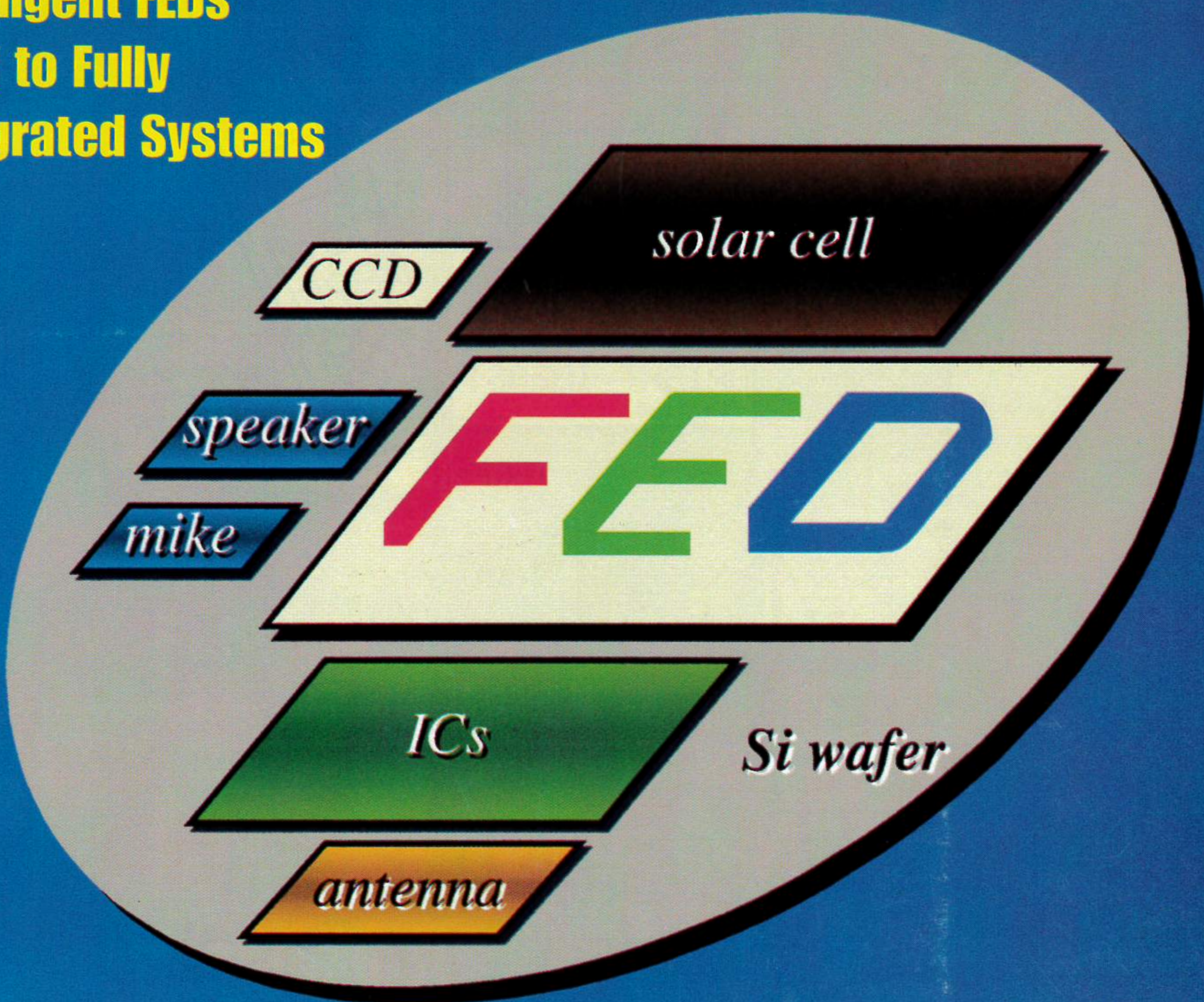
Official Monthly Publication of the Society for Information Display

INFORMATION DISPLAY

January 1998
Vol. 14, No. 1

SID ANNUAL MONITOR ISSUE SID

Intelligent FEDs Lead to Fully Integrated Systems



"*i*-FEDs" Reported at IDRC
LC Materials for FPDs
CRT Technology Advances
New Column: View from Europe

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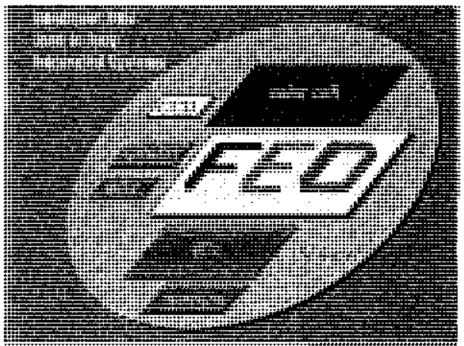
COVER: Silicon field-emission tips can be made as part of an MOS transistor, which can provide the tip with logical intelligence and allow the "intelligent FED" to be integrated with other system components on a silicon wafer. See Ken Werner's IDRC report on page 28.



Credit: Electrotechnical Laboratory

For more on what's coming in *Information Display,* and for other news on information-display technology, check the SID Web site on the World Wide Web: **http://www.sid.org.**

Next Month in
Information Display

Flat-Panel Issue
- Ferroelectric LCDs
- Electronics development for FEDs
- Dynamic human-machine interfaces
- SMAU '97 report
- FLC '97 report

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editorial

Point ... Shoot ... and Poetry

Point and shoot. More than a hundred press releases cross my desk in the course of a month, and some of them are even interesting. Zenith certainly made the "interesting" category with the announcement of its National Academy of Television Arts and Sciences "Emmy" Award for pioneering the development of wireless remote controls for consumer television.

The first practical wireless remote control was invented by Robert Adler in 1955 – the same Robert Adler who later developed Zenith's flat-tension-mask CRT and became the company's VP of research.

Zenith's corporate push of remote control derived from founder Eugene McDonald's conviction that TV viewers would not tolerate commercials. While waiting for the collapse of commercial television and its replacement with commercial-free subscription television, McDonald believed viewers would appreciate a wireless remote for muting the sound of commercials.

The first attempt – and the first wireless remote – was Eugene Polley's "Flashmatic," a directional flashlight that could be aimed at photocells located at the four corners of the screen (for rotate tuner clockwise, rotate counter-clockwise, sound on/off, power on/off). There were some problems – sunlight shining on the set could start the tuner rotating – but McDonald loved the concept and ordered further development.

This was very much in the era of vacuum-tube electronics, so designing a compact, lightweight remote control was not trivial (and the sales department was opposed to using batteries in the remote). So the stage was set for Bob Adler's truly clever design for the "Zenith Space Command": a spring-loaded hammer struck a lightweight aluminum rod that produced an ultrasonic frequency. Four rods of different lengths produced four frequencies for controlling the four basic functions.

