≡ Official Monthly Publication of the Society for Information Display

INFORMATION DISPLAY

February 1994
Vol. 10, No. 2

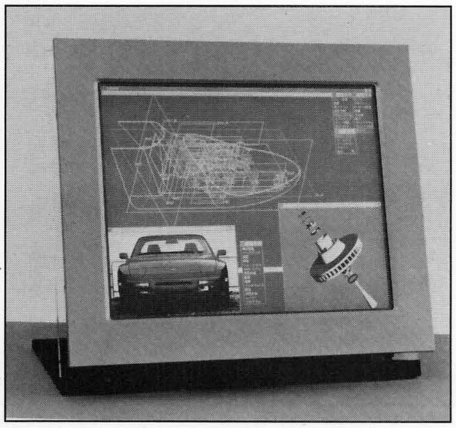
FLAT-PANEL ISSUE

JTEC update
Ferroelectric marketing strategies
Eurodisplay '93 report

Non-Profit Organization
U.S. Postage
PAID
Phillipsburg, NJ
Permit No. 187

Official Monthly Publication of the Society for Information Display
INFORMATION DISPLAY
FEBRUARY 1994
VOL. 10, NO. 2

Cover: The world's largest AMLCD, made by Sharp, is 17 in. on the diagonal, has 1024 × 1280 full-color (RGB) pixels, and offers multimedia capability. An a-Si TFT is used at each of the 3,932,160 subpixels. Sharp has not yet commented on product availability.



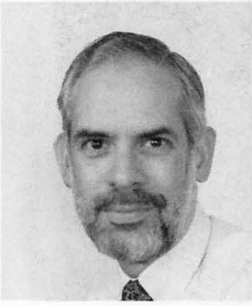
Sharp Corp.

Next Month in Information Display

SID '94 Preview Issue
- SID '94 preview
- DMTC '94 review
- Fertilizing the green machine
- Projection-display market update

INFORMATION DISPLAY (ISSN 0362-0972) is published ten times a year for the Society for Information Display by Palisades Institute for Research Services, Inc., 201 Varick Street, New York, NY 10014; David Slater, Chief Executive Officer; Leonard H. Klein, President; Laura Manganiello, Secretary/Treasurer. EDITORIAL AND BUSINESS OFFICES: Palisades Institute for Research Services, Inc., 201 Varick Street, New York, NY 10014; telephone 212/620-3371. Send manuscripts to the attention of the Editor, ID. DISTRICT SALES OFFICES: WEST/MID-WEST – Ted Lucas, 5428 N.W. Pinery, Newport, OR 97365; telephone 503/265-9140. EAST – Jay Morreale, Palisades Institute for Research Services, Inc., 201 Varick Street, Suite 1006, New York, NY 10014; 212/620-3371. INTERNATIONAL – Caracal Communications, Lee Branst, P.O. Box 1513, Redondo Beach, CA 90278; telephone 310/542-4233. SID HEADQUARTERS, for correspondence on subscriptions and membership: Society for Information Display, 8055 West Manchester Avenue, Suite 615, Playa del Rey, CA 90293; telephone 310/305-1502. SUBSCRIPTIONS: Information Display is distributed without charge to those qualified and to SID members as a benefit of membership (annual dues $55.00). Subscriptions to others: U.S. & Canada: $36.00 one year, $5.00 single copy; elsewhere: $72.00 one year, $6.50 single copy. PRINTED by Sheridan Printing Company, Alpha, NJ 08865. Third-class postage paid at Phillipsburg, NJ. POSTMASTER: Send address changes to Society for Information Display, 8055 West Manchester Avenue, Suite 615, Playa del Rey, CA 90293.

editorial



A Pyrrhic Defeat

In *The Lives of the Noble Grecians and Romans* – which was on *The New York Times* bestseller list for 36 weeks in the year 100 A. D. – Plutarch relates the story of Pyrrhus, king of Epirus. Pyrrhus defeated the Romans and their allies several times between 280 and 275 B.C., but the victories were so costly that the Epirotes could not bring their campaign to a successful conclusion. The expression "Pyrrhic victory" entered the language to describe a victory that paves the way to defeat.

The CRT-monitor industry has implemented a clever reverse on the Pyrrhic victory. It has capitulated, after barely firing a shot, on the issue of building monitors that comply with various national and ISO limits on electromagnetic emissions.

As has been documented in the pages of *ID* and other publications, there is no evidence that electromagnetic emissions from ordinary monitors cause any harm to the people who use them. Furthermore, if you are inclined to set emission limits, there is no physiological or epidemiological data that would help you select what those limits should be. Given this situation, the technical purists among us might be inclined to dig in our heels and say, "No! We will fight these absurd limitations that will raise the price of monitors without providing any demonstrable benefit to users." Happily, wiser heads have prevailed.

Although scientifically justified, a refusal to accommodate concerns about monitor emissions would be seen by many potential customers as industry insensitivity to a public-health issue. The marketing gurus accurately saw this as an extremely undesirable position to defend. It would be far better to withdraw from the confrontation, cooperate with the limit-setters, and bask in the rosy glow that surrounds you when you are seen as a responsible, health-conscious manufacturer. And this is exactly what manufacturers of premium displays have done. Thus far, according to industry sources, engineering monitors for low emissions has added only slightly to the cost and price of their products. (And the customers of manufacturers whose business depends on wringing every ha'penny of cost from their products tend not to be interested in intangibles like low emissions.)

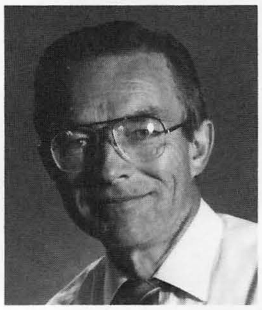
So, the CRT monitor industry has created the Pyrrhic defeat: a seemingly pusillanimous retreat that has created warm customer and government relations, and improved sales of premium product.

– Kenneth I. Werner

Official Monthly Publication of the Society for Information Display

INFORMATION DISPLAY

the display continuum



By the Way . . . What Do Sewing Machines Have to Do with Displays?

by Aris Silzars

Several weeks ago I met a really classy gentleman, one of those interesting people that we all run into once in a while. His name is Bill Webb. He and his wife own a fabric shop, and he sells sewing machines. (Try saying that three times real fast!) Bill looks like a kindly old philosopher, complete with a full, mostly white beard and gentle demeanor. And he sure knows a lot about sewing machines.

Now fabric shops are not my usual venue. You are much more likely to find me in a bookstore or hardware shop. Nevertheless, here I was getting a tutorial on the latest sewing machine technology, all on the pretense of helping a daughter with a choice that she had already made.

I learned from Bill that not only are today's sewing machines more impressive than I would have thought, but he further enlightened me on what we are likely to see in future generations of products. As I was carrying our new microprocessor-controlled mechanical wonder to the car, I decided that the least I could do would be to share some of this new learning with you. And, yes indeed, it has some very interesting implications regarding the use of displays. (Were you beginning to think I might not make the connection?)

Technology has done for sewing machines what stepper motors and numerical control (NC) did for milling machines and lathes. Machinists in today's shops quite often do more programming than machining. Similarly, the sewing machine has become a computer-programmed stepper-motor-driven sensor-controlled mechanical marvel. The concept is – using our NC milling-machine comparison – that the needle is like the milling tool and the table that holds the fabric is like the bed. And even though one would think that flimsy and stretchy fabrics would be quite difficult to position and control, it is being done with surprising precision.

As each manufacturer tries to exploit this new design approach for competitive advantage, ever more complex patterns and stitches are being programmed into the machines. The user (sewperson?) makes the desired selection by finding the correct pushbutton and/or knob. However, with all these features there is a plethora of buttons and knobs. The machines have taken on the look of mechanical porcupines. The point has been reached that even with multiple overlay templates there is no room left for adding more. So the newest machines have incorporated menu-driven LCD panels. The resemblance in function to a computer-driven milling machine couldn't be closer. (Just think of the fun you can have with your older machinist friends when you tell them that they are already trained to take up sewing as an alternate career.)

Serviceability on these machines is surprisingly good, although not cheap. The electronics modules are relatively easy to replace and most servicing is done by using factory-supplied diagnostic routines to guide the service technician to the correct module and/or board swap.

However, the really exciting developments are still to come. My friend Bill tells me that the connection between computers and machines is going to get tighter. He predicts that in just a few years there will be a download mode so

continued on page 27

Society for Information Display
8055 W. Manchester Ave.
Suite 615
Playa Del Rey, CA 90293
310/305-1502
Fax: 310/305-1433
e-mail: MCI-ID: 424-2462

Ferroelectric LCDs: The Way to the Marketplace

Should a capable new technology be sent against an entrenched opponent head to head, or should it first take on simpler applications for which it is uniquely suited?

by Alan Mosley

FERROELECTRIC LCDs (FLCDs) are among the latest in a long line of liquid-crystal (LC) technologies. Their two main attributes are very fast switching – typically less than 100 μsec – and bistability. This combination of properties enables FLCDs potentially to provide complex alphagraphic displays for laptop computers and similar applications. The complex alphagraphic display may be the obvious approach to the marketplace but it may not be the correct one. Should the exploiters of FLCD technology be seeking an alternative point of entry? Our answer to this question begins with a brief description of the history and operation of FLCDs.

History and Operating Principles

In 1975, R. B. Meyer and his colleagues predicted, and later demonstrated, that chiral tilted smectic LCs would exhibit ferroelectricity and would therefore possess a large spontaneous dipole (P_s) oriented perpendicular to the long axis of the LC molecule.[1] The chirality required to induce ferroelectricity also promotes a helical structure. This structure tends to average out the direction of the spontaneous dipole, which suppresses the ferroelectric behavior.

Meyer realized that making a useful device depended upon removing the helical structure. This was first done by shearing the glass substrates that enclosed the ferroelectric liquid crystal (FLC) and is now done by using rubbed polyimide surface-alignment layers similar to those used in nematic-based LCDs.

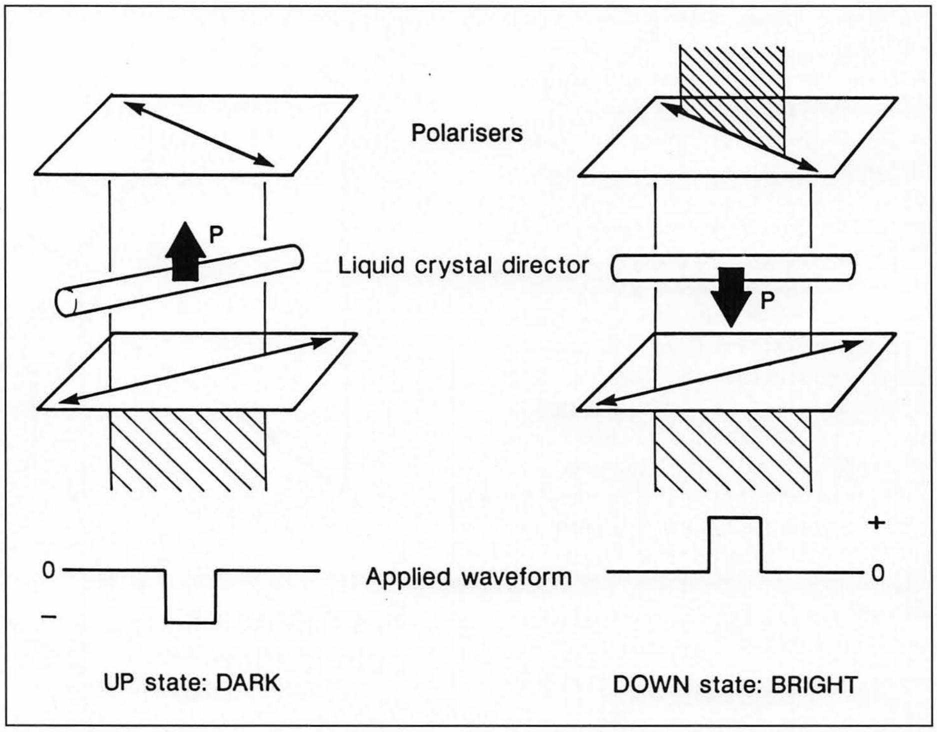


Fig. 1: An FLCD operates by changing the orientation of the LC molecule in the plane of the display. This mechanism differs dramatically from that used in the more familiar LCDs containing nematic LCs.

Alan Mosley is Business Development Manager of the Science Directorate at the GEC-Marconi Hirst Research Centre, Elstree Way, Borehamwood, Herts WD6 1RX, England; telephone 44-081-732-0096, fax 44-081-732-0100. Dr. Mosley received his Ph.D. in Raman spectroscopic studies of liquid crystals in 1974 and has a background in liquid-crystal materials and LCD production. He was Chairman of the U.K. & Ireland Chapter of SID from 1991 to 1993.

In either case, the spacing between the two substrates is about 2 µm, a spacing that is also required if the FLC cell is to act as a half-wave plate. (In a half-wave plate, $\Delta nd/\lambda = 0.5$. If $\Delta n = 0.13$ and $\lambda = 0.5$ µm, then $d \sim 2$ µm.) The operation of an FLC optical device – a display or an optical shutter – depends on the orientation of the LC's dipole (Fig. 1). That orientation is determined by the polarity of the addressing pulse. But the FLC molecule cannot simply rotate about its own axis; instead, it is constrained to rotate about an imaginary cone (Fig. 2). If the half-cone angle θ – which is equal to the tilt angle of the molecules in the smectic layer – is approximately equal to 22.5°, then the orientation of the LC molecule will change by 45° when the polarity of the address pulse is reversed. This is the angular change that produces optimum optical transmission and contrast ratio (Fig. 3).

