating such that, at the region of the isolation, the main portion of the one conductive layer which forms the respective electrode commences at a line spaced inwardly from the outer edge of the lamp. The preapplied conductive coating material may be removed to form a line of interruption that leaves in place a narrow margin of conductive coating in the edge region which is electrically isolated from the main portion of the coating forming the first electrode. The lamp may be formed by exposing preselected portions of the preapplied conductive coating to laser radiation sufficient to remove the preselected portions and form the region of isolation. A scribing technique or a mask, which may be a printed functional layer of the lamp, are employed.

U.S. Patent No. 5,331,348; Issued 7/19/94

Adaptive Leak HDTV Encoder

Inventors: Knauer, Scott C.; Matthews, Kim N.; Netravali, Arun N.; Petajan, Eric D.; Safranek, Robert J.
Assigned to: AT&T Bell Laboratories

An improved predictive encoder where the leak signal is a function of the buffer fullness of the encoder. More specifically, the signals stored in the encoder output buffer are further encoded based on the fullness of the buffer, and information about this further encoding is used in determining the leak factor level. In accordance with another improvement, this leak factor level is not constrained to granularity that is imposed by the decoder hardware. Removal of the constraint is accomplished by cycling through a sequence of permissible leak levels that averages at the desired level.

U.S. Patent No. 5,331,334; Issued 7/19/94

Vacuum Fluorescent Display Device

Inventors: Murayama, Yoichi
Assigned to: NEC Corp., Japan

A chip-in-glass type vacuum fluorescent display device includes an IC chip for driving a display unit in a vacuum glass envelope. The IC chip is connected to a plural number of external terminals to be supplied with an electric power from an external power supply, so that resistances of the external terminals themselves, and those of the connecting points of the external terminals and conductor patterns which connect the terminals to the IC chip. As a result, the potential change at pads of the IC chip, which causes unstableness in operation of the IC and changes of characteristics thereof, is decreased.

U.S. Patent No. 5,331,447; Issued 7/19/94

TFT Active-Matrix Liquid-Crystal-Display Devices with Plural TFTs in Parallel Per Pixel

Inventors: Matsumoto, Shinji; Nashimoto, Ryuuzoh; Oritsuki, Ryouji; Sasano, Akira; Someya, Sakae; Suzuki, Hirofumi; Taniguchi, Hideaki; Yarita, Katsuhiko
Assigned to: Hitachi Ltd., Japan

There are disclosed various types of TFT active-matrix LCD devices in which a pixel is divided into three parts, a capacitor is added to each pixel, light shielding is applied to each TFT, and the matrix is driven by a dc cancelling technique.

U.S. Patent No. 5,326,712; Issued 7/5/94

Method for Manufacturing a Thin Film Transistor

Inventors: Bae, Byung-seong
Assigned to: Samsung Electronics Co. Ltd., Korea

A method for manufacturing a semiconductor device which utilizes anodic oxidation. A first semiconductor layer of a first conductive type is formed on an insulating substrate, a highly doped second semiconductor layer of the first conductive type is formed on the first semiconductor layer, and then an antioxidizing pattern is formed on the second semiconductor layer to expose a predetermined portion of the second semiconductor layer. After forming the anti-oxidizing pattern, anodic oxidation is performed to oxidize the exposed portion of the second semiconductor layer. Instead of employing a conventional plasma etching process for removing the portion of the ohmic contact layer which is not in contact with the source and drain electrodes, the portion of the ohmic contact layer to be removed is subjected to anodic oxidation, to thereby form an anodic oxidation layer, thus facilitating removal of the unnecessary portions of the ohmic contact layer without the use of a plasma etching step. Accordingly, the problems resulting from the use of a plasma etching process can be avoided, so that a TFT having a high reliability can be obtained.