The original version of Space Command was introduced in 1956. It added 30% to the cost of a TV set because a six-tube receiver/processor had to be added to the set, but the control itself was compact and used finger power instead of battery power. As transistors replaced receiving tubes, the ultrasonic sounds were generated electronically and the in-set receiver dropped in price. In this form, the ultrasonic remote control lasted through the 1980s. Over nine million were sold by Zenith and other manufacturers over 25 years, until they were completely replaced by infrared remotes.

I remember, as a boy, being fascinated by the Zenith Space Command receiver at a friend's house. I never expected then that I would someday meet its inventor. In fact, although I have spoken with Robert Adler several times over the last ten years, I did not know he was the inventor of this ingenious device until the arrival of Zenith's interesting press release.

... and Poetry. Although some of us may find a kind of poetry in the baroque pathways that lead from quantum mechanics through electronic and optical engineering to a viewer's direct experience of art, drama, foreign cultures, distant friends, and momentous events (and, yes, *Beavis and Butthead* and afternoon soap operas), display technology does not generate much poetry of the words-on-paper variety. In fact, I've never seen any at all – until now.

I am grateful to Mike Brill of Sarnoff Corporation – until recently, the David

continued on page 40

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Powerful Video Generators. The Smart Choices.

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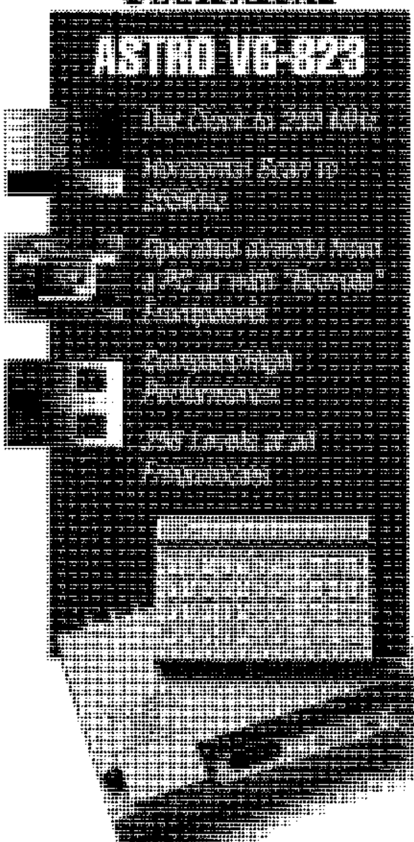

Standalone Units from **$2950**

If you want a very flexible Video Generator, the Astro VG-823 is a high performance, lightweight and compact unit that offers the capability to test any high resolution display system up to 1600x1280 at high refresh rates.

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It can be programmed and operated from a PC or with the RB-646 "Remote" frontpanel or operated only with the RB-614C Controller.

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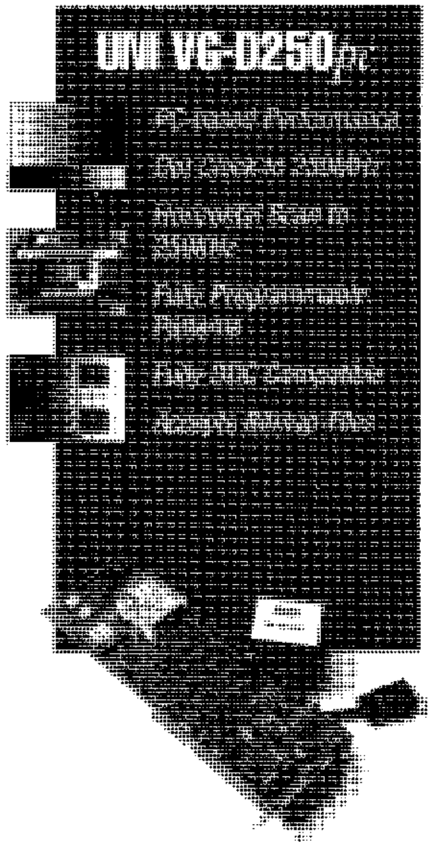

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Circle no. 2

the display continuum

A World Full of Electronic Peepholes ...

by Aris Silzars

One morning Andy awoke, got dressed, and went to work. After he had settled himself in front of his computer screen in his cubicle office, a realization hit him. All the stores he normally passed on his way to work were gone! Yes, you know, the kind of stores where you buy stuff like television sets, microwave ovens, books, CDs, clothing, and most everything else. They were all gone. Closed up. All that was left were convenience stores combined with gas pumps, grocery stores selling pre-prepared meals, and restaurants. The streets were crowded with UPS, FED-EX, and other delivery-service trucks making their never-ending rounds in response to shoppers now doing all their purchasing using on-line computers and WEB televisions.

Was this just a weird dream? It couldn't be. He had awakened as always, gotten ready for work, and followed his normal commute route. But seemingly overnight, the world had changed.

He remembered reading a few predictions recently about how on-line commerce would replace conventional shopping. One in particular that now came back to him was a magazine article that he had seen one Sunday evening in the local Barnes & Noble bookstore. It was a column by a well-known and frequently quoted industry prognosticator. In his column, this prognosticator contended that bookstores are on their way out. The fnture would belong to Amazon.com and similar all-electronic transaction providers. All of our shopping would be electronic, with no need for dealers, stores, or others to get in the way and cause prices to go up. Except for magazines, that is. And especially the one for which he was writing. Magazines, as "context" providers, were somehow going to be excluded from this revolution.

And why would all this happen - which now, it seemed, it already had? According to this writer, we buy books, for example, because we want to read what a specific author has to say. Therefore, we can order these books just as well over the Internet as we can by going to a bookstore. In other words, the bookstore adds no value to the transaction and, therefore, just causes prices to increase unnecessarily.

Now from the look of things, as far as Andy could tell, this author and others predicting the on-line Information Society had been right on target.

For lunch, Andy went across the street to his favorite deli, had a quick sandwich, and decided to take a walk and maybe browse for a new CD. But the CD store was no longer there. Oh well, might as well go back and work at the computer in his cubicle some more.

On his way home from work, he stopped at the grocery store, bought a pre-prepared dinner, and thought he might like to find an interesting book to read later that evening. He wasn't quite sure what might inspire him. In any case, it would be fun to just look around. However, as he pulled into the parking lot, he could already see that his favorite Barnes & Noble store had been replaced with a giant magazine emporium. A big sign out front said, "THE WORLD'S LARGEST CONTEXT PROVIDERS." Disappointed, he got back in his car and headed for home. Somehow, he would try to search on-line to see if he could find anything interesting. However, spending more time in front of the

continued on page 36

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european views

United Kingdom: The UK's Display-Technology Alliance

by Alan Mosley

With this issue we are pleased to begin publication of "European Views," a bi-monthly column focusing on European display developments and viewpoints of the European and global display scenes. "Views" is plural, and columns will be written/compiled/edited by various members of the European display community.
– KIW

With support from the UK Government's Foresight Challenge technology program, UK industrialists and academics have formed the Display Technology Alliance (DTA) in order to work together to improve flat-panel-display technologies. Total funding for this 3-year program, which started in January 1997, is approximately $7.5 million, of which almost $5 million comes from UK industry.