Much of the pioneering work on FLCDs was carried out by Clark and Lagerwall, whose efforts brought the potential of FLCDs to the attention of the displays community.[2] Between 1985 and 1987, there was a great deal of activity on FLCDs, notably by several Japanese companies. Seiko-Epson was particularly active and demonstrated a display at SID '85. The same company also provided the first electrical addressing scheme for FLCDs, which became known as the Seiko four-slot scheme. The four slots are required to provide dc balance and to overcome the fact that the first pair of bipolar row and column pulses can only, for example, switch black pixels to white or leave white pixels unchanged. The second pair of bipolar pulses is needed to switch pixels to the black state. One consequence of needing four time slots is an increase in the frame time of the display – which is defined by $n \times t_s \times N$, where n is the number of time slots, t_s is the slot time, and N is the number of rows.

I believe that much of the early interest in FLCDs was due to the extreme difficulties being experienced at the time by researchers working on active-matrix-addressed LCDs. (It is usually the case that new areas of research are approached with great optimism – which soon disappears once the problems associated with the new technology become apparent.) The impact of this situation was that FLCD technology was driven in the direction of providing complex alphagraphic displays of the type now realized by super-twist (ST), active-matrix, electroluminescent (EL), and plasma-panel displays (PPDs).

Cost-to-Performance Ratio

From 1987 onwards only a small number of groups maintained their interest in FLCDs, including Canon, Hoechst, the UK Joers-Alvey Consortium, and the European FELICITA Consortium. The most notable of these is Canon, which seems to have directed huge resources to the development of large-area FLCDs for use in workstations. Although Canon has fabricated and demonstrated both color and monochrome FLCDs with diagonals of up to 24 in. (Ref. 3) and have repeatedly announced plans to move into production, commercial ferroelectric displays are still not available. Another FLCD that has been widely demonstrated is the 10.4-in. color VGA display fabricated by Thorn EMI.[4]

The structure and fabrication of FLCDs are very similar to those of supertwist LCDs (ST-LCDs) (Fig. 4). The two main differences are

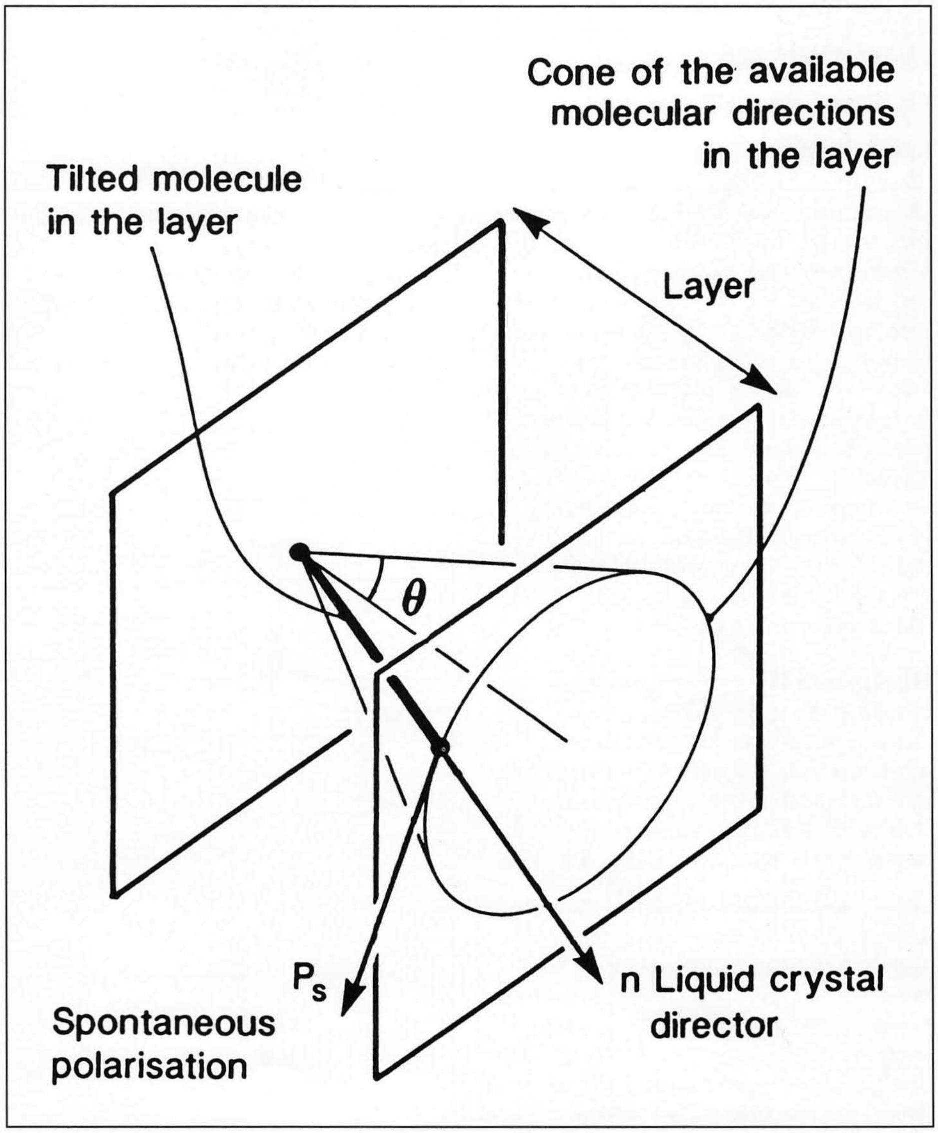


Fig. 2: The orientation of the LC's dipole is determined by the polarity of the addressing pulse, but the FLC molecule cannot simply rotate about its own axis. It is constrained to rotate about an imaginary cone.

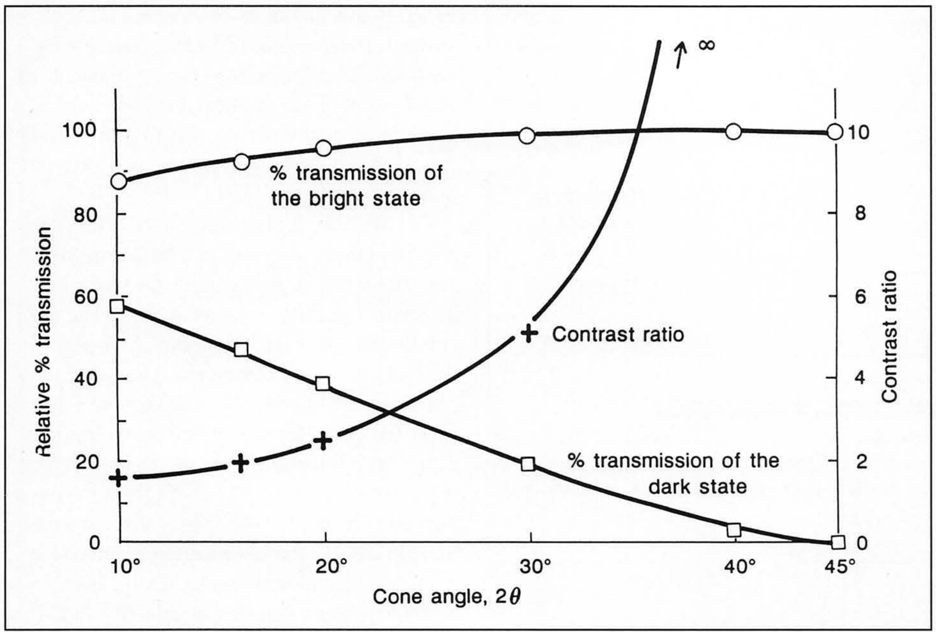


Fig. 3: Contrast and transmission of an FLCD versus the switched cone angle. A half-cone angle θ of approximately 22.5° results in the orientation of the LC molecule being changed by 45° when the polarity of the address pulse is reversed. This is the angle that produces optimum optical transmission and contrast ratio.

(1) the use of a 2-μm cell spacing instead of the 5-6 μm used for ST-LCDs, and (2) the requirement for heating both the FLC and the display cells to between approximately 80 and 100°C during the vacuum-filling process. The heating is required because the smectic LC used in FLCDs is highly viscous, unlike nematic LCs. In my experience, the reduction in cell spacing does not cause significant problems if a Class 1000 cleanroom is used together with "spike-free" indium-tin-oxide (ITO) glass substrates.

The reduced spacing and heated filling process are likely to make the volume manufacturing costs of FLCD glass about 10% higher than those for ST-LCDs. The cost of the drive electronics for FLCDs is likely to be similar to that for ST displays. Although the cost of the drivers for complex alphagraphic FLCDs with frame times of ≤50 msec will probably be higher because FLCDs need a voltage swing of 100 V compared with 35 V for ST-LCDs, the higher multiplexing capability of this technology will result in the use of fewer column drivers. Looking at all of these factors, one can conclude that the selling price of FLCDs will be slightly higher than that of ST displays.

Having compared the manufacturing costs of FLCDs and ST-LCDs, let us now compare the performance of color VGA displays made in each of the two technologies (Table 1). An important property of FLCDs is that their optical characteristics are derived from changing the orientation of the LC molecules in the plane of the display; that is, the molecules effectively switch across the surface of the substrates. This differs dramatically from displays utilizing nematic LCs, in which the molecules switch their orientation relative to the glass substrate from parallel to perpendicular. The parallel-to-perpendicular mechanism makes the contrast ratio strongly dependent upon viewing angle because the maximum contrast occurs when one is looking parallel or perpendicular to the long axes of the LC molecules. [This phenomenon is also the cause of the strong viewing-angle dependence of active-matrix LCDs (AMLCDs) showing gray scale.] In principle, the bistability of FLCDs leads to their contrast ratios being independent of the level of multiplexing, so relatively high contrast ratios can be achieved in complex displays.

Another key feature of FLCDs is that they are driven both on and off, unlike ST and other nematic-based LCDs, which are driven "on" but relax "off." This leads to reduced total on-plus-off times – a typical line address time for an FLCD is 70 μsec. The main established disadvantage of FLCDs is their inability to produce gray scale. Although gray levels can be achieved by spatial or temporal dither, both of these techniques increase the complexity – and the cost – of the display module.

FLCDs have acquired a reputation for being sensitive to mechanical shock. This sensitivity, which certainly existed in earlier displays, results from the FLC's tendency to revert to its natural helical structure as a result of flow induced by an external force. The only way to recover the required alignment of the FLC is to heat it to 80°C, the temperature at which it turns into its nematic or isotropic liquid phase.

Improvements in cell technology have dramatically reduced the mechanical-instability problem. Although it has not been totally

Table 1: A Comparison of the Characteristics of Color VGA FLCDs and ST-LCDs

	FLCDs	ST-LCDs
Contrast ratio	25:1	15:1
Viewing angle	Very good	Limited
Frame time	35 msec	>100 msec
Gray levels	0	~16
Robustness	Not well established	Very good
Operating temperature	Not well established	0 to +50°C
Storage temperature	Not well established	-20 to +60°C

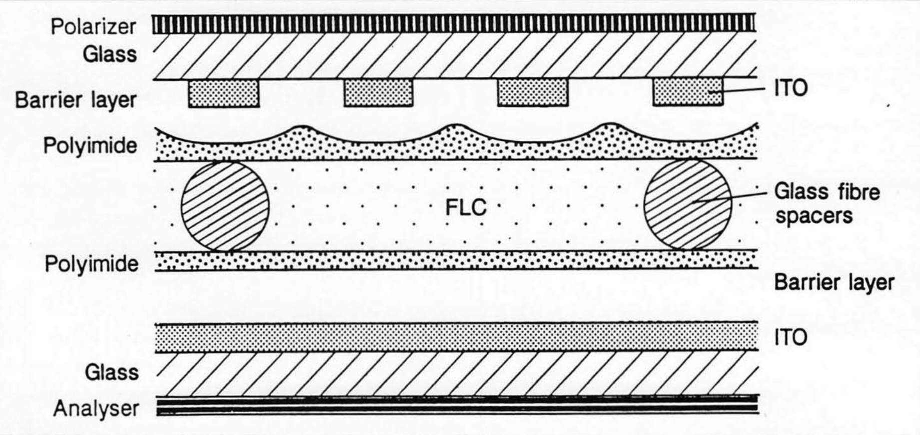
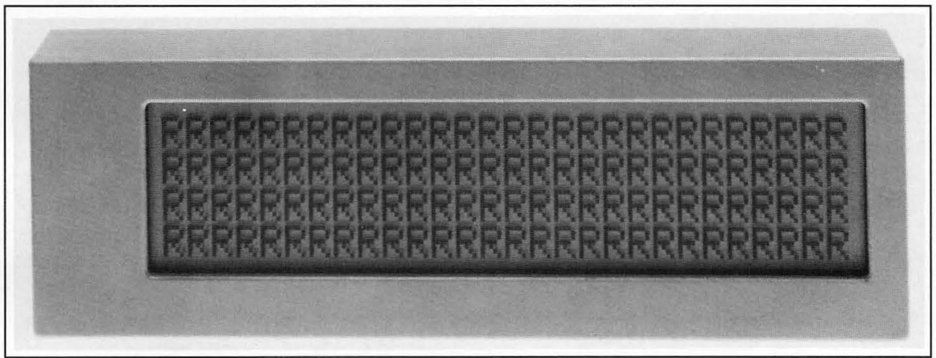


Fig. 4: *The cross section of an FLCD is very similar to that of an ST-LCD, but the cell spacing is typically 2 μm instead of the 5–6 μm used for an ST-LCD.*



GEC-Marconi Hirst Research Centre

Fig. 5: *GEC's latest non-volatile FLCD maintains good contrast without any power being applied to the display. (The display is* **not** *restricted to displaying the letter "R"! The display's drive electronics had not been completed when the photo was taken.)*

eliminated from large-area displays, small-area displays – of about 6 square inches or less – no longer suffer from this disadvantage in practical use. Many people in the field anticipate that this will apply to large-area displays within the next 2 years.

The operating and storage temperature ranges of FLCDs are not well established, although a storage temperature range from -15 to +65°C and an operating temperature range from +15 to +50°C have been reported.[4] There is no fundamental reason why these temperature ranges cannot be extended to match those of current ST displays.