U.S. Patent No. 5,331,256; Issued 7/19/94

Focus Yoke, Electromagnetically Focused CRT Display with the Focus Yoke, and Negative Feedback Circuit with Stray-Capacitor-Cancellation Means Used for the CRT Display or the Like

Inventors: Ikeda, Miyuki; Kimoto, Toshiyuki; Ogino, Masanori
Assigned to: Hitachi Ltd., Japan

A focus yoke used for an electromagnetically focused CRT display comprises: a cylindrical permanent magnet unit which is disposed around a neck portion of a CRT and is spaced from the circumference of the neck portion; a core unit which defines a toroidal space together with the cylindrical magnet unit for substantially surrounding the neck portion, the core unit forming a magnetic path to guide magnetic lines of force generated by the cylindrical magnet unit; a dynamic focus winding unit disposed in the toroidal space; and a winding unit disposed externally of said toroidal space for eliminating an undesired magnetic field of an inverse polarity generated due to the cylindrical magnet unit.

U.S. Patent No. 5,327,044; Issued 7/5/94

Electron Beam Deflection Lens for a CRT

Inventors: Chen, Hsing-Yao
Assigned to: Chunghwa Picture Tubes Ltd., Taiwan

An electron gun for a CRT includes a cathode, a low-voltage beam-forming region (BFR), and a high-voltage deflection focus lens disposed in the beam-deflection region of the CRT's yoke for simultaneous focusing and deflection of the electron beam on the CRT's display screen. The deflection lens includes a first electrode either in the form of a cylindrical metal grid or a conductive coating disposed on the inner surface of the CRT's neck portion and extending into the magnetic deflection field. The deflection lens further includes a second electrode disposed either on or immediately adjacent to the inner surface of the CRT's frusto-conical funnel portion intermediate the magnetic deflection yoke and the CRT's display screen. By positioning the CRT's focus lens within the deflection field, the deflection center of the beam is disposed within the focal point of the focus lens permitting the focus lens to operate as a deflection lens to not only focus the beam, but also increase beam-deflection sensitivity. The coincidence of the beam focus and deflection regions reduces beam "throw distance" (field-free zone) resulting in a corresponding reduction in beam magnification and space-charge effect and improved beam spot on the CRT's display screen. Positioning a focus electrode on the CRT's neck or funnel portion increases the equivalent diameter of the main focus lens which reduces the lens spherical aberration effect on the beam, while co-locating the beam focus and deflection regions also allows for shorter CRT length.

U.S. Patent No. 5,327,003; Issued 7/5/94

Semiconductor Static RAM Having Thin Film Transistor Gate Connection

Inventors: Ema, Taiji; Itabashi, Kazuo
Assigned to: Fujitsu Ltd., Japan

A semiconductor memory device includes a semiconductor substrate, a memory cell provided on the semiconductor substrate and including first and second transfer transistors, first and second driver transistors and first and second TFT loads, where each of the first and second transfer transistors, the first and second driver transistors, and the first and second TFT loads have a source, a drain and a gate electrode, and a connecting region in which the drain of the second TFT load, the gate electrode of the first TFT load, and the gate electrode of the first driver transistor are connected. The gate electrode of the first driver transistor, the gate electrode of the first TFT load, and the drain of the second TFT load are made of conductor layers which are stacked on the semiconductor substrate with an insulator layer interposed between the conductor layers, and a top one of the stacked conductor layers makes contact with a top surface of a bottom one of the stacked conductor layers and with side surfaces of each conductor layer provided between the top and bottom conductor layers within the connecting region.

U.S. Patent No. 5,333,262; Issued 7/26/94

Imaging System with Multilevel Dithering Using Two Memories

Inventors: Ulichney, Robert A.

Assigned to: Unassigned

Disclosed is an image-processing system which relies upon quantization and dithering techniques to enable an output device, which has a given number of output levels, to accurately reproduce a image which is generated by an input device, which has a greater or equal number of input levels. Generally, neither the number of input nor output levels need to be a power of two. The present invention is implemented in a number of different embodiments. These embodiments generally rely upon an image processor which, depending on the particular implementation, includes memory devices and an adder, a comparator, or a bit shifter. Additional embodiments use an image adjustment system.

U.S. Patent No. 5,333,259; Issued 7/26/94

Graphic Information Processing System Having a RISC for Displaying Information in a Window

Inventors: Jung, Jae-heon

Assigned to: Samsung Electronics Co., Ltd., Korea

A computer-related system including a reduced instruction-set computer (RISC) central processing unit for effectively processing a data bottleneck phenomenon due to a great deal of data on a bus occurring from the use of graphic processing and windows. The system comprises a RISC central processing unit having address, instruction, and data buses, a memory device for storing and reading instructions and/or data, which is connected to a RISC CPR via the buses, an image processor for processing information as a video signal so as to be displayed on a video display apparatus.