Fourteen UK-based companies and six UK universities form the founding partners of the DTA, which is managed by CRL. The DTA aims to improve display technologies and components in order to give the UK displays industry, which is primarily composed of distributors and value-added resellers, a competitive advantage.

The DTA Partner Organisations, and their areas of expertise relevant to the program, are as follows:

- British Aerospace (Sowerby Research Centre) – human-factors affecting displays.
- Cambridge Display Technology – development of light-emitting polymers.
- CRL – passive-matrix LCDs and backlight technologies (Program Manager).
- Epigem – polymeric micro-optics development and manufacture.
- Fibredata Group – fibre optics and components.
- Heriot Watt University – optics research and holography.
- Hewlett-Packard Laboratories – display-systems prototyping and evaluation.
- IBM UK – open video standards and interconnections for monitors.
- Meggitt Electronic Components – display modules and systems development.
- Merck – liquid crystals and optical-film development.
- Philips Research Laboratories – AMLCD-architectures research.
- Pilkington Optronics – optical-systems development.
- Pilkington Technical Glass Division – glass substrates and coatings.
- Screen Technology Ltd. – display-system architectures and design.
- Smiths Industries Defence Systems – high-intensity backlights and display systems.
- University College London – optical modelling and design, and analogue and digital circuit design.
- University of Brighton – structure analysis.
- University of Cambridge – optics modelling and design.
- Loughborough University – thin-film coatings.
- University of Oxford – materials for FEDs.

The DTA program has been divided into five sub-projects which are summarised below.

continued on page 40

calendar

Display Technology

Display Works 98: Display Manufacturing Technology Conference. Co-sponsored by SID, SEMI, and USDC. Contact: Mark Goldfarb, Palisades Institute for Research Services, Inc., 201 Varick St., Suite 1006, New York, NY 10014; 212/620-3380, fax 212/620-3379.
January 20-22, 1998 San Jose, CA

EUROMONITOR '98: The Second International Exhibition-Fair of Information Display Devices and Projection Equipment. Organizers: Russian National Association of Display Manufacturers, Distributors, and Consumers. Contact: E. G. Goushchin, President, SPS Concept Engineering, Office 902, 41 Vernadskogo av., Moscow, 117981, Russia; (095) 430-8650, 338-9582, 339-5726, e-mail: concept@aha.ru; Internet: http://www.aha.ru/~concept.
April 14–17, 1998 Moscow, Russia

The 1998 SID International Symposium, Seminar & Exhibition (SID '98). Sponsored by SID. Contact: Jay Morreale, Palisades Institute for Research Services, Inc., 201 Varick St., Suite 1006, New York, NY 10014; 212/620-3371, fax 212/620-3379, e-mail: jmorreal@newyork. palisades.org.
May 17-22, 1998 Anaheim, CA

9th International Workshop on Inorganic and Organic Electroluminescence (EL 98) and The Fourth International Conference on the Science and Technology of Display Phosphors. Sponsored by SID, PTCOE, DARPA, and the Oregon Center for Advanced Technology Education. Contact: Mark Goldfarb, Palisades Institute for Research Services, Inc., 201 Varick St., Suite 1006, New York, NY 10014; 212/620-3380, fax 212/620-3379.
Sept. 14-17, 1998 Bend, OR

The 18th International Display Research Conference (Asia Display '98). Sponsored by KPS and SID. Contact Prof. S. Lim, Secretary General; +82-417-550-3542, fax +82-417-551-9229, e-mail: limsk@ns.dankook.ac.kr, Internet: http://tftlcd.kyunghee.ac.kr/idrc98.
Sept. 28-Oct. 1, 1988 Seoul, Korea ■

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LCD Type	Active Matrix	

Both models are compatible with PC, Mac, Workstation or any VESA compliant analog RGB signal, no special card required.

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Liquid-Crystal Materials for Flat-Panel Displays

Liquid-crystal materials are engineered as precisely as the displays that exploit their electro-optical characteristics.

by Mitsuhiro Koden

Over the three decades of liquid-crystal-display (LCD) evolution, tremendous efforts have been poured into liquid crystals (LCs) - the drops of half-opaque liquid sandwiched between the two glass plates of LCDs.

LC materials were discovered and named in the 19th century. As used in today's LCDs, they usually consist of 10–20 organic compounds produced from petroleum oils and other feedstocks by multi-step organic reactions. The development of LC materials has been crucial to the expansion of the LCD business because their properties are closely related to such critical aspects of display performance as contrast ratio, response time, luminance, information content, drive voltage, power consumption, viewing angle, color quality, operating-temperature range, and storage-temperature range.

In addition, the recent expansion of the LCD business has stimulated the rapid development of exotic materials - such as polymer LCs, discotic LCs, and the combination of LC materials with polymers - because they can add novel functions to LCDs. Some of the recent developments in LC materials will be reviewed. In addition to the materials with ordinary thermotropic, rod-like LC molecules of low molecular weight, some of the more exotic materials, such as polymers and discotics, will be reviewed.

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LC Materials for TFT-LCDs

An LC material used in a thin-film-transistor LCD (TFT-LCD) functions as a capacitor dielectric, with the capacitor being driven by the TFT switching circuitry. In their development of these materials, chemists have therefore focused on electrical properties, such as resistivity and dielectric constants - a rather different strategy from that used to develop the materials for the other types of LCDs.

High LC resistivity is required for a high holding ratio (long *RC* time constant), which is needed to obtain high picture quality in TFT-LCDs. Extensive research efforts have led to the conclusion that the mean dielectric constant of the LC material should be minimized to obtain high resistivity.[1] To realize lower dielectric constants, we have seen a recent trend to formulate LC materials for TFT-LCDs with fluorine atom(s) instead of CN groups (Fig. 1).

Although a CN group tends to produce high dielectric anisotropy - which is needed to reduce drive voltage - it also tends to produce a large mean dielectric constant and high viscosity. Terminal groups containing fluorine(s), on the other hand, tend to exhibit moderate dielectric anisotropy, low mean dielectric constant, and low viscosity. An example of the effect of fluorination on the *RC* time constant is shown in Fig. 2.