In summary, FLCD technology can be used to make large-area complex alphagraphic displays with performance and manufacturing costs that are generally comparable to those associated with other flat-panel display (FPD) technologies. This has seduced some developers of ferroelectric displays into trying to compete with those entrenched technologies head to head. Unfortunately, precisely because the costs and performance are generally comparable in the case of these large-area displays, it is not obvious that FLCDs have an advantage in cost/performance ratio over other FPD technologies.

The Way to the Marketplace

It is clear that FLCDs have great potential as alphagraphic displays. However, bringing FLCDs into the marketplace as displays for laptop computers, for example, seems extremely risky. Color VGA displays are complex, expensive, and have large areas, requiring a large investment – perhaps $50,000,000 – in plant and machinery, and low initial yields. In addition, ST and active-matrix displays are already very well established in this marketplace and both have strong infrastructures of finance, manpower, knowledge, and materials. The proponents of FLCD technology must establish such infrastructures if their technology is to grow. To do this, they require a high-volume product, but does such a product exist?

FLCDs exhibit bistability. Under the correct conditions, they can exhibit bistability at zero field; that is, they can be non-volatile. This non-volatility can – again under the right conditions – be very long term. A display at the Hirst Research Centre has retained a displayed image at zero power for 6 years! No other flat-panel technology currently has this capability. It therefore seems sensible to identify products that would benefit from having a non-volatile display – a display that can continue to display the last image presented to it without consuming power. Clearly, any portable product that uses a reflective FPD (a backlight would negate any power savings) and updates its displayed information infrequently (e.g., at intervals of 1 min or more) will greatly extend its battery life with a non-volatile display. For example, the power consumption of a non-volatile FLCD that is required to update its image every minute would be about 1/3600 the power consumption of a comparable ST display refreshed at 60 Hz.

Many conventional FLCDs do not exhibit non-volatility or they exhibit non-volatility with a much reduced contrast ratio. This reduced contrast is due to relaxation in the orientation of the LC director when the applied electric field is removed. The relaxation stems from a restoring force induced by the alignment of the LC molecules at the surface of the glass substrates. Having recognized this problem in 1987 and subsequently patented ferroelectric cell structures that overcome it, GEC's Hirst Research Centre was well placed to develop a high-contrast non-volatile FLCD.[5] Our latest generation of technology provides a relaxed – that is, zero power – half-cone angle of 15°, which produces a bright high-contrast display with a very wide viewing angle (Figs. 5 and 6).[6]

Products that seem ideal for a simple non-volatile FLCD include autonomous electric labels, portable data loggers, and personal telecommunication devices. The autonomous electric label could be used in an electronic shelf-edge labeling system for supermarkets.

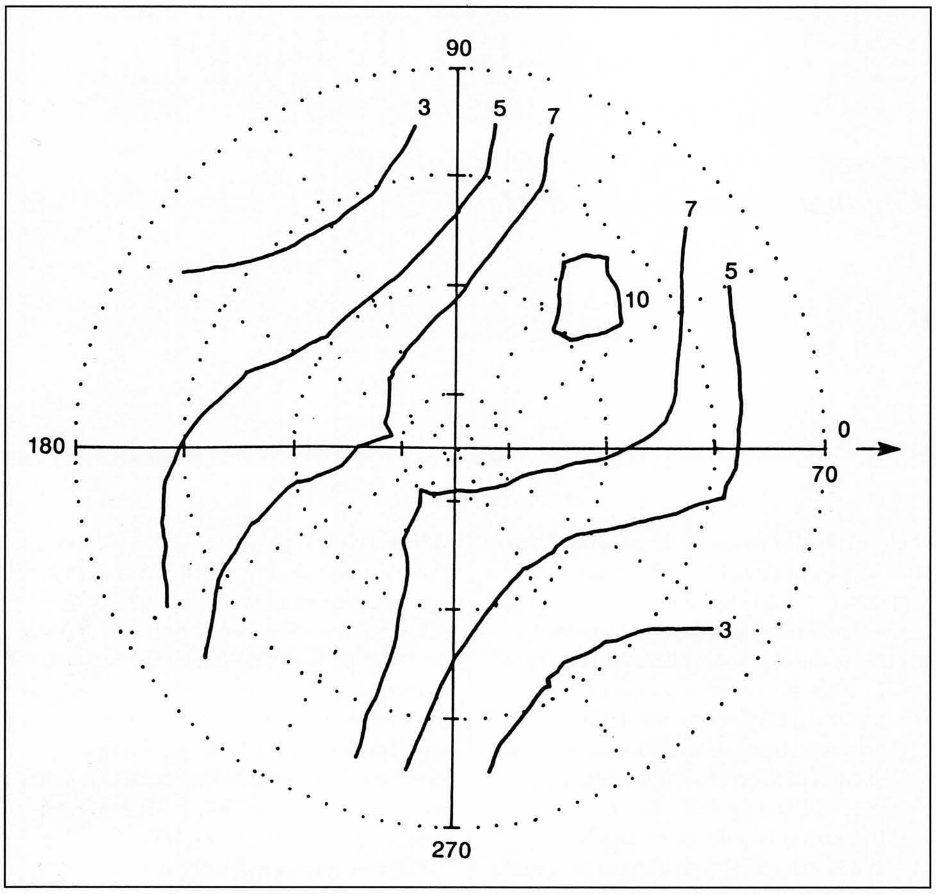


Fig. 6: Iso-contrast curves for the display in Fig. 5 (optimized for brightness) indicate a bright high-contrast display with a very wide viewing angle. (Measurement made by Autronic Melchers GmbH.)

Potentially, this is an extremely high-volume market: there are roughly 20,000 products in a typical UK supermarket. Another high-volume application for this device is as the reservation label for train seats. Data loggers and personal telecommunication devices also have high volume requirements and require relatively simple displays. Simplicity is important because it reduces the required investment in plant and machinery – and therefore the financial risk. While these markets must still be accessed, they should be relatively safe once they have been established because of the unique non-volatility of FLCDs.

We have therefore concluded that FLCDs should enter the marketplace by providing simple low-cost non-volatile displays for high-volume applications. The infrastructure formed by the mass production of these simple displays will then enable FLCD technology to grow and expand into other product areas requiring complex non-volatile displays and will ultimately allow it to compete with the mainstream flat-panel technologies. This proposed route to the marketplace, through the high-volume production of simple displays having a specific advantage, is not new. After all, LCDs started off as watch displays!

Acknowledgments

Much of the work undertaken by GEC on FLCDs was supported by the European Commission as part of the ESPRIT Project 2360, FELICITA.

Notes

[1]R. B. Meyer *et al.*, *J. Phys. Lett.* **36**, L-69 (1975).

[2]N. A. Clark and S. T. Lagerwall, *Appl. Phys. Lett.* **36**, 899 (1980).

[3]Y. Hanyu *et al.*, "Molecular Alignment of a Very-Large-Size FLCD," *SID International Symposium Digest of Technical Papers*, 364 (1993).

[4]P. W. Ross *et al.*, "Color Digital Ferroelectric LCDs for Laptop Applications," *SID International Symposium Digest of Technical Papers*, 217 (1992).

[5]C. Bowry *et al.* (including the author), U.S. Patent No. 4,832,462.

[6]B. M. Nicholas, Electronic Information Display Conference, Sandown, England, November 1993. ■

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.

Flat-Panel-Display Technologies in Japan

An update of JTEC's 1991 report reveals a new bullishness toward AMLCDs and a clear understanding that CRTs are here to stay.

by Lawrence E. Tannas, Jr.

IN OCTOBER OF 1991 a panel of six experts and five observers visited 33 Japanese sites under the auspices of the Japan Technology Evaluation Center (JTEC).[1] Their mission: to report on the extent to which the Japanese had advanced the state of the art in flat-panel displays (FPDs) in general, and in high-information-content (HIC) liquid-crystal displays (LCDs) in particular.[2-4]

JTEC subsequently asked me, as one of the two co-chairmen of the original JTEC Flat Panel Display Technology Committee (the other was William Glenn of Florida Atlantic University), to do a follow-up study. This is the report of that study.

A recent re-reading of the JTEC Committee's original report leaves me with the conviction that the Committee did a thorough and accurate job of reviewing Japanese FPD technology as it was and seemed to be developing in late 1991. Attendance at the 1992 and 1993 Japan Electronics Shows and recent visits to Japanese FPD manufacturers have convinced me that our predictions of production ramp-up of FPDs in general and active-matrix LCDs (AMLCDs) in particular were, if anything, on the conservative side. In retrospect, this is understandable because the mood in Japan was also conservative at the time. Nonetheless, K. Odawara's recently updated prediction of global display production is essentially the same as was given to the JTEC panel in September of 1991 (Fig. 1).

The figure reflects several fundamental changes in the electronic displays industry:

- In 1989, FPDs became a multibillion-dollar industry, with annual growth rates between 18 and 35%, thanks to the introduction of supertwisted-nematic LCDs (STN-LCDs) for PCs.
- Because of two developments in the 1980s – the STN type of passive-matrix LCD (PMLCD) and the amorphous-silicon (a-Si) thin-film-transistor (TFT) type of AMLCD – LCD flat-panel technology advanced over the last decade to such an extent that it is now orders of magnitude ahead of all other FPD technologies. In addition, AMLCDs with full-color video performance were introduced in the early 1990s.
- The sales of all HIC displays will double in 10 years, corresponding to a compounded annual growth of 7%.
- Because of cost differentials, CRTs will not be replaced by FPDs.
- CRT sales will continue to grow, but at a much slower rate than FPDs.
- By the year 2000, one-half of all HIC display sales will be in FPDs.
- The share of the FPD market captured by AMLCDs and PMLCDs is highly dependent on the technical evolution and cost reduction in these two approaches, as well as on the end-market demand for consumer products. There will be more sales volume in PMLCDs and more sales value in AMLCDs.

What's New?

The present status of the displays industry – as exhibited, for example, at JES '93 and the U.S. Consumer Electronics Show – confirms the JTEC study. What is new and was not predictable is the second round of Japan's investment in LCDs: another $2-plus billion over and above the $2-plus-billion figure compiled in the 1990 Nikkei electronic FPDs study, updated in late 1991 by Tannas Electronics, and reported by the JTEC Committee.

The new investment is for the second generation of AMLCD production machinery. It comes as a surprise because the JTEC panel was told there would be no second generation of AMLCD machinery until the first generation proved the viability of a-Si TFT-AMLCDs. This viability has now been proved to the satisfaction of Japanese HIC LCD manufacturers.

Price, Price, and Price

The price differential between CRTs and LCDs is immense; 14-in. color CRT televisions are available in Asia at OEM unit prices of $50[5] and 10-in. VGA a-Si TFT-AMLCDs are available at sample prices of about $1400, and might be available for $1000 in OEM quantities. Only the highest-tech market segment can afford and use AMLCDs. In a world in which more than half the population still does not have television, the continued production of CRTs is ensured well into the 21st century. (Lower-cost STN-LCDs are still more expensive than CRTs, and offer substantially less performance.)

The price of a-Si TFT-LCDs has been studied extensively in Japan, and the consensus is

Lawrence E. Tannas, Jr., is a display-industry consultant and the President of Tannas Electronics, Orange, California; telephone 714/633-7874; fax 714/633-4174. He is a Fellow and Past President of the Society for Information Display.

that a price of ¥50,000 ($500) can be achieved by 1996. This consensus arises because the next generation of machinery is expected to provide a productivity of from 3 to 5 times that obtained today. AMLCD factory yields have been significantly improved by many of the Japanese manufacturers, and several of them are now saying they are making a profit.

Profitability and yield have never been an issue with STN-LCDs, which are neither capital intensive nor technically risky. The anticipated price pressure STN-LCDs are expected to exert on AMLCDs will not occur until the production capacity of AMLCDs meets the market demand, which won't occur until more factories come on line with the next generation of manufacturing machinery.

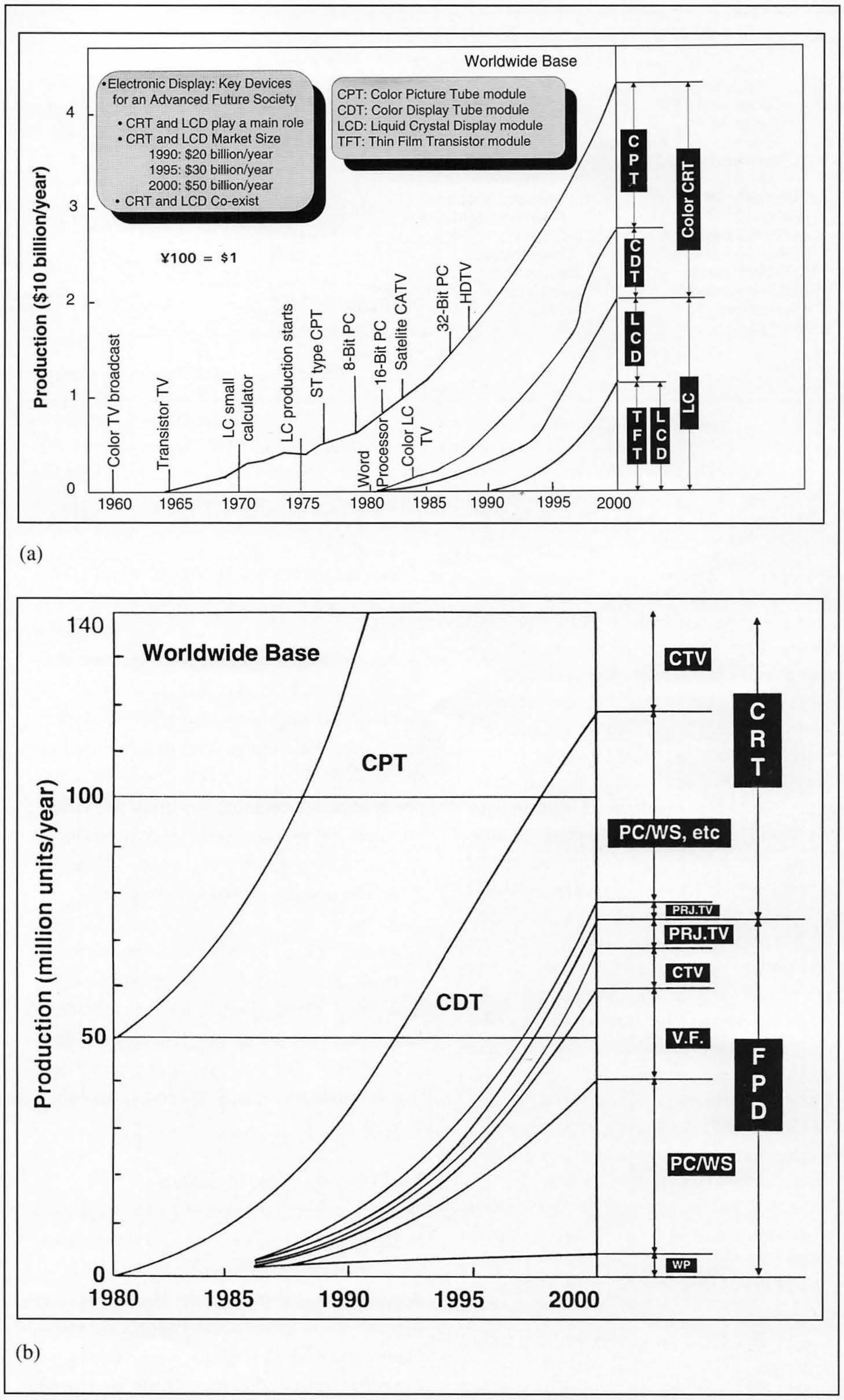
Expanding Applications

There has been a continuing debate whether STN or AMLCD will dominate the HIC FPD market. But rather than converging on one dominant technology, market needs are diverging, which should create long-term application areas for both technologies. If you insist on an estimate of which technology will have the largest slice of the pie, Nomura Research Institute predicts that a-Si TFTs will have 60% of the HIC FPD market by 1996.