U.S. Patent No. 5,326,989; Issued 7/5/94

Semiconductor Device Having Thin Film Transistor and Method of Manufacturing the Same

Inventors: Muragishi, Takeo

Assigned to: Mistubishi Denki K K, Japan

A TFT is used as a load transistor in a memory cell in a SRAM. A load TFT is arranged on an interlayer insulating layer on the surface of a silicon substrate. A silicon layer in which source/drain regions of the TFT are formed is covered with an oxidation preventing film. An interlayer insulating layer which is to be subject to high-temperature reflow processing is formed on the surface of the oxidation preventing film. The oxidation- preventing film is formed of polycrystalline silicon, amorphous silicon, silicon nitride, or the like and formed on the silicon layer in the TFT directly or through an insulating layer to cover the surface of the silicon layer. ■

book review

Color in Electronic Displays

edited by Heino Widdel and David L. Post
Defense Research Series, Vol. III, 335 pp.
Plenum Press, New York, 1992
Price: $104.95

Reviewed by STEVEN E. SHIELDS

Color in Electronic Displays is the third volume in the Defense Research Series. The editors report that the idea for this book grew out of the work of a NATO-sponsored research study group on "Human Engineering Evaluation on the Use of Colour in Electronic Displays." Its purpose is to consolidate and summarize information on color vision, color perception, colorimetry, and color displays that may have appeared in many diverse publications, so that this information might be more readily available to scientists, engineers, and designers who work with color displays. Thus, it is meant as a compendium of information, both for people who are designing color display hardware as well as for those who create the images to be presented on that hardware.

The book is divided into four sections. The first, on color vision, perception, and measurement, consists of separate chapters by Jan Walraven and Terry Benzschawel, respectively. The first of these, "Color Basics for the Display Designer," is a well-written synopsis of how color is perceived by people, as well as how it might be used in a display. The second goes into colorimetry in much greater depth, covering the various color spaces and how they are related. Both chapters have a wealth of references to the original literature (Walraven's chapter alone has 6 pages of references!)

Section two is entitled, "Research on Color Vision." Its three chapters (by Harry Snyder and Leonard Trejo, David Post, and S. M. Luria) discuss the methods used to study color vision, the results of those studies, and the effects on color vision of environmental effects (ranging from factors such as dark adaptation to other factors not normally considered, such as lack of oxygen, drugs, acceleration or weightlessness, stress, etc.). All of these chapters, again, have extensive lists of references. The chapter by Post is especially good in its explanations of how the measured color vision research results interact with each other and affect real-world applications.

Section three is the shortest section, with only 30 pages. It centers on how color should be used in displays, and has chapters by David Hopkin and J. D. Grossman. The first of these covers some criteria for how and when to use color in displays, and describes several specific system applications. The chapter by J. D. Grossman discusses the standards that currently exist for color usage in displays. The brevity of this section is further evidence of the problem that there is a wealth of information on how the human visual system works, and much information on how to generate color in a display device, but very little practical information on how to best use that color on the display to communicate with the end user.

The final section describes color display technology. There are chapters on CRT Technology (T. R. H. Wheeler and M. G. Clark), Flat-Panel Displays (M. G. Clark), Color Projection Displays (Ron Gold), and Colorimetric Measurement, Calibration, and Characterization of Self-Luminous Displays (David Post). These chapters are generally brief survey-type introductions to the various technologies. The chapter on CRTs is especially well written and complete; it even includes a chronology of CRT development. The final chapter on measurement techniques describes many of the pitfalls inherent in making such measurements, and probably should be required reading for anyone measuring the performance of a color display.

This book should be a valuable reference, especially for those of us who are active in display device and system development, but who are not as knowledgeable about color vision and the reasons one might choose particular colors for particular applications. It may also be useful for people who are doing research into color vision, helping them to understand the display devices most commonly used for display systems. One thing is puzzling, though. Why, in a book on the use of color in electronic displays, are there no color illustrations (not even a color jacket)? ■

Dr. Steven E. Shields is a Senior Scientist with Hughes Aircraft Co., Technology Products Division, Carlsbad, California.

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