Low optical anisotropy improves the viewing angle not only of ordinary TN-mode LCDs but also of in-plane-switching (IPS) LCDs, plasma-addressed LCDs, and other

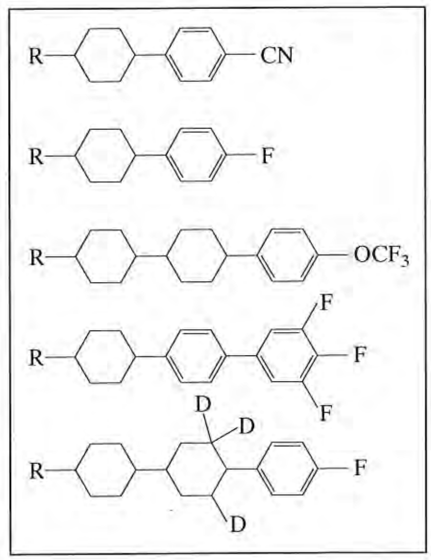

Fig. 1: *In LC materials for TFT-LCDs, there is a tendency to use fluorine atoms instead of CN groups to increase resistivity.*

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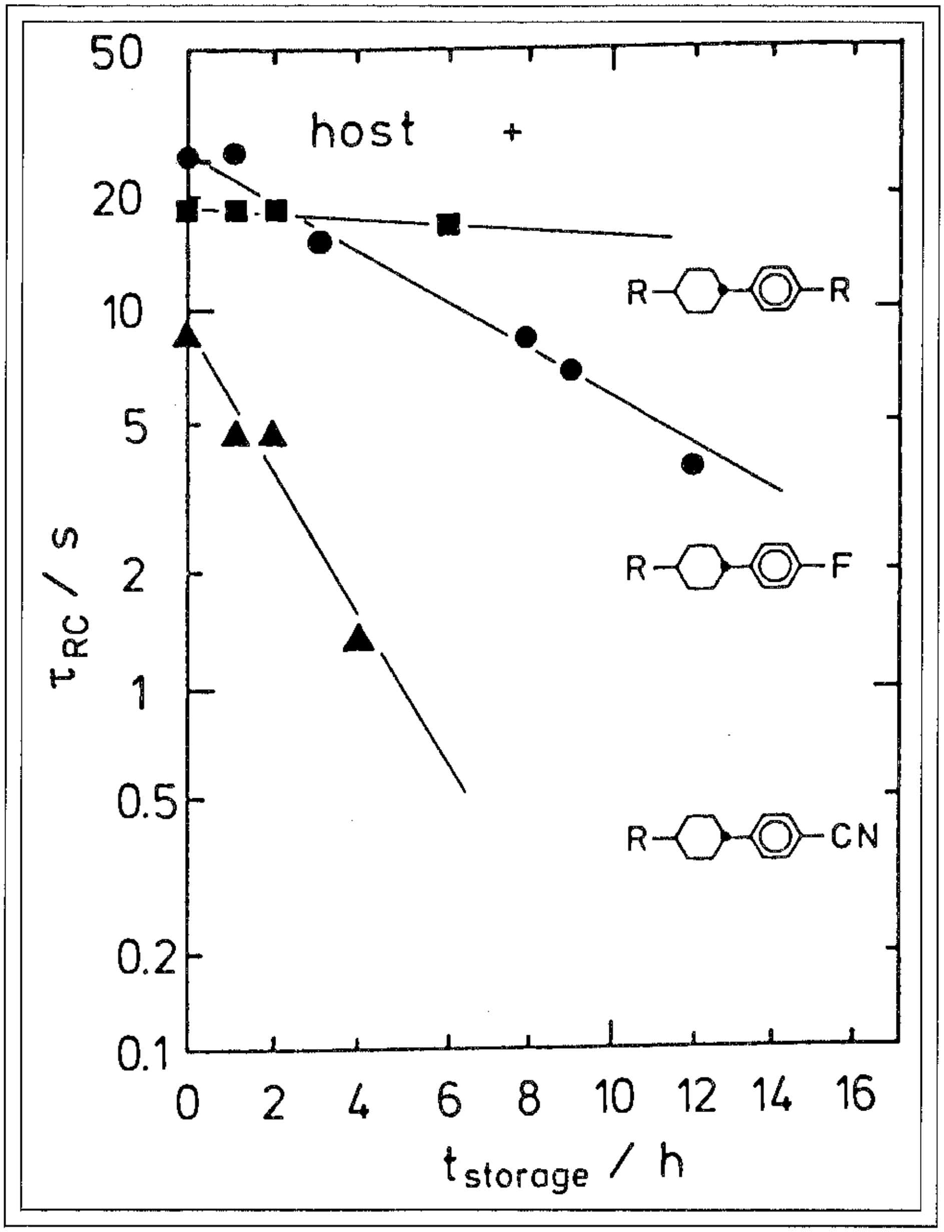

Fig. 2: The RC *time constant* vs. *time of exposure at 150°C varies strongly with fluorination of a liquid crystal. [From H. J. Plach, G. Weber, and B. Rieger,* SID Intl. Symp. Digest Tech. Papers, *91 (1990).]*

types. Therefore, fluorinated compounds are also useful from this point of view.

LC Materials for STN-LCDs

A recent design goal for supertwisted-nematic LCDs (STN-LCDs) is the fabrication of large displays that can present moving images – a goal that requires high information content (HIC) and fast response time. Realizing HIC in an STN-LCD requires a steep voltage-transmission characteristic, which can be achieved by an increase in the elastic-constant ratio K_3/K_1. The response time can be improved by decreasing the LC viscosity and also by increasing the LC optical anisotropy because high optical anisotropy permits designers to use a thinner LC layer. These characteristics were recently combined in a novel LC-compound design containing fluorine and/or acetylene groups.

FLC and AFLC Materials

Ferroelectric liquid-crystal (FLC) materials are expected to be utilized in new types of displays. FLC materials and displays have several valuable characteristics, such as fast response time resulting from the FLC's spontaneous polarization (P_s), memory effect because of the bistability, and wide viewing angle because of IPS.

The combination of fast response time and memory effect can be utilized to make large LCDs with simple multiplexing that feature very high information content and wide viewing angle. Canon, for example, demonstrated a 15-in. color FLC display (FLCD) with 768 × 1024 dots at the Sixth International Conference on Ferroelectric Liquid Crystals (FLC '97) last summer in Brest, Brittany. At the International Display Workshops (IDW '97) last November in Nagoya, Sharp and DERA presented information on a 6-in. color FLCD with 240 × 320 dots and 262,000 colors.

FLC materials – which must exhibit a tilted chiral smectic phase such as the chiral smectic-C phase – are usually prepared by mixing a small amount of chiral compounds (Fig. 3) with host LC materials (Fig. 4).

Anti-ferroelectric liquid-crystal (AFLC) materials also have valuable properties, such as fast response time, the absence of ghosting, and gray-scale capability (Fig. 5). Since normal AFLC materials have double hysteresis, simple multiplexing displays can be realized by utilizing the hysteresis property. Last October, *LCD Intelligence* reported the demonstration by Denso of a 17.4-in. full-color AFLC display with 1240 × 1024 dots.