Market applications for all types of LCDs are expanding, and the difference in performance-to-price ratios between a-Si TFTs and STN-LCDs is becoming more sharply defined. Super-MIM, active-addressing, and dual-scan color STNs may find market positions between a-Si TFT and STN-LCDs (Fig. 2).

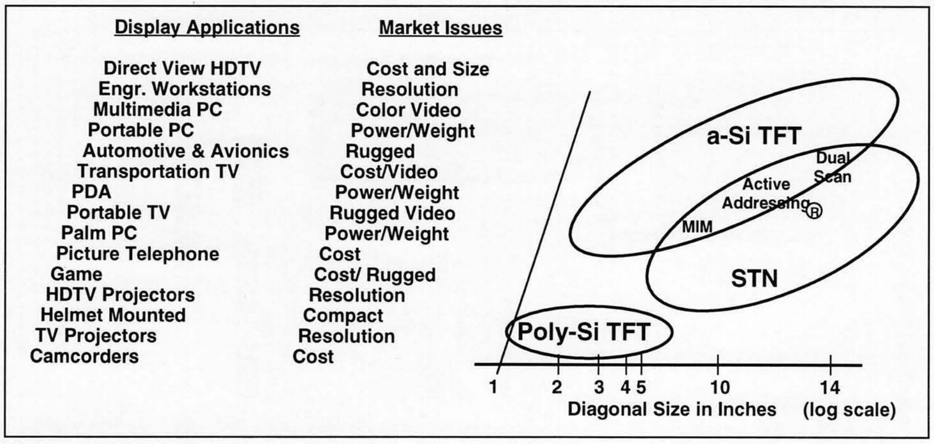
One new product area into which HIC FPDs are expanding is the color camcorder viewfinder. This product was just emerging when the JTEC panel went to Japan in 1991. Now a major component in production by Hitachi and Seiko-Epson, among others, it uses polysilicon (p-Si or poly-Si) TFT-LCDs with integral driver chips made in-situ (Fig. 3). New products, such as virtual-reality goggles and small projectors, are spinning off this component.

A new product made possible by Global Positioning Satellite (GPS) navigation is a moving-map display for automotive, marine, and avionic use. This product – with laser-disk map storage and player, an LCD displaying maps of Tokyo, a GPS signal antenna, and a processor computing the user's present posi-



Courtesy of K. Odawara, Hitachi, Ltd.

Fig. 1: (a) A September 1993 update of the value of historical and projected display production, along with significant applications developments. (b) Production volume.



Prepared by Tannas Electronics

Fig. 2: Market applications for all types of LCDs are expanding. Super-MIM, active-addressing, and dual-scan color STNs may find market positions between a-Si TFT-LCDs and STN-LCDs.

tion for display on the maps – is now being sold in the Tokyo electronics district of Akihabara for $2000 (Fig. 4).

Thus far, the engineering workstation market has not been penetrated by FPDs because there aren't any FPDs on the market with sufficient size and resolution. But AMLCDs capable of workstation-level performance have been demonstrated (see cover) and could go into production between 1996 and 1999.

An AMLCD of workstation size will present the marketplace with an interesting paradox and will, for the first time, present a direct challenge in a market now dominated and satisfactorily served by the CRT. The AMLCD itself will be much more expensive than the CRT, but for the first time users will have an opportunity to replace the bulky CRT with an FPD and recover valuable desktop space. It will be interesting to see how much of a premium the marketplace will pay for this opportunity.

The price differential between CRTs, AMLCDs, and PMLCDs is a major issue. The different prices buy a different mix of attributes in each technology (Table 1). Whether LCDs can penetrate the workstation market will depend upon a delicate weighing of these metrics.

The FPD industry is going after HDTV in several ways:

- a-Si TFT-LCD projectors – Sharp and Sanyo
- p-Si TFT-LCD projectors – Seiko-Epson and Sharp
- Direct-view AMLCDs in research – GTC (Hitachi)[6]
- Direct-view PDPs in research – NHK and Matsushita

Despite the research activity, there is not yet an obvious solution to the problem of making a consumer-priced display for HDTV.

Another important product is the personal digital assistant (PDA). This product is emphasizing displays with VGA resolution but with smaller dimensions than we usually see in VGA displays. PDAs, along with other portable and pocketable electronic devices, are focusing attention on display ruggedness, as well as on reduced weight and volume. A similar display is used in camcorders (Fig. 5).

At JES '93, Sharp addressed this market by showing a display fabricated on plastic rather than glass. Interestingly, reducing the cost of the display was *not* among the reasons Sharp used plastic. The common conception that a plastic substrate reduces the cost of an FPD is incorrect.

LCD Production in Japan

The increase in the value of LCD production in Japan is a dramatic story, and it coincides with a production volume that is actually decreasing as the production of lower-technology and lower-pixel-count PMLCDs go to other parts of Asia (Fig. 6). The Nomura Research Institute/Sharp has forecast a growth rate in market value of 35%, which produces a dollar value of $15.6 billion by the year 2000 (Fig. 7).

Next-Generation Production Machinery

In 1991 the JTEC Committee visited brand-new Sharp and DTI AMLCD factories incorporating first-generation machinery – machinery that can handle glass substrates measuring approximately 300 × 400 mm using larger PECVD and photolithographical exposure equipment than had ever been used before in production. We were impressed by the expense of the machines and the stipulation that these machines would have to pay for themselves before any further developments could be considered. The first-generation machines were not on line during our visit and the future was uncertain. The yields on "zero-generation" AMLCD pilot lines factories using modified MOS machines were rumored to be less than 10%.

At that time, many people in the displays industry believed that AMLCDs could not be produced profitably because first-generation machines would be unable to process enough glass at sufficient speed and yield. Obviously, Sharp, DTI, NEC, Hosiden, and other companies disagreed, but no one was willing to speculate beyond the first generation.

In 1991 there was clearly a high technical, financial, and market risk. Among the many considerations that tempered commitment to a-Si TFT-AMLCDs were:

- The unresolved question of whether a-Si TFT-AMLCDs could be manufactured economically.
- Technical challenges from MIM and a-Si diodes, p-Si TFTs, and improved lower-cost STN-LCDs.
- Uncertainty over whether the market would accept the most expensive electronic-display product ever offered.
- The absence of a proven consumer market for any high-performance FPD with full color and video speed.
- New technical breakthroughs in other FPD technologies that could mitigate the advantages of a-Si TFTs.

The industry's direction and rate of change were both unclear, and the obvious technical advantages of a-Si TFTs were clouded by market and economic issues.

It is now time to update the appraisal of 1991. The technical, financial, and market risk is over. It is now clear that:

- The technical manufacturability of a-Si TFT-AMLCDs has been proved and the industry is improving performance.

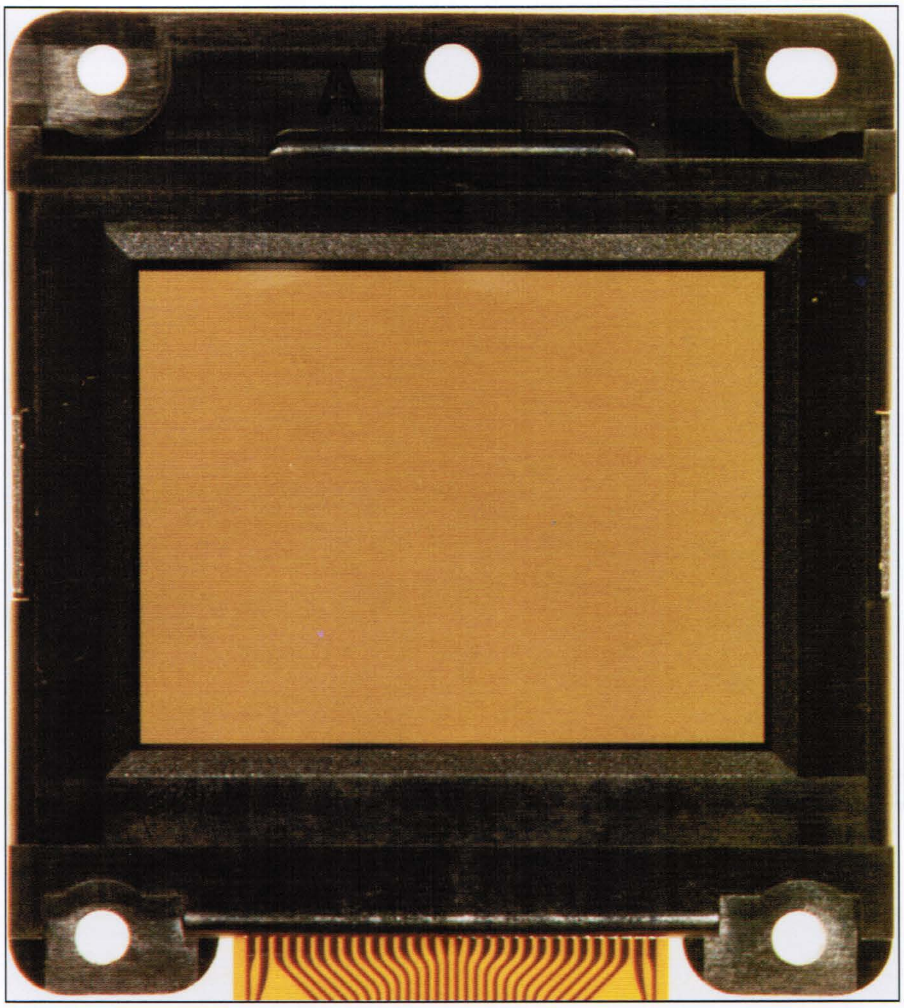
- The financial risk is over. The industry is vigorously working on product cost reduction, and the Japanese AMLCD industry is expanding despite the general slowdown of the global economy. Several AMLCD manufacturers say they are making a profit. The industry is now progressing to the second generation of machinery, which has 3–5 times the productivity of the first generation (Tables 2 and 3).
- Market demand exceeds production capacity. The marketplace has focused on a product size of approximately 10 in. on the diagonal, with VGA resolution and 9–18 bits of color. The focus is on products that use a-Si AMLCDs because of their superior performance and speed of response. The greatest growth is in high-end portable PCs. The PMLCD market is also very strong and growing at a rapid rate.

The new round of investment is the strongest statement the Japanese displays industry could possibly make about its commitment to LCDs. The sample of reported investments shown in Table 3 exceeds $2 billion – that's $2 billion above and beyond the more than $2 billion reported in 1991. NEC is leading the charge toward second-generation machinery; installations started in late 1993. In late 1992, Sharp announced its largest single capital investment ever – ¥80 billion – which included new machinery for a new line, machinery upgrades on the first two lines at the 3-year-old Tenri factory, and a new factory in Mie Prefecture.

The new round of investment is causing a shakeout of Japanese AMLCD manufacturers. The cost of entry is now so high that we are not likely to see new manufacturers entering the marketplace. Sharp is now, by far, the world leader in the production of PMLCDs and AMLCDs, and may capture 50% of the world's AMLCD market by 1995.

Second-Generation Production Machinery

The a-Si TFT-AMLCD industry is now following the same growth pattern we have seen in the MOS, DRAM, and microprocessor industries (Table 2). Note that the technological life of production machines is expected to be approximately 3 years while production



Target Specifications for 1.3-in. Polysilicon Liquid-Crystal Display

Item	Specifications
Module size (mm)	38 (H) × 42 (V)
Display-area dimensions (mm)	26.88 (H) × 20.16 (V) (1.32-in. diagonal)
Number of dots	640 (H) × 480 (V)
Dot pitch (μm)	42 (H) × 42 (V)
Aperture ratio	0.3
Transmittance	0.07
Contrast	>100:1
Response time	50 msec at 25°C

Seiko-Epson

Fig. 3: *Seiko-Epson has introduced this new 1.3-in.-diagonal poly-Si AMLCD having 480 × 640 color pixels – 307,200 addressable dots. Seiko-Epson expects to have engineering evaluation units ready for the Japanese market in June.*

Sony Corp.