Recently, thresholdless AFLC materials were discovered. Of interest because they can exhibit wide viewing angle, gray scale, and fast response time when used with TFTs, these materials are AFLCs but of a type that has smooth voltage–transmission characteristics without threshold or hysteresis. Casio presented a paper on a thresholdless AFLC-TFT at SID '97 in Boston, and Toshiba presented one at FLC '97.

Application of Polymers

Active research into various polymer applications, motivated by the expectation that LCDs will be endowed with novel functions, has recently come to fruition.

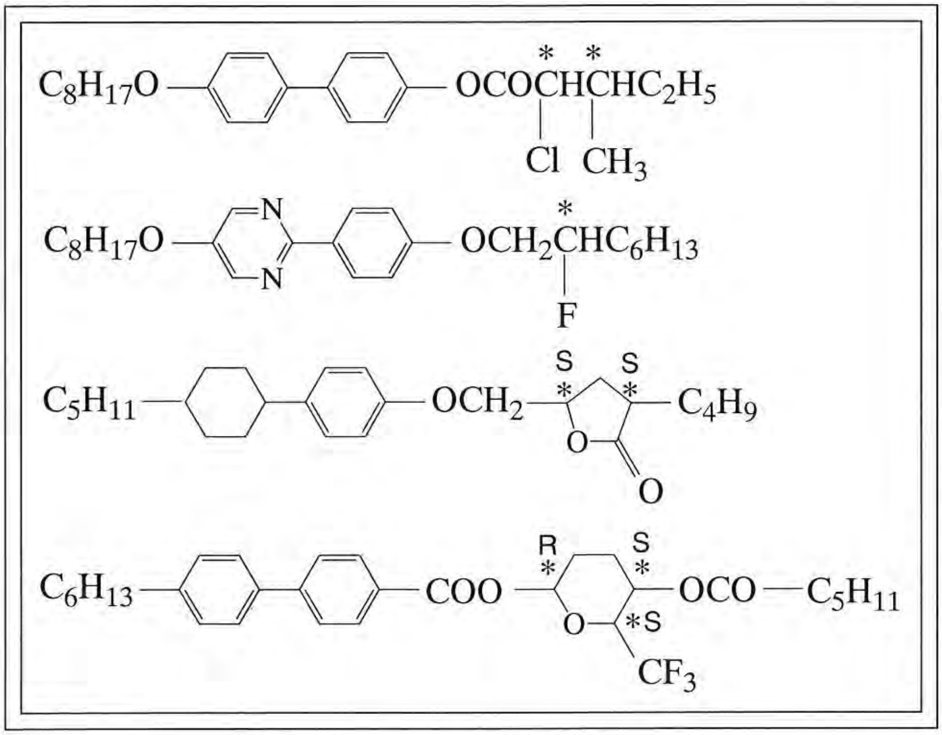

Fig. 3: Some examples of chiral compounds for FLC materials.

Discovered a dozen years ago by Jim Fergason, the polymer-dispersion LC (PDLC) is one polymer technology that is well known. But three other interesting polymer technologies have been developed more recently. One is the application of the polymer-stabilization effect to LCDs. The second is the fabrication of polymer walls within a cell by photo-irradiation and phase separation. The third is a realization of analog gray scale in FLCs by adding a small amount of dispersed polymer to FLC materials.

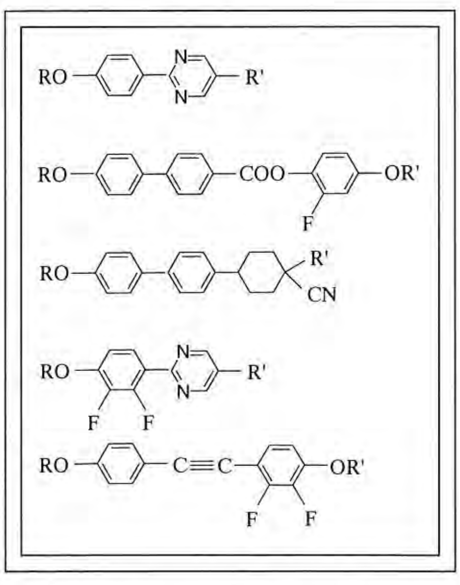

Fig. 4: Some examples of host compounds for FLC materials.

The polymer-stabilization method produces a polymer network in LC cells. A small quantity of monomers - just a few percent - is used to dope the LC material. After a mixture of LC material and monomers is applied to an LC cell, the cell is exposed to UV light in order to induce polymerization. The polymer network tends to stabilize the molecular orientation that exists at the time of exposure, which makes it possible to select the desired initial molecular orientation by controlling variables such as the applied electric field or temperature.

Although the aligning film and rubbing process used in conventional LCD fabrication control the molecular orientation at the surface in order to obtain the preferred molecular orientation of the bulk LC material in the cell, the polymer-stabilization method can *directly control* the bulk orientation. Therefore, this method is very useful when a desired molecular orientation is not stable. T. Konno and his colleagues at Tohoku University, for example, have applied the polymer-stabilization method to optically compensated bend (OCB) cells, which have the advantages of wide viewing angle and fast response time. The polymer network can stabilize the bend structure instead of the twist orientation.

At SID '95 in Orlando, T. Yamada and his colleagues at Sharp first presented the axially symmetrically aligned microcell (ASM) (Fig. 6). The ASM mode is realized by performing phase separation from a mixture of LC and polymerized resins. The polymer walls that constitute the microcell structure in each pixel are formed by UV irradiation. In each microcell, the axially symmetrical orientation of the LC molecules is stabilized by the polymer wall. Yamada and his co-authors reported that the ASM mode showed significantly

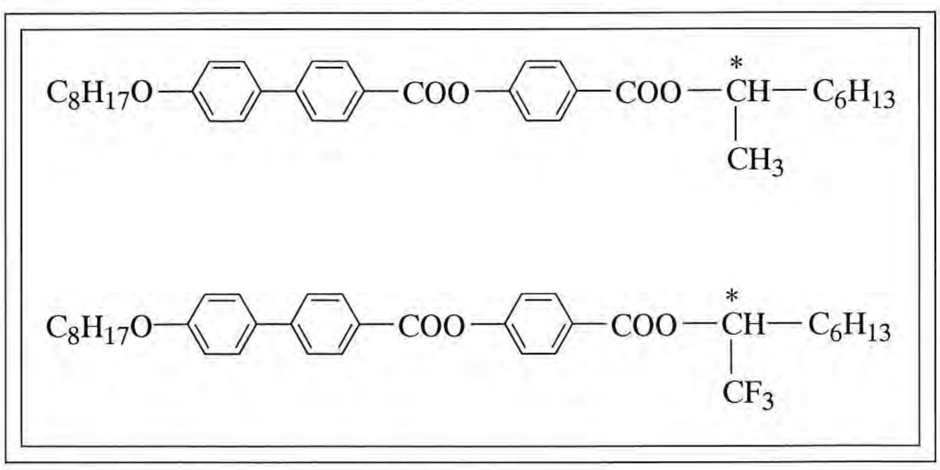

Fig. 5: Some examples of anti-ferroelectric liquid-crystal (AFLC) compounds.

improved viewing angle because of the axially symmetrical molecular orientation.