Fig. 4: *The newest Sony Portable Global Positioning System (GPS) was released in September. It uses the C-Map Marine Database on a removable Info-Card. For portability, the system uses an STN-LCD.*

life may be as long as 7 years. Quantum jumps in size and market are anticipated every 3 years. It is too early to confirm many of the details for generations 3 and 4, but generation 2 has started with NEC.

Extrapolations of when new generations come on line may change with time, but the evolutionary stage is set. Upon that stage, corporate actors will adjust their tactics as shifts in the marketplace demand – and as the electronics industry has often done in the past.

One ramification of the dramatically increased confidence in the FPD industry is that the required broad base of industries has become more supportive. The chemical, glass, printing, electronics, and machinery industries, as well as all of the other industries associated with displays manufacturing, are investing in new plants and capacity.

The JTEC Committee predicted that AMLCD production would not exceed 16 in. by the year 2000, but Sharp demonstrated a 17-in. 1024 × 1280 full-color AMLCD at JES '92 and '93. Samples of sizes over 14 in. on the diagonal may be available from Sharp in the 1995-1996 time frame. Matsushita demonstrated a 15-in. 900 × 1152 full-color AMLCD at JES '92 and '93. Matsushita is sampling the display in Japan but has not announced plans to sample it in the U.S.

Significant Advances

The most significant technical movement within AMLCDs since the original JTEC study has involved the p-Si TFT-AMLCD. The market driving force for this device has been the 0.7-in. 100,000-subpixel color camcorder display. Seiko-Epson has demonstrated a 480 × 640-subpixel color p-Si TFT device that has a 1.3-in. diagonal (Fig. 3).

A second market driver is the p-Si TFT-AMLCD for video projection of TV and HDTV. Perhaps the most significant LCD advance shown at JES '93 was the Sharp HDTV p-Si AMLCD projector (Fig. 8). As exhibited, the display substrate was approximately 1.9 in. on the diagonal with 1.3M pixels (monochrome). Such substrates can be used for color HDTV projectors and, in a truly impressive exhibit, Sharp was using them in that configuration to project an image on a 10-ft. screen. (Two HDTV projectors projected superimposed images for added luminance.)

At SID '93 in Seattle, Washington, Sharp described the device in a technical paper.[7]

p-Si appears to be emerging as the technology for the smaller and larger projectors, viewfinders, goggles, and direct-view displays. Examples of all these applications – including a rear-projection desktop-PC display, virtual-reality goggles, camcorder viewfinders, monocular displays, and direct-view displays – were shown at JES '93. There were no signs of p-Si in devices larger than 2 in. on the diagonal.

In 1991 most projectors used a-Si TFTs. The p-Si TFTs have gained on a-Si for several reasons:

- Lower sensitivity to light, which permits higher luminous flux density.
- Row and column drivers fabricated on the substrate along with the TFTs for pixels, allowing higher-resolution images.
- High-resolution images obtainable from devices with smaller diagonals, which allow the use of smaller optics and smaller projectors.
- Higher-mobility TFTs that can be smaller for a larger pixel aperture.

A second area of dramatic advances is in more-compact displays with highly efficient fluorescent backlights. Two examples, in particular, have established a new level of accomplishment in the use of advanced backlights for FPDs.

The first of these was demonstrated by Sharp at JES '93. It is an a-Si TFT-AMLCD with 480 × 640 × 3 subpixels – 480 rows by 640 columns of full-color pixels, with each pixel containing a red, a green, and a blue subpixel – on a 0.2-mm pitch. It is 6.4 in. on the diagonal, has 2% reflectivity of ambient light for good sunlight readability, weighs 220 grams, and consumes 1.5 W.

The second example was first demonstrated by Hitachi at JES '92. It is an a-Si TFT-AMLCD with 480 × 640 × 3 subpixels. It is 9.4 in. on the diagonal, displays 4096 colors, weighs 590 grams, and consumes 6 W.

A third rapidly advancing area is in STN multiple-row addressing (also known as active addressing, a term that has been registered as a trade name by In Focus Systems). At JES '93, Optrex showed a color STN display with VGA resolution that uses multiple-row addressing in sets of seven rows. The speed of response was 50 msec – about the speed of a typical a-Si TFT-AMLCD. Optrex said that the preprocessing required to achieve this increased speed would raise the cost of the STN display by 20%. Seven-row sets were considered optimum for increasing speed while maintaining conventional STN viewing angles and contrast ratio.[8]

Reduced Emphasis

Several areas mentioned by the 1991 JTEC Committee have not materialized to the extent we expected or they are not being renewed.

- The ferroelectric LCD (FLCD) being developed by Canon has not reached production as anticipated. Canon will continue research and development on FLCDs.
- Stanley's electrically controllable birefringent (ECB) PMLCD configuration – also called the vertically aligned configuration – has not reached production as anticipated. This configuration was developed by LETI of France and developed further for production by Stanley in a joint agreement between the French and Japanese Governments.
- The Giant Technology Corporation (GTC) consortium, which has been headed by Hitachi, will come to an end as planned. GTC was initiated as a 5-year research and development effort to make a 1-m HDTV display using p-Si for

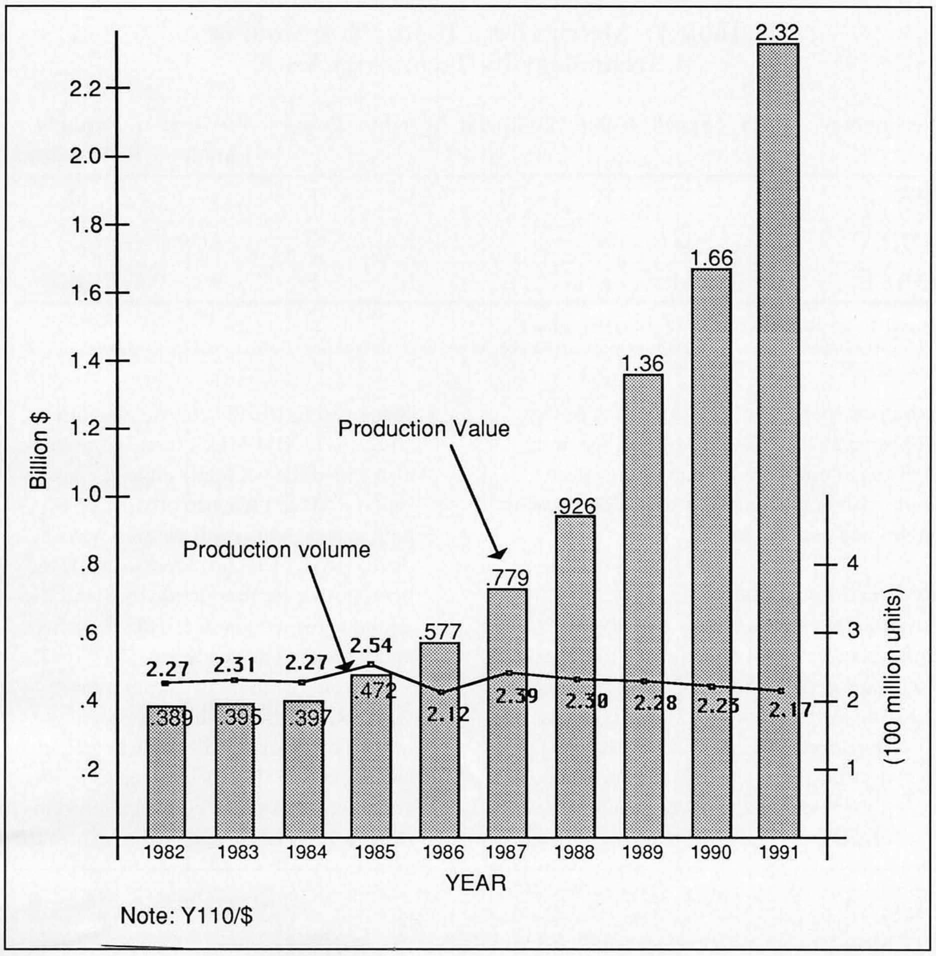
Table 1: Metrics for a 10-in. VGA Monitor
A Technology-by-Technology View

Technology	Price	Speed	Color	Footprint	Weight	Power	Viewing Angle	Sunlight Readability*
CRT	E	E	E	M	M	F	E	M
AMLCD	M	G	E	E	E	G	G	E
PMLCD	G	M	F	E	E	E	F	E

Legend: E = excellent; G = good; F = fair; and M = marginal.
*Sunlight readability refers to a display's ability to be adjustable for and readable in ambient illuminations from full darkness to full direct sunlight.

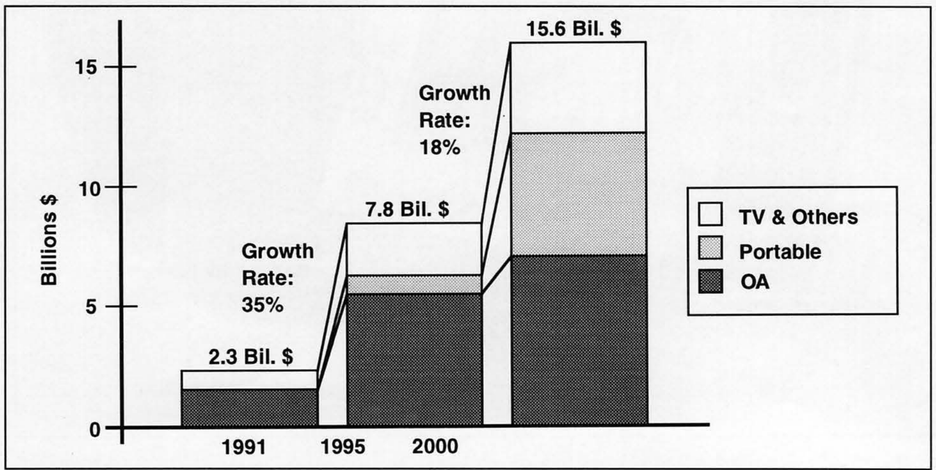
Sharp Corp.

Fig. 5: *The new Viewcam™ VL-E3OUP by Sharp Corp. uses a 3-in.-diagonal color a-Si TFT-AMLCD for its innovative viewfinder. This new application of LCDs, which required increased viewing angle and decreased reflectivity, has had a major impact on camcorders.*



Source: Japanese Ministry of International Trade and Industry

Fig. 6: The increase in the value of LCD production in Japan is dramatic, and it coincides with a production volume that is actually decreasing as production of the lower-technology and lower-pixel-count PMLCDs go to other parts of Asia.



Source: Nomura Research Institute/Sharp

Fig. 7: A forecast growth rate of 35% in the market value of LCDs produces a dollar value of $15.6 billion by the year 2000.

TFTs and printing in place of the standard photolithography process. The consortium plans to build a 20-in. breadboard demonstrator, which will be a section of the 1-m panel.

- The High Definition Technology Corporation (HDTEC) consortium headed by Seiko-Epson will come to an end as planned. HDTEC was initiated as a 5-year research and development effort to make a p-Si HDTV projector. The consortium has made significant progress.

Other FPDs

The entire FPD industry is dominated by LCD technology, but there are important niche-market activities involving other technologies:

- ***The 21-in. VGA color plasma display developed by Fujitsu.*** Fujitsu is sampling the display and building a factory for modest production. The display was demonstrated at JES '92 and '93 with full multimedia capability. The PDP technology is well-suited to larger sizes because it uses screen printing for pixel definition. It has the disadvantage of low luminous efficiency, which limits its ultimate application unless significant materials improvements are made. At the present time, the PDP is the only direct-view FPD that can (1) be made with a diagonal over 20 in., (2) operate in full color, and (3) operate at video speeds.
- ***The 40-in. PDP with near-HDTV display resolution developed by NHK and Matsushita.*** This is the only existing direct-view display that approaches HDTV resolution and size requirements. The technology currently lacks efficiency, long life, and luminance. Further research and development is necessary before production can be anticipated.
- ***The flat CRT display developed by Matsushita.*** Matsushita continues to develop and demonstrate flat CRTs, and showed a high-quality 14-in. color version at JES '93. But the weight, size, and cost parameters do not hold promise that these displays can compete with AMLCDs. One market application well-suited to the flat CRT, with its wide viewing angle, is "TV on the wall," but this will be a niche market until the price is decreased and the size is increased.

Table 2: AMLCD Machinery Production Generation in Japan Direct-View a-Si TFT-LCDs

Generation	Zero	1st	2nd	3rd	4th
Year start	1987 LSI	1990 New generation	1993–94 Installation	1996 Planning	1999? Future
Glass sheet size	6 × 6 in. 6 × 8 in.	320 × 400 mm 300 × 350 mm 300 × 400 mm	360 × 465 mm 380 × 480 mm (1994)	500 × 700 mm 500 × 600 mm 450 × 550 mm	TBD
Display size	1 @ 6 in. 1 @ 9 in.	4 @ 8 in. 4 @ 6 in. 2 @ 10 in.	4 @ 10 in. 2 @ 14 in. 6 @ 7 in.	4 @ 14 in. 1 @ 30 in.	
Cycle time	Variable	normalized @ 1	2×		
Productivity		normalized @ 1	3× to 5×		
Yield	<10% initially	>50%	>70%		
Major market	Portable TV	Notebook PC	Desktop PC Subnotebook PC	Engineering workstation	HDTV?

Machine technology life, 3 years.
Machine production life, 7 years.

Source: Tannas Electronics, Orange, California

- ***The Sharp line of EL displays.*** This technology supplied the first HIC FPD manufactured for a consumer product. (PDPs were the first type of FPD manufactured, but they were initially limited to military and industrial markets because of their cost.) Sharp is the only Japanese company manufacturing ELDs – in a product line of approximately a dozen sizes. Sharp claims to have over 50% of the world's market in ELDs.

ELDs have the advantage of wide viewing angle and a fast response speed comparable to a CRT's. They have the disadvantage of limited color capability and limited gray shades. ELDs are several times more expensive than STN displays that are comparable in all respects except speed and viewing angle. Sharp is continuing research to develop a white-color phosphor.

Summary

The Japanese have long recognized that both the computer and television industries will need new display technologies as we enter the "Information Age," and that these new technologies will play a critical role in keeping Japan's electronic products competitive in the international market. Japanese industrialists have thought of FPDs as the last remaining "seed" for new-product innovation. In part, this helps explain Japan's apparent overemphasis on the research and development of FPDs during the last 20 years.

During the 1980s Japan's electronics industry achieved worldwide dominance in FPDs generally and LCDs in particular. FPDs made it practical to produce new products that stimulated the entire Japanese electronics industry.

All the pieces have now been assembled that will allow Japanese laboratories, universities, and companies to dominate the research, development, and production of HIC FPDs. This situation appears more obvious now than in 1991. The dominance is based on phenomenal advances in LCD technology in both the low-cost compensated STN-LCDs and the high-performance a-Si TFT-AMLCDs.

However, one should not assume that these technologies will displace the CRT. They won't because of the CRT's lower cost and high level of performance – except in markets where physical volume, footprint, or sunlight readability are issues. By the year 2000,

Table 3: New Round of Investment for Large AMLCDs (Partial List, 1993–1995) Second-Generation Machines

Company	$M	¥B	Plans
Sharp	727	80	Upgrade two Tenri lines Add line at Tenri New plant in Mie Prefecture
NEC	272 273	25 30	Upgrade Kagoshima plant New plant at Akita
DTI (Toshiba/IBM)	273	30	Expand Himeji production line
Hosiden	64	7	Expand Seishin plant ('93 only)
Fijitsu	355	39	Begin mass production
Hitachi Ltd.	273	30	New line at Mobara
Total = >$2 Billion			

Source: Tannas Electronics, Orange, California

Photo courtesy of L.E. Tannas, Jr.

Fig. 8: *The first showing of a poly-Si active-matrix liquid-crystal display (AMLCD) with high-definition-television (HDTV) resolution and aspect ratio was by Sharp Corp. at the 1993 Japan Electronics Show (JES '93) in an HDTV projector/theater. No technical details were revealed and an availability date was not given.*

worldwide sales of CRTs and LCDs are expected to be about equally divided, with the growth in LCDs occurring primarily in new display-based products.

LCDs now completely overshadow all other flat-panel technologies, another statement that appears more obvious today than it did to the JTEC Committee in 1991. The development during the 1980s of techniques to successfully matrix address high-resolution LCDs is bearing fruit in the 1990s.

Successful production of color AMLCDs and low-cost STN-LCDs in Japan has changed the entire picture in the FPD industry. Of all the FPD technologies, the LCD will dominate through the 1990s and beyond. A new paradigm must be created before this can change.

AMLCD production is maturing rapidly and is starting to follow the evolutionary pattern previously seen in the MOS and DRAM industries. The second round of investments and second generation of machinery for AMLCD production is the ultimate confirmation that LCDs are firmly in place and guaranteed to be with us well into the 21st century.

The achievements in AMLCD technology are the most significant since the invention of the shadow-mask color CRT, and there is no close rival left for high-performance color video displays except the CRT itself. It is even conceivable that by the year 2000 the AMLCD may be superior to the CRT as an HIC electronic display. But regardless of FPD performance, the CRT will remain a potent force because of its absolute price advantage and the worldwide need for low-cost television sets. As yet, no one is predicting that the cost of FPDs will ever be competitive with that of CRTs.

Notes

[1]The Japan Technology Evaluation Center (JTEC) is operated for the U.S. Federal Government to provide assessments of Japanese research and development in key technologies. The lead support agency is The National Science Foundation.

[2]JTEC Flat Panel Display Technology Committee, L. E. Tannas, Jr., and William Glenn, Co-Chairmen, "Display Technologies in Japan," NTIS Report #PB92-100247

(National Technical Information Service, phone 703/487-4650, June 1992).
[3]L. E. Tannas, Jr., "Japanese Flat-Panel Displays: What JTEC Saw," *Information Display*, 18-22 (July/August 1992).
[4]In this article, we define an HIC display as one with 100,000 or more pixels – a pixel count that historically required a CRT.
[5]K. Odawara, private communication.
[6]Giant Technology Corporation (GTC) is a consortium funded by MITI and the Japan Key Technology Center with the single objective of researching and developing a 1-m HDTV display that uses p-Si as the TFT semiconductor and is fabricated with high-resolution printing instead of the more expensive photolithography.
[7]Y. Takafuji *et al.*, "A 1.9-in. 1.5-M Pixel Driver Fully-Integrated Poly-Si TFT-LCD for HDTV Projection," *SID International Symposium Digest of Technical Papers*, 383-386 (1993).
[8]Takeshi Kuwata, Asahi Glass Co., Ltd., R&D Center, Kanagawa, Japan. Private communication. ■

To participate as an exhibitor at SID '94 in San Jose, please call Erika Suresky, Exhibit Manager, Palisades Institute for Research Services, Inc., at 212/620-3375.

Please send new contributions or noteworthy news items to Aris Silzars, Contributing Editor, Information Display, c/o Palisades Institute for Research Services, Inc., 201 Varick Street, New York, NY 10014.

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.

SID '94

Symposium, Seminar, and Exhibition
San Jose Convention Center
San Jose, California
June 12–17, 1994

conference report

Eurodisplay '93

Despite a small exhibition, Eurodisplay is primarily a research conference that provides an exciting window on the future rather than a snapshot of the present.

by Bryan Norris

THE THIRTEENTH International Display Research Conference took place September 1-3 in the august setting of the Palais d'Europe in the beautiful city of Strasbourg, France – the home of the hosts, the European Parliament, Council of Europe, and Commission of European Communities. With emphasis on research, this conference was a much more refined, leisurely, and restrained affair for the 700 delegates than the usually much larger European exhibitions, where crowds, bustle, and buy-me-now products are the order of the day.

Organized by the French Chapter of the Society for Information Display and Le Club Visu, the conference itself offered a choice of nearly 70 papers over 3 days, generally presented in two parallel sessions. The papers were backed up by a similar number of explanatory poster and author-interview sessions, while a relatively small collection of exhibition booths demonstrated display products or measurement techniques that are currently available or promised in the near future. (Quite a few of the exhibits had received a preview at SID '93 held in May in Seattle, Washington, U.S.A.)

Here is an overview of the Strasbourg conference and highlights from Eurodisplay '93. They should provide an indication of the current display scenario, in particular where flat-panel displays (FPDs) now stand in relation to conventional CRT products. The papers themselves will be published in the *Journal of the SID.*

***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 44-582-405-828. He is a frequent contributor to* Information Display.

The CRT Sets the Standards

One of the most noticeable features of the conference was the fact that the CRT is still used as the standard for displays. A common question was whether the new-technology flat-panel products could meet the CRT's price and performance characteristics. The CRT challenges alternative displays to measure up to its brightness, high resolution, extensive gray-scale capability, easy addressability, and suitability for important niche applications.

For example, Anthony Lowe from IBM UK pointed out in his excellent invited-speaker summary paper, "Display Requirements for Computer Workstations of the Future," that, among other things, the modern workstation must have a display capable of addressing a minimum pixel format of 1280×1024 with extension capability to 2056×2056. And even K. Odawa of Hitachi, in his highly philosophical invited paper, "Forwarding Active Matrix LCDs – Technology and Market," used the CRT as "reference mark 1" in his "Relative Consumption" chart. (To make TFT-AMLCDs takes 8 times the floor space needed to make CRTs, and consumes 30 times the electrical power, 90 times the water, and 65 times the solvent and resist.)

Furthermore, evolution of the CRT carries on. There were six papers and four posters concerned with CRT improvement. These included a paper by a French team from Thomson about improvements being made on the emissions from blue CRT phosphors. A poster related how Mitsubishi personnel had tackled and reduced problems in developing its new display-monitor 21-in. CRT. The Mitsubishi team used an aperture-grill tension mask to decrease doming and raster-moire, and a three-gun/three-beam electron gun to decrease CRT depth. Furthermore, an improved suspension system for the tension mask lessened the problem caused by the heavy frame necessary to provide the grill's tension.

Of immediate benefit to CRT monitor makers are the tests carried out by the German test house TÜV Rheinland and the resulting test-approval certificates. Gerd Dziambor explained that TÜV performs its tests to measure emission levels on the basis of the Swedish MPR II recommendations, and also checks image quality to ensure the display is flicker-free, gives good character focus even at the edge, has a broad contrast range, and provides low distortion levels. Thus, the TÜV "Ergonomie geprüft/Ergonomics approved" test mark is awarded to products that not only meet the minimum legal requirements of the new EC directive on work with visual display terminals (90/270/EEC), but also meet all significant ergonomics recommendations, in line with the current and proposed ISO 9241 (EN 29241) directives. (It was pointed out that the TCO 92 and Nutek power-saving recommendations were not yet fully specified.) For some of its tests, TÜV Rheinland uses measuring equipment from two other companies that had booths at Strasbourg: Test Systems and Photo Research.

Following on from its viewing at Seattle, George Stoeppel of Team Systems brought his PC-based programmable video generator (VG5515PC) to Europe. With resolutions from NTSC/RGB to 1280 × 1024, this generator simulates any graphics card and is thus ideal for checking, servicing, or on-site repairing of CRT monitors. As it is simple to operate, the generator can also significantly improve turnaround time.

Also traveling across the pond, Photo Research from Chatsworth, California, again showed off, this time to Europe, its PR-900 Video Photometer – a PC-based measuring system developed to perform spatial, photometric, and colorimetric inspection of displays. Having the ability to learn a measurement procedure and then automatically repeat it, the system significantly reduces the time required to carry out a series of checks or inspections to ensure that a display is within prescribed limits.

Sony brought and displayed its prototype 28-in. (V) monitor – Trinitron, of course – with a 16:9 aspect ratio, 84-kHz horizontal scan rate, 216-MHz video bandwidth, and (at the moment) 1920 × 1080 square pixels refreshed at 72 Hz. Other features include active beam-current feedback for stability of color temperature, remote adjustment and digital correction of the multi-scan deflection system, full MPR II adherence, and user-selectable color temperature and field rate.

OCLI from Santa Rosa, California, reported a contract signing by a major monitor manufacturer for Directcoat™, its new anti-reflection coating process. Directcoat™ was demonstrated in OCLI's booth by the now-familiar half-a-monitor-screen-with-it/half-without demonstration. Premiered in Seattle, this highly conductive thin-film anti-reflective coating is deposited directly on the face of the completed CRT without damaging sensitive components. OCLI claims that the coating is a superior and more effective means of reducing glare, and that it is cost effective, as there is no need for a separate bonded panel.

OCLI, again following on from Seattle, and in conjunction with Nitto Denko Corp., announced to Europe a jointly engineered solution to improve LCD viewing under a wide range of ambient-light conditions. OCLI will precoat Nitto Denko's linear polarizer products with its patented High Efficiency Anti-Reflection (HEA®) coating before they are sent to the LCD manufacturer. The HEA® coating increases transmission by about 4%, which means both backlit and reflective LCDs require less light for viewing. In addition, Nitto Denko's coated polarizer eliminates background reflections, improves contrast ratios, enhances display images, and virtually eliminates glare by permitting light to pass through surfaces with little light being reflected into the user's eyes.

The LCD Scenario

In his keynote address, J. C. Stuve of Flat Panel Display Co., a joint venture established by Philips, Thomson CE, and Sagem/CNET early in 1993, gave an emotive discourse entitled, "The Strategic Importance of a Significant European Flat Panel Display Business." He outlined the need, potential, and likely applications of FPDs (automotive, avionics, and PCs, where light weight and a compact package are vital) and stated that it was "generally regarded that LCD is the most promising technology." (Ah, but is it? See later.) "The present NLG1.5 billion (US$0.83 billion) global market [for AMLCDs] will grow to NLG5.6 billion (US$3.1 billion) by 1998." Not only are the LCDs themselves important components, but also their inherent IC drivers must be developed and produced in Europe to remain competitive on a world scale. Thus the reason for setting up FPD Co., BV, the only company with AMLCD mass production outside Japan from which commercial deliveries to European and other customers has started.

After this, there followed seven papers on LCD materials and technology: three from Europe, two from Japan, one from the U.S.A., and one from Russia. Another 25 or so papers were presented during the following two days, again from a variety of worldwide sources. The papers dealt with further aspects of LCD or AMLCD technology, production, or applications, including using the devices as light filters.

In one of the rooms near the exhibition area, Barco, the Belgian monitor manufacturer that nowadays seems to concentrate its marketing emphasis much more on projection systems than on conventional CRT monitors, demonstrated an LCD light-valve projector alongside a three-tubed CRT projector. This permitted a convenient side-by-side comparison (Table 1).

Talking of light filters, Texas Instruments had a poster giving an overview of its digital micromirror device (DMD) spatial light modulator, its use in an NTSC projector, and its potential use in high-definition projection displays – fascinating!

Also in the exhibition area, Crystaloid Europe demonstrated its wide range of more conventional LCDs (from seven-segment to specialized multicolor alphanumeric displays) made at its plant in Boecillo, Valladolid, Spain.