Shinomiya and a group from Sharp's Liquid Crystal Labs have modified the ASM technology for application to STN-LCDs. Their goal is to improve the structure's mechanical stability for pen-hased portable LCDs. The polymer walls in their design provide high resistance to pressure, and prevent the pressure from fingers or a stylus from distorting the image.

There have been some reports that the combination of polymers with FLC material can be used for realizing analog gray scale in FLCs, while normal FLCs are bistable. For example, A. Sakaigawa and a team from Sharp reported at IDW '97 that FLC materials containing a few percent of polymer tend to show analog gray-scale switching with domains of small size and uniform distribution.

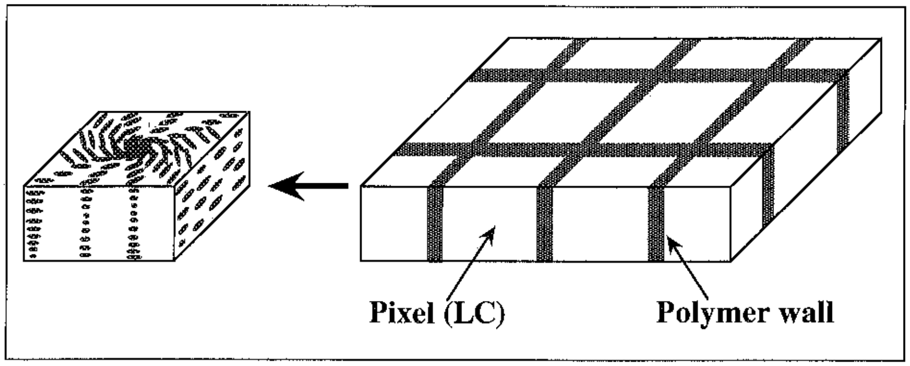

Fig. 6: In the axially symmetrically aligned microcell (ASM) LCD, the symmetrical orientation of the LC molecules, which is stabilized by the polymer walls, produces a significantly improved viewing angle. [From N. Yamada et al., SID Intl. Symp. Digest Tech. Papers, *595 (1995).]*

Polymer and Discotic LCs

Recently, various applications of LC polymers to flat-panel displays have been reported. At SID '96 in San Diego, Merck Ltd., U.K., announced wide-bandwidth reflective cholesteric polarizers, which utilize cholesteric LC polymers. This technology can substantially improve luminous efficiency compared with normal polarizers. At SID '95 in Orlando, Nippon Oil described an LC-polymer film functioning as an optical compensator for a fast-response STN-LCD.

Idemitsu has described displays in which FLC polymer is sandwiched between two flexible plastic substrates with ITO electrodes. A good molecular orientation was obtained by shearing cells with bending, despite the absence of an aligning film in these displays. Such displays may not present fast-moving images, but they can be applied to large information displays in public places.

Over the last 2 years, Fuji Photo Film, Nippon Oil, and Kent State University's Liquid Crystal Institute have presented papers on a discotic LC film with a hybrid molecular orientation for improving viewing angle. This negative-birefringence film has a normal optical axis, which compensates for the LC layer's positive birefringence (Fig. 7). The film can be made by a process in which a discotic compound layer is coated on an alignment layer of a film substrate.

The discotic layer is aligned and then polymerized by UV light to fix the structure. A significant advantage of this method - which may be the first application of discotic LCs to displays - is that the film is external to the LC cells and requires no modification of the cell structure.

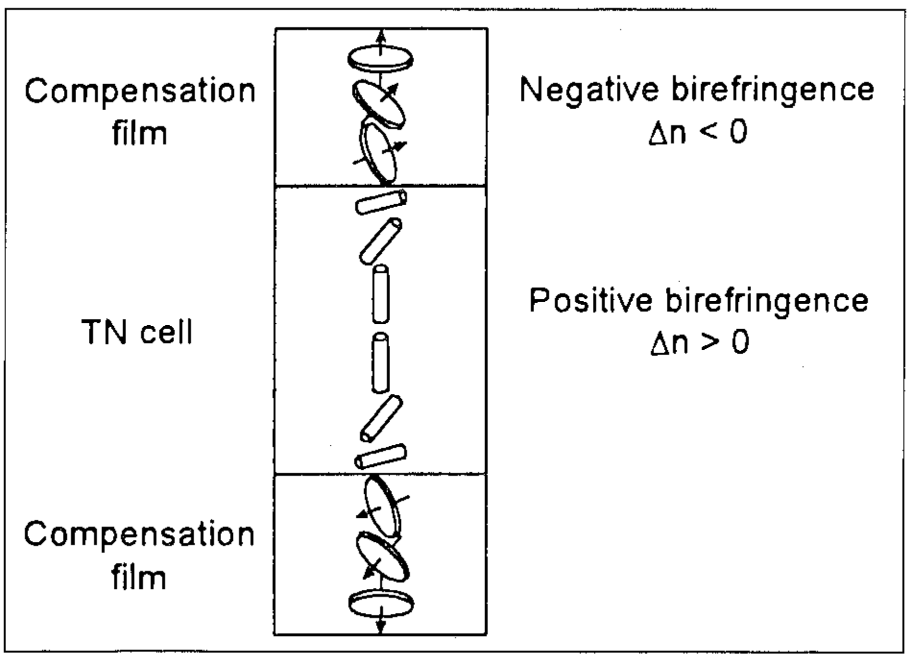

Fig. 7: A negative-birefringence discotic film can be made to compensate for the positive birefringence of the LC in a conventional TN cell. [From T. Yamada et al., IDW '96 **2**, *349 (1996).]*

Conclusion

Thermotropic LC materials with low molecular weight and rod-like structure are reliable, effective, and widely used - and they now feel as conventional as cathode-ray tubes. But new LC-material technologies - including polymeric and discotic LCs - are being used to create a new generation of LCDs with enhanced viewing angle, contrast ratio, optical response, luminous efficiency, and gray scale. Materials scientists continue to pursue research on display materials vigorously, and we expect to find a wide range of new LCD applications.

Note

[1]Mean dielectric constant $\varepsilon \equiv (2\varepsilon_{\perp} + \varepsilon_{\parallel})/3$. ■

Opinion: Reducing the Risk of Moving to Flat Panels

Most government systems continue to use CRTs, so how can console and display-system makers design for the future while recognizing the realities of the present?