Table 1: Comparison of Barco LCD and CRT Projection Displays

Barcodata 5000 **High-brightness full-color LCD light-valve projector**	**Barcographics 1200** **Ultra-high-resolution digitally controlled graphics projector**
Lights three 5.8-in. AMLCD panels	Improved 9-in. CRT with EM focus and super-high-definition lenses
Light output equivalent to CRT peak white greater than 5000 lum	Light output over full bandwidth of 120 MHz greater than 1000 lum
Resolution greater than 750 × 550 pixels	Resolution up to 2500 × 2000 pixels
Screen width up to 10 m (30 ft.)	Wide-range autolock 15–135-kHz horizontal scan frequency
Displays all video images, VGA, and Mac 640 × 480	Vertical 37–140-Hz autolock
Easily installed and controlled by IR remote control and on-screen menus	IR remote control unit
Price: $45,000	Price: $35,000

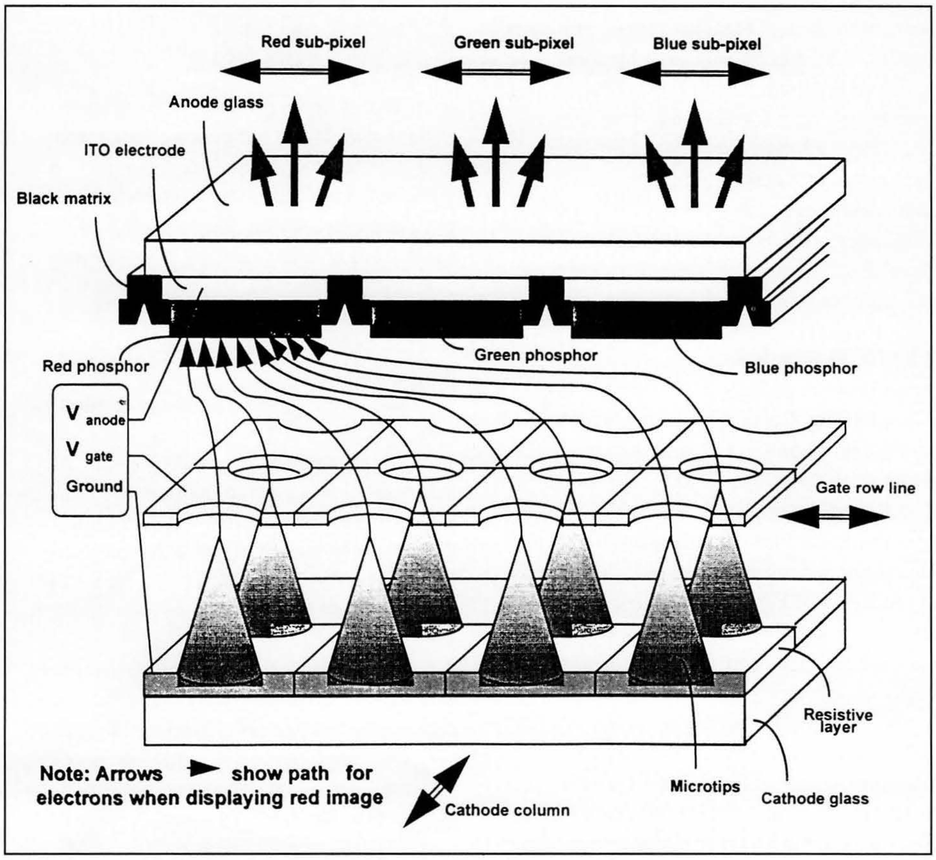


Fig. 1: Classic microtip pixel structure for field-emitter display.

And Holtronic Technologies of Switzerland showed its holographic lithography system capable of generating 0.3-µm geometries in a lensless large-field proximity printing process compatible with standard wafer processing.

Ferroelectric liquid-crystal topics were given a whole afternoon session in which four papers (two each from Europe and Japan), covering topics from materials to infrared valves, were backed up by six posters.

EL, PDP, and VFD Advancement

Friday afternoon was the time for the electroluminescent (EL) session, and three out of the five papers related to the perplexing problem of getting an efficient and stable blue-emitting phosphor to further the goal of fabricating an adequately bright full-color EL FPD. The Finnish arm of Planar International was well represented, being responsible for two of the papers and providing an impressive display of ready-to-use panels in its booth – including a 10.4-in. "monochrome/yellow" VGA standalone monitor and an 8-in. eight-color EGA display. A prototype full-color EL display gave a glimpse of the future.

Plasma-display-panel (PDP) structure, construction, and driving electronics were discussed and explained in three papers and two posters, while vacuum-fluorescent-display (VFD) developments were limited to two poster exhibits. Commercial products were shown in the Thomson booth.

FEDs: A Star is (Re-)Born?

Conceived in the mid-60s, the first attempts to make acceptable field-emission displays (FEDs) ended in frustration and failure. In FEDs, electrons emitted from a multitude of cathode microtips under the influence of an electric field pass through a gate and are directed and collected by appropriate RGB anode-phosphor pixels (Fig. 1).

Although they have a comparatively simple structure that is not difficult to make, the first FEDs suffered extensive degradation of the tips and phosphors that produced premature aging – still the most difficult hurdles to overcome. This resulted in the device's being virtually written off, at least in the U.S.A. where much of the initial work had been carried out.

However, LETI in France took up the challenge and over the past few years has made extensive improvements in the structure, microtips, and phosphors. The improvements are so impressive that it looks as though the FED has been reborn and has a promising commercial future. In June 1992, Pixel International, a company founded with funding from venture capital and private sources, was formed. The following September, the company secured exclusive rights to LETI's patented technology. By the beginning of 1993, Pixel's engineering group was in place at LETI, which resulted in Pixel's first presentation of a color FED panel at IVMC, Newport, Rhode Island, U.S.A., in July.

The pre-prototype 6-in. Pixel FED panel in their booth at Eurodisplay '93 displayed a remarkably clear and colorful video picture. Certainly it was not bright enough, but brightnesses of 7000–8000 lumens have recently been achieved in the U.S.A. Pixel should be able to obtain similar values when they zero in on the right voltages and phosphors. Not an easy problem, but not insurmountable given a little time and investment. In August, Texas Instruments became the first company to sign a licensing agreement with Pixel, and two further signings followed.

Like CRTs, FEDs can display high-quality monochrome or color images transmitted via digital or analog interfaces. The TV and fast-motion graphic images (for multimedia, etc.) are presented without artifacts. In addition, they are very thin, typically 2.4 mm, and have low power consumption – 2 W for a 10-in. color VGA panel. Thanks to relatively simple construction and few production stages, yields of over 50% are confidently expected, even for 12-in. panels.

Pixel has selected a manufacturing plant in France, will install equipment in March 1994, plans engineering samples in September 1994, and expects to be producing 6-in. VGA panels by the end of the year. These should be ideal for applications such as portable and display telephones, personal communicators, and portable instruments. For portable PCs and similar applications, production of panels up to 10 in. is planned in 1995, and up to 12 in. in 1996. Quite exciting, really! ■

display continuum

continued from page 4

that complete designs can be created on a PC and the sewing machine programmed to carry out the work with only initial setup and some simple monitoring by the user. The computer programming will be done in a graphics mode using a pen plotter and a high-resolution display. The machines will, in addition, have their own displays, which will be used for monitoring the operating sequences and for indicating what the program is doing.

Not too many years ago, there were questions about what people would do with their home computers. Doing the family's checkbook and household budget were thought to be real important applications. It sure hasn't worked out that way, has it? We are adding capability to our homes that a few years ago was not available to even the most sophisticated professional users. Computer graphics, computer imaging, and high-quality displays are the keys to making this happen.

If a craft as old, tradition-bound, and stereotyped as sewing can go high-tech, what else do you think is out there that is ready for change? I'm sure that some of the companies we report on each month in this column will be contributing to some of these interesting future developments.

Let's begin this month's industry segment with a follow-up item from a company mentioned in last month's column on overhead projectors. **Boxlight** from Poulsbo, Washington, sent me an announcement on the VideoShow® PRESENTER™, a hand-held full-color teleprompter for guiding a speaker through a computer-generated overhead presentation. This product, developed by **General Parametrics**, has features for displaying the speaker's notes, showing the presentation outline, and previewing images privately. It sure looks like an easy-to-use and interesting product.

BARCO Chromatics of Tucker, Georgia, has announced the appointment of **Paul Spickard** as Western Regional Sales Manager. BARCO is a recognized leader in the design and manufacture of high-performance, commercial and MIL-tailored, ruggedized, real-time graphic controllers, workstations, and high-resolution monitors utilized in the military, aerospace, scientific, and commercial markets. Mr. Spickard will be responsible for the combined sales effort for both avionics and rugged displays, the BARCO Chromatics high-performance graphics controllers, and ultra-high-resolution monitors.

Please send new contributions or noteworthy news items to Aris Silzars, Contributing Editor, Information Display, c/o Palisades Institute for Research Services, Inc., 201 Varick Street, New York, NY 10014.

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.

Two new appointments were recently made by **IRIS Graphics** of Bedford, Massachusetts, a manufacturer of high-resolution color ink-jet printers. The company's new Vice-President of Sales is **Robert Dusseault**. Prior to this appointment, Dusseault served as IRIS's Senior Director of Re-Seller Operations. He brings over 25 years of experience to this position, with previous assignments at Honeywell Bull Information Systems and 5 years in Paris as a Director of International Sales.

The second appointment at IRIS Graphics is **Alan Renda** to the position of Director of Marketing. Renda's prior accomplishments include 12 years at Digital Equipment Corporation as Director of Strategic Planning & Marketing Research. He was also a Senior Partner and Vice President at Total Quality Marketing, a company specializing in market research for both the high-technology industry and the consumer-product markets. In his new position, he will report to **Douglas Smith**, IRIS's Vice President of Marketing.

Hibino Audio-Visual USA, Inc., based in Irvine, California, has promoted **Peter Pacione** to Vice-President of Engineering. He will operate from Hibino's Chicago branch office. Mr. Pacione has been a member of Hibino's staff since its acquisition of DataDisplay Corporation in June, 1993, where he worked since 1987 as Director of Engineering. He has more than 25 years experience and was the first American engineer hired by the Hitachi Corporation in the 1960s. He will be responsible for overseeing the design and development of a wide variety of A/V systems, including high-technology boardrooms, RF-distribution systems, signal-routing systems, distribution-amplifier equipment, and video-wall effects programs.

If you are in need of a consultant in the general area of phosphor technology, **Dr. R. C. Ropp** of Warren, New Jersey, tells me that he is willing to accept new clients. He is affiliated with **Cecon, Inc.** of Newark, Delaware, for whom he also does various consulting assignments. His authorship of the book, *The Chemistry of Artificial Lighting Devices – Lamps, Phosphors and Cathode Ray Tubes*, is indicative of his extensive knowledge and experience in this area.

As always, contributions to and comments about this column are welcome. You may call me in person at 302/733-8927, or fax me at 302/733-8923. ■

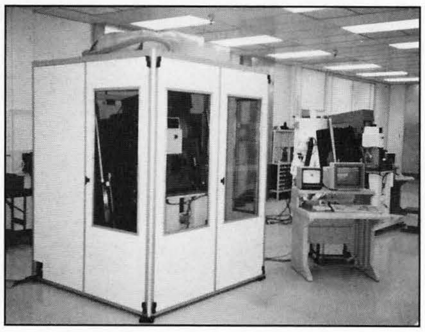
new products

Edited by JOAN GORMAN

Lithography tool

Tamarack Scientific Co., Inc., Anaheim, California, has introduced the Model 300 LGPX, a new 1:1 scanning projection system intended for the manufacture of flat-panel displays, large multichip modules, or solar-cell systems. The 300 LGPX can expose any substrate size up to 20 × 24 in., providing 5-μm optical resolution and 2-μm overlay accuracy. Mask and substrate are scanned on a common X-Y table below an exposure field of 30 × 30 mm^2 and 1:1 imaging optics. During processing, a distance of 200 mm is kept between mask and artwork, preventing any mask damage. The system provides 500-mW/cm^2 UV light over the exposure field and can expose up to 60 panels per hour.

Information: Tamarack Scientific Co., Inc., 1040 North Armando Street, Anaheim, CA 92806. 714/632-5030, fax 714/632-1455.



Circle no. 1

VGA flat-panel monitor

Planar Systems, Inc., Beaverton, Oregon, has announced the ELM-VGA, a new VGA flat-panel monitor designed for applications in the hospital-information-systems (HIS) and point-of-care (POC) markets. Designed with the aid of healthcare professionals, the ELM-VGA is ideal for space-constrained applications such as bedside computing, radiology, laboratory, and nursing stations. The 2.7-in.-thick 10-in.-diagonal 4.2-lb. EL display requires one-tenth the space of a comparable CRT and offers bright monochrome images that can be clearly seen from any angle. The ELM-VGA draws only 26 W in a typical application, compared to the 67 W of a 14-in. monochrome CRT monitor. The standard IBM VGA interface makes the ELM-VGA plug-compatible with most standard VGA cards. It also features automated color mapping and mode selection.

Information: David Thompson, Sales Representative, Planar Systems, Inc., 1400 N.W. Compton Drive, Beaverton, OR 97006. 503/690-6952.

Circle no. 2

Next-generation LEDs

Hewlett-Packard Co., Palo Alto, California, has developed a new technology to produce what it believes are the world's brightest light-emitting diodes (LEDs). Versions operating in the amber portion of the spectrum are up to four times brighter than current-production amber LEDs from other manufacturers and are expected to replace incandescent lamps in many applications. The existing technology, light-absorbing gallium arsenide (GaAs) substrates on aluminum indium gallium phosphide (AlInGaP) LEDs, has been replaced with a transparent gallium phosphide (GaP) substrate, producing a new transparent AlInGaP (TS AlInGaP) substrate structure. TS AlInGaP LED devices have typical luminous efficiencies of 40 lum/A in both the reddish-orange (615 nm) and amber (592 nm) portions of the spectrum. They are twice as bright as

HP's highest-performance AlInGaP LED devices with absorptive substrates (AS AlInGaP). In the green (571 nm) portion of the spectrum, luminous efficiency levels of 19 lum/A have been demonstrated, more than three times the brightness of HP's green GaP LEDs. The new reddish-orange and amber lamps typically have on-axis luminous intensities of 10–14 cd when packaged in a T-1¾ (5 mm) lamp with a half-power viewing angle of 6°, powered by 20 mA. First production units will be available mid-year and will be competitively priced.