Michael Forde

OVER THE LAST SEVERAL YEARS, we have witnessed the introduction of AMLCD technology to industrial, aerospace, and military applications, and we've been impressed with the progress and quality of many of the products now in production. At trade shows and symposia, we have seen most of our competitors showing products based on AMLCDs. But when we go to exhibitions sponsored by our largest customers - the U.S. Army, Navy, and Air Force - we get a different picture.

Most of the military platforms we see at these events have CRT-based technology installed (Fig. 1). There are not many AMLCDs - or any other flat-panel technologies. We would think that at these exhibitions the Services would be showing their most sophisticated machines, demonstrating how the latest technology is being implemented to make their systems the most effective possible. So where are all these flat panels going?

Now, I don't wish to imply that there aren't *any* systems using flat-panel technology. The most notable is the new C-130J, with its instrument AMLCDs and plasma CDUs - which are made by BARCO, we're happy to say. And there are many programs that are in the development and certification stage and close to fielding pre-production units. But these are still the exception rather than the rule.

Now, BARCO has jumped onto the flat-panel train with as much enthusiasm as anybody. We have been aggressively investing significant development funds to produce a family of AMLCD-based products to parallel our existing CRT-display line. Our product-development strategy for AMLCDs is the same one we have always pursued. We carefully survey the market segments that interest us, then design standard display-system products that meet the critical requirements, and offer options for the requirements that are less in demand.

Having standard products allows us to offer lower-priced units through economies of scale: making relatively large materials purchases for common hardware and implementing mass-production techniques. We can then customize a standard product for specific requirements by installing options or making minor mechanical or electrical changes.

The non-returning engineering (NRE) involved is usually small enough so that we do not have to pass it on to our customers directly. The benefit is a lower-priced monitor for the military (or civilian) market that has a proven reliability heritage because the standard product is used in many applications worldwide.

Development Issues

While developing our line of flat-panel products, we've noticed that many of our existing customers are still undecided about making the transition to AMLCDs. The cost is still usually more than twice as high as CRT products, and there are still many concerns about the long-term availability of glass and the reliability of the backlight.

The benefits of going to AMLCDs are obvious - lower weight, less power consumption, and magnetic immunity - but it is not clear that these benefits outweigh the costs of implementation for many systems. And this is a particularly difficult decision in an era when the dollars available for defense and civil projects are declining. On the other hand, it is widely recognized that the world is going to flat panels, and that in the not-too-distant future makers of military and civilian systems will be incorporating these panels as regularly as CRT-based displays are today.

Designing Tomorrow's System Today

A significant problem facing display-system engineers is that they must design the consoles and systems of tomorrow today. Display choices must be made just when crucial technology is changing, and this generates uncertainties in critical areas:

- Which is the best technical solution?
- Will new flat-panel company A be in business just when we need its support (2-3 years ARO)?
- Are we proposing and designing a system that will be obsolete before it reaches full-scale production?

Display-system designers must decide which display technology to incorporate in their proposed new console or system and - if theirs is the winning proposal - they need to begin developing prototypes and, eventually, pre-production units.

So, the dilemma the designer faces is (1) choose a lower-cost, proven technical approach (the CRT), or (2) choose a design that provides the best technical solution and makes use of a technology that will be supported as standard product in the not-too-dis-

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BARCO

Fig. 1: The U.S. Navy's AN/UYQ-70 console is an example of the extensive use of CRT-based displays in today's military systems and the potential market for large AMLCDs.

tant future and beyond, but presents many uncertainties that may affect the program schedule. It is certain that upper management will push the most advanced design so that the company will be perceived as possessing the most advanced and competitive technology. But, in reality, the dilemma is still present.

Risk Reduction through Phased-In Development

How can a display-system designer reduce the risks of transitioning to AMLCDs? At BARCO, we have been advocating a phased-in approach with some of our customers. We are designing the flat-panel-display (FPD) electrical and mechanical interfaces to be compatible with those of our CRT line. This will allow any customer who has purchased our 19-in. CRT product, for instance, to make the transition to our 16.1- or 20.1-in. AMLCD products without having to make any modifications to his or her existing console or electrical interfaces.

This allows a system designer to design and build a concept system around existing CRT products, knowing that these units can be directly replaced with FPD products when those products - and the designer - are ready. Console and display-system design risk can be significantly reduced by allowing the design to go forward without the worry of having to choose the FPD today, but with the certainty that the mechanical and electrical interfaces will stay the same.

This flexibility also permits evolutionary technology insertion. If the program budget doesn't support a flat-panel product today, the design team can develop the console with CRTs, knowing that an expensive console retrofit won't be required when it makes financial sense to convert.

In most front-of-the-aircraft avionics - where the displays are not large - the push to get away from CRTs came early, and good repair-support systems are in place. In this case, there is probably little need for our transitional approach. But the really large worldwide markets for new applications and retrofits, with tens of thousand of displays needed, are found in naval and ground applications (fighters and helicopters needing avionics displays number only in the thousands). Much of this market requires displays that are 17 in. or larger. AMLCDs of this size and larger are just being introduced now, or soon will be introduced into commercial production.

Waiting for Large Displays

Most of BARCO's customers are interested in larger displays, and in this arena the transitional approach can offer substantial value to display-system and console designers who need to design-in flat panels today - and it is likely to do so for years to come (Fig. 2).

The only large-area (relatively speaking), high-resolution AMLCD that has been in production for some time is the DTI (IBM-Toshiba) 16.1-in. SXGA panel. There has been a lot of interest in this panel since its introduction, but what customers really want is a 20-21-in. SXGA panel. And this is where

(a) (b) BARCO

***Fig. 2:** Design a console or display system with a CRT display and swap it for an AMLCD when appropriate, says the author. BARCO's 20.1-in. AMLCD-based display (a) is a plug-out/plug-in swap for its 20-in. (19V) CRT display (b). Both are 19 in. and rack mountable.*

customers have really been on the fence: to go with the 16.1-in. or not.

When this panel first came out in 1994 and IBM (later Loral, now Lockheed Martin) began to make military-use displays with it, a few customers chose to use it because of its larger size and high resolution. But we believe that most of these customers felt that they had compromised their systems because what they really wanted was a 21-in. LCD. However, 21-in. LCDs were nowhere in sight and people chose to use the 16.1-in. for all the obvious reasons.

Now, please don't misunderstand me. The 16.1-in. is a fine panel and BARCO happily offers it. The panel has many suitable applications, and we see a large and profitable market for it. But now that a 20.1-in. SXGA unit is here, the pent-up demand speaks for itself.

Both the 16.1- and 20.1-in. AMLCDs are available in 19-in. rack-mountable configurations. While a custom 16.1- or 20.1-in. AMLCD is designed and qualified for a specific application, standard and qualified rack-mount CRT displays can be used for console or display-system integration.