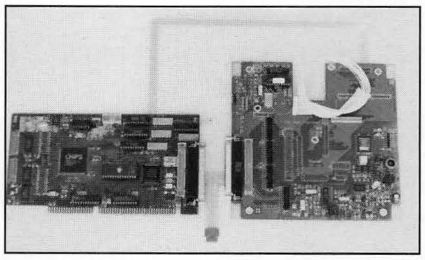
Information: Hewlett-Packard Co. Inquiries, 5301 Stevens Creek Blvd., P.O. Box 58059, Santa Clara, CA 95052-8059. 1-800-537-7715 x8003.

Circle no. 3

Simplified FPD/touch-screen interface

Gounder Technologies, Inc., Northbrook, Illinois, has introduced an integrated solution that simplifies the flat-panel display and touch-screen interface with IBM-AT-compatible computers. The components consist of a flat-panel controller, a flat-panel interface, a touch-screen controller module, and a touch screen. The FPC-0530-XX is a flat-panel display controller that supports color-TFT, STN, mono-FSTN, EL, and gas-plasma panels with resolutions up to 1280 × 1024, and is available with 256KB VRAM and 256K x4 VRAM frame buffer or 512KB VRAM for higher performance. The FPI-0530-XX interface card simplifies the connections between controller and flat panel. The RTI-0530-XX analog resistive touch screen and controller has a resolution of 1024 × 1024. It provides a sample rate of 160 points/sec. OEM price for the controller starts at $289; interface board starts at $79; touch screen and controller module starts at $249. Delivery 2-6 weeks ARO.

Information: Contact Kris Ponmalai, Gounder Technologies, Inc., 115 Avon Road, Northbrook, IL 60062-1335. 708/559-9291, fax 708/205-9411.



Circle no. 4

Multiple video windows

RGB Spectrum, Alameda, California, has announced SuperView™, a multiple video windowing system that displays up to four real-time video windows on a single high-resolution monitor. Each video window can be positioned, scaled to full screen, overlaid with computer graphics, or overlapped with other video windows. It meets the exacting requirements for advanced video conferencing, command-and-control, surveillance, simulation, and robotics applications. SuperView is a third-generation system based on a proprietary design that guarantees real-time video performance under all conditions without burdening the host CPU or graphics controller. It accepts NTSC (or PAL) composite video and Y/C (S-Video) signals from up to four cameras, tape recorders, video disc, and teleconferencing systems simultaneously. It will also accept various high-line-rate video signals from FLIR and medical imagers.

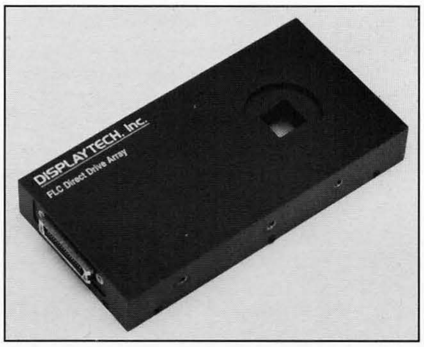
Information: Carol Fogel, RGB Spectrum, 950 Marina Village Pkwy., Alameda, CA 94501. 510/814-7000, fax 510/814-7026.

Circle no. 5

Transmissive liquid-crystal arrays

Displaytech, Inc., Boulder, Colorado, has introduced a new generation of linear and two-dimensional transmissive arrays for high-performance spatial light modulation and display systems. The ferroelectric liquid-crystal (FLC) arrays are versatile instruments for spatial light modulation applications such as optical signal processing, optical correlation, optical interconnects, digital-to-optical information conversion, and programmable masking. Since FLC technology is more than 10 times faster than traditional liquid crystals, these devices excel in applications that require high-speed performance and real-time operation. These arrays come in two standard configurations: the 10 × 10B, a two-dimensional array of 100 square pixels within a 1-cm^2 active area, and the 1 × 64B, a linear array of 64 rectangular pixels within a 1.6-cm^2 active area. The linear arrays are available in custom configurations.

Information: Christopher J. Sherman, Senior Products Engineer, Displaytech, Inc., 2200 Central Avenue, Boulder, CO 80301. 303/449-8933, fax 303/449-8934.



Circle no. 6 ■

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.

Chapter Notes

Bay Area Chapter

The Bay Area Chapter's monthly meeting for October was held on Tuesday evening, October 19, at Apple Computer. **Dr. John Macaulay**, Scientist, Field Emission Program, Silicon Video Corp., provided an overview of the characterization of Spindt-type cathodes for use in field-emission displays (FEDs). His talk focused on the physical characterization of these evaporated metal cones using the SEM and TEM, including the instances of emitter disruption due to Joule heating.

Dr. Macaulay's talk began with a background description of Spindt cathodes in which he presented a schematic diagram of the thin-film field-emission microcathodes (TFFEMCs). He described the general characteristics of TFFEMCs, including packing density (10^7 emitters/cm^2), emission current (up to 500 μA per cathode), current density (up to 1000 A/cm^2), and life test data (8 years, 2 months demonstrated at SRI). He also described various Spindt-cathode applications, noting the display work done by LETI, Pixel International, and Coloray.

Dr. Macaulay illustrated the uniformity and surface roughness of the cones with a presentation of high-resolution SEM and TEM images. He also discussed occurrence of thermal failures in the TFFEMCs and described the design improvements implemented to reduce the incidence of these failures. Such improvements included increasing the cone angle, reducing device capacitance, reducing operating voltage (from 50 to 10 V), and incorporating resistive film (which also improved the uniformity of cone emission).

Dr. Macaulay wrapped up his talk with a discussion of cesiation of the Spindt-type cathodes, a technique which lowers the required voltage between the emitting tips and the acceleration electrode. He concluded that adding cesium metal to the tips is a viable process for reducing operating gate voltages, enabling performance in the 10–15-V range. A critical process issue mentioned was to grow a sub-monolayer of cesium on the emitter but to avoid contact with the dielectric layer in order to minimize leakage current.

The Chapter expresses our thanks to Dr. Macaulay for his very interesting and informative presentation.

Detroit Chapter

The Detroit Chapter participated in a tour of the Philips Display Components facility in Ann Arbor, December 7, 1993. This was a joint activity of the Optical Society of America, SID, and the Human Factors/Ergonomics Society. About 50 people (from the Detroit, Toledo, and Ann Arbor areas) toured the Philips Labs and were shown equipment used in the areas of matrix fabrication, shader fabrication, evaluation of glass stipple, phosphor pigmentation, spectroradiometry of CRTs, spot profile, and modulation transfer function generation. Upon the completion of the tour, Bob Donofrio (Eng. Group Leader at Philips) gave the audience a brief presentation on, "How White is White?" ■

Edited by JOAN GORMAN

Courtaulds certified to ISO 9001

Courtaulds Performance Films, Canoga Park, California, has announced the certification of their Canoga Park film-manufacturing site to ISO 9001 standards. The review was performed by Bureau Veritas Quality International, which performed an extensive audit of Courtaulds' quality procedures, documentation, manufacturing practices, and personnel. All areas of the audit met the standards set forth in the ISO 9001 guidelines, the most stringent of all the ISO 9000 levels. To date, Courtaulds Performance Films is the only producer of sputtered films in the U.S. to attain certification.

New facility for custom LCDs

GEC-Marconi Ltd., Borehamwood, Herts, U.K., has announced the availability of state-of-the-art custom LCDs and modules beginning in March, 1994. A new suite of rooms has recently been completed to undertake this project. HRC-LCD's proprietary production processes, based on 10 years of experience in LCD research and development, will be used to provide active-matrix full-MIL-SPEC modules; ferroelectric fast optical shutters and non-volatile dot-matrix displays; supertwist high-performance displays and modules; dichroic high-brightness dye phase change and high-contrast Heilmeier displays; and twisted-nematic fully optimized displays and modules.

Information: Dr. Alan Mosley, GEC-Marconi Limited, HRC-LCD, Elstree Way, Borehamwood, Herts, WD6 1RX. Telephone 44-081-732-0041.

Kodak photo-CD alliances

Four manufacturers (Crosfield, Dainippon Screen, Linotype-Hell, and Scitex) have signed letters of intent with Kodak to develop a new Print Photo CD for prepress applications. Eventually, each company's scanners will be able to retrieve images from all photo CDs, display them in CMYK, CIELab, or the standard photo CD YCC format, and store them on photo CDs. Also, an agreement between Kodak and Adobe Systems that will interface Kodak's Color Management System Photo CD with Adobe Photoshop 2.5.1 has been reached. The image quality of files retrieved into Photoshop 2.5.1 and converted into an RGB format will be significantly enhanced.

Shooting star

More than 20 vendors have already delivered computer systems or pledged support for the EPA's Energy Star program announced in June 1992. Compliant systems must use 30 W or less of electricity in the standby or sleep modes, including the monitor, CPU, and peripherals. Vendors of products which now qualify for the Energy Star rating include Acer America, AST Research, ATI Technologies, Compaq, Gateway, Hewlett-Packard, IBM, Intel, Lexmark International, Mag Innovision, NCR, NEC, STB Systems, and Tektronix. Compliance with the cooperative program is voluntary.

Sayett to deliver AMLCDs

Sayett Group, Inc., Pittsford, New York, has announced that its active-matrix LCD (AMLCD) venture is taking orders and delivering sample displays for 640×480-resolution AMLCDs. Prototype displays exhibit the speed, contrast, and gray scales of AMLCDs that Sayett has traditionally utilized in its projection equipment, and exhibit the potential for higher brightness than traditional AMLCDs. The prototype display is less than 2 in. in diagonal and has on-board drive circuitry. The initial manufacturing capacity of 1000 AMLCD displays per month is expected to increase to a high of 50,000 displays per month by the end of 1995. According to Sayett, the AMLCD market is currently $3-4 billion worldwide, predominantly supplied by foreign firms. The venture seeks to obtain a significant share of this market, which is expected to grow to $7 annually by 1996.

ELtech moves EL lamp production to new facility

ELtech, Austin, Texas, has announced the relocation of its operations from Horsham, Pennsylvania, to a larger facility in Austin, Texas, effective January 1, 1994. The recently constructed 30,000-ft.^{2} facility has been designed to better accommodate the process flow and manufacturing requirements of ELtech's new Novalite™ screen-printed EL lamp, as well as the company's 100/50 process for EL foil-lamp production. ELtech has consolidated operations with Touch Technology Corp. of Austin, a sister company that manufactures high-quality touch screens. Brad Lizotte, Vice President of Sales, will continue to handle national sales management from Horsham. ELtech's new address is: ELtech (Electroluminescent Technologies Corp.), 5524 Bee Cave Road, Austin, TX 78746; 512/327-9801, fax 512/327-9802. ■

sustaining members

Ad-Vance Magnetics, Inc.
AEG Corp.
Arconium Specialty Alloys
Babcock Display Products
Brewer Science, Inc.
Canon, Inc.
Capetronic USA (HK), Inc.
Celco
Cherry Electrical Products
Chunghwa Picture Tubes, Ltd.
Clinton Electronics Corp.
Corning Inc.
Corning Japan K.K.
Dale Electronics, Inc.
David Sarnoff Research Center
Diagnostic/Retrieval Systems, Inc.
Dickey-John Corp.
DISCOM/Display Components, Inc.
EEV, Inc.
EG&G Gamma Scientific
Electro-Plasma, Inc.
Endicott Research Group, Inc.
F-P Electronics
Futaba Corp.
Graseby Optronics
Grimes Aerospace Company
Hewlett-Packard Co.
Hitachi, Ltd.
F. Hoffman-La Roche
Honeywell, Inc.
Hoya Optics, Inc.
Hughes Aircraft Co.
Hughes Display Products
IBM Corp.
Incom, Inc.
Industrial Electronic Engineers, Inc.
Industrial Technology Research Institute
In Focus Systems
Infodex, Inc.
Interface Products, Inc.
Interstate Electronics Corp.
ISE Electronics Corp.
Kollmorgen Corp., Photo Research Div.
Leybold AG
Libbey-Owens-Ford Co.
Litton Systems Canada Ltd.
Loral Librascope
Magnetic Radiation Labs
Micron Display Technology
Microphase Laboratories
Microvision Corp.
Minolta Corp.
Mitsubishi Electronics America, Inc.
MRS Technology, Inc.
MTL Systems
National Semiconductor Corp.
Nippon Seiki Co., Ltd.
Norden Systems, United Technologies Corp.
nView Corporation
OI-NEG TV Products, Inc.
OIS Optical Imaging Systems, Inc.
OKI Electric Industry Co., Ltd.
Optical Coating Lab., Inc.
Penn-Tran Corp.
Photon Dynamics
Photonics Systems, Inc.
Planar Systems, Inc.
Plasmaco, Inc.
Plasmaterials, Inc.
Precision Electronic Glass, Inc.
Quantum Data Inc.
Q.C. Optics, Inc.
Rank Brimar Ltd.
Rantec Microwave & Electronics
Regisbrook Group, Ltd.
Schott Corp.
Semiconductor Systems, Inc.
Sony Corp. of America
Sony Corp./Corporate Research Labs
Spectron Engineering, Inc.
Standish Industries, Inc.
Stanford Resources, Inc.
Supertex, Inc.
Syntronic Instruments, Inc.
Tamarack Scientific Co., Inc.
TEAM Systems
Thomas Electronics, Inc.
Thomson Components and Tubes Corp.
Toshiba America, Inc.
Villa Precision
Viratec Thin Films Inc.

index to advertisers

Business and Editorial Offices
Recruitment Advertising
Palisades Institute for Research Services, Inc.
201 Varick Street
New York, NY 10014
Jay Morreale, Advertising Manager
212/620-3371 Fax: 212/620-3379

District Sales Office – West/Mid-West
Ted Lucas
5428 N.W. Pinery
Newport, OR 97365

District Sales Office – East
Palisades Institute for Research Services, Inc.
201 Varick Street
New York, NY 10014
Jay Morreale, Advertising Manager
212/620-3371 Fax: 212/620-3379

District Sales Office – International
Lee Branst
Caracal Communications
P.O. Box 1513
Redondo Beach, CA 90278
310/542-4233 Fax: 310/542-8754