Apples and Oranges

When comparing the sizes of flat panels and CRT-based monitors, it is important to remember that the flat panel's specifications represent the true viewable area. For CRTs, the diagnal-size specification typically refers to the bottle size, and the diagonal of the viewable area may be more than an inch less than this size. In addition, connecting the monitor to a particular graphics or video generator may further reduce the viewable area. Therefore, a 20.1-in. AMLCD's viewable area may be equivalent to the viewable area of a 21- or even a 22-in. CRT monitor, depending on how it's set up.

Keeping this in mind, it is necessary to actually see the unit and determine first-hand what the viewable area looks like before deciding what size of flat panel to use. Most people in the government-systems business still only have experience with CRT-based displays, so asking them to compare CRTs and flat panels by specifications only – without providing them with the opportunity to see the differences – may not allow them to make a proper evaluation.

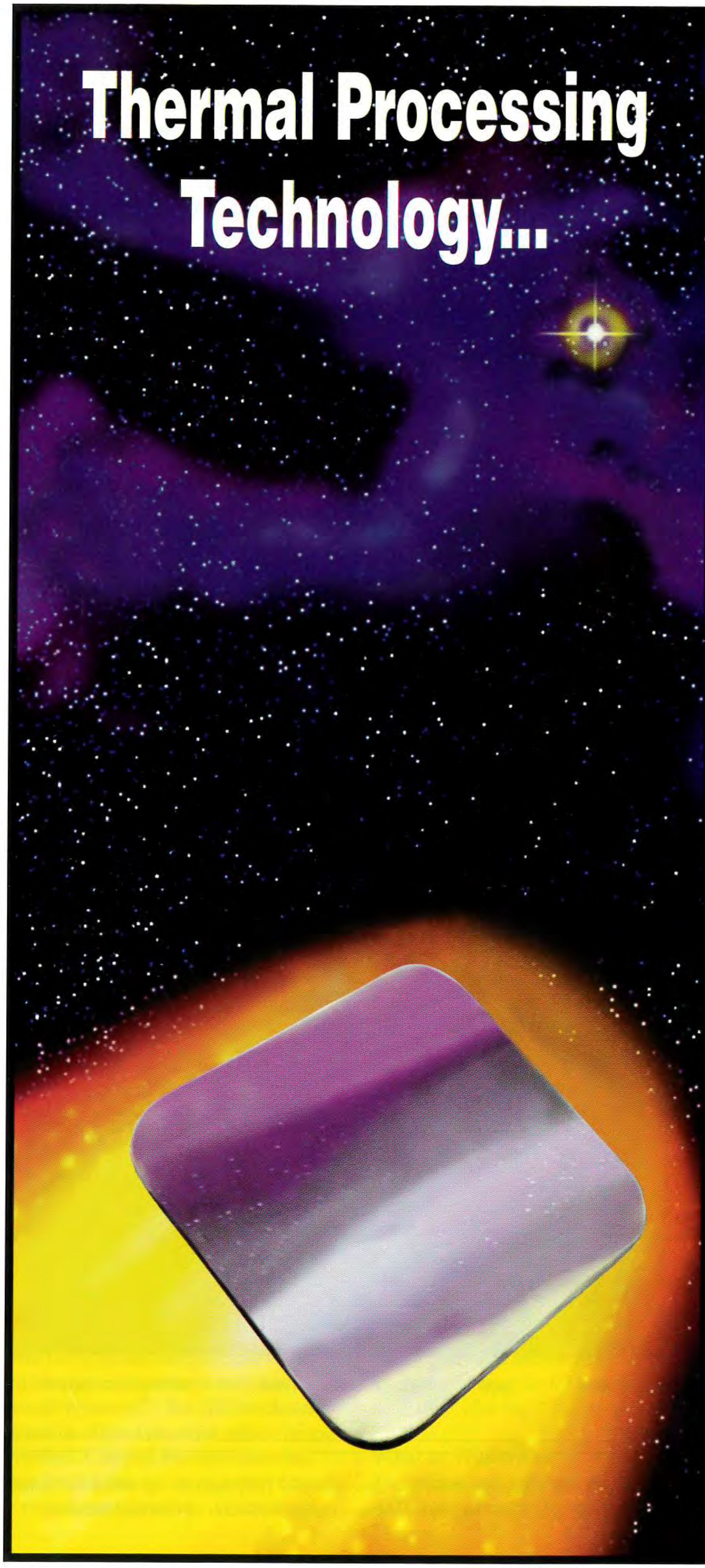
Buyers Impatient

BARCO believes that the market for 20-in. and larger, high-resolution flat panels is an explosive one. The demand for display systems in this size range is huge, and we receive daily requests on the status of our efforts to develop standard products.

But there's a problem: only one manufacturer has promised to have production panels in 1997. Other suppliers are developing similar sizes and resolutions, but we don't expect their panels to be available until mid-1998 at the earliest – and then a display system will have to be designed around the panel, adding 6–9 months of development and testing. This is where a transitional, phased-in approach can truly benefit the customer. And to date, this effort has been successful. Customers have been able to proceed with console development and demonstrate their latest concepts, while informing their customers that the console display has been designed to accept 20.1-in. flat panels when they are ready.

Looking Ahead

As AMLCD technology evolves into larger sizes, the availability of reliable, widely produced, large-area, high-resolution glass will open up applications that have not been previously considered for these sizes – not even for a CRT-based product. With CRT-based products, as the diagonal size increases, the depth and weight increase proportionately, making it impossible to use these displays in any application where space, power, and weight are at a premium. As large-area (greater than 19 in.) flat panels become available, the desire of end users to use these panels for applications not previously considered will increase. ■



Circle no. 8

Touch, Don't Type

From their traditional bastions in industrial control and scientific instrumentation, touch-screen interfaces are spreading to many new applications.

by Robert Steinberg

EQUIPMENT DESIGNERS are always visualizing more-complex machines for manufacturing today's products. As they do, control-system designers are using touch screens in ever-greater numbers to provide input for the overall human-machine interface (HMI) solution. This is so because, in many applications, touch screens offer flexibility, control, and cost advantages over more traditional input alternatives.

In 1994, Dataquest estimated that touch-screen revenues in the U.S. could reach $300 million by 1998. And Frost & Sullivan's report on industrial operator-interface (OI) devices in North America predicted the total market could reach revenues of $2 billion, also in 1998 (Fig. 1).

The HMI, through which an operator instructs and controls a machine to perform a given task, comprises a number of functional components. The OI is one of those components and the primary focus of this article.

In its simplest incarnation, an OI may be an array of pushbuttons, pilot lamps, switches, and perhaps a numeric indicator display. But as the complexity of the processes being controlled increases, the need for more-sophisticated operator controls also increases - sometimes dramatically.

In the most sophisticated operator interfaces, simple switches and indicators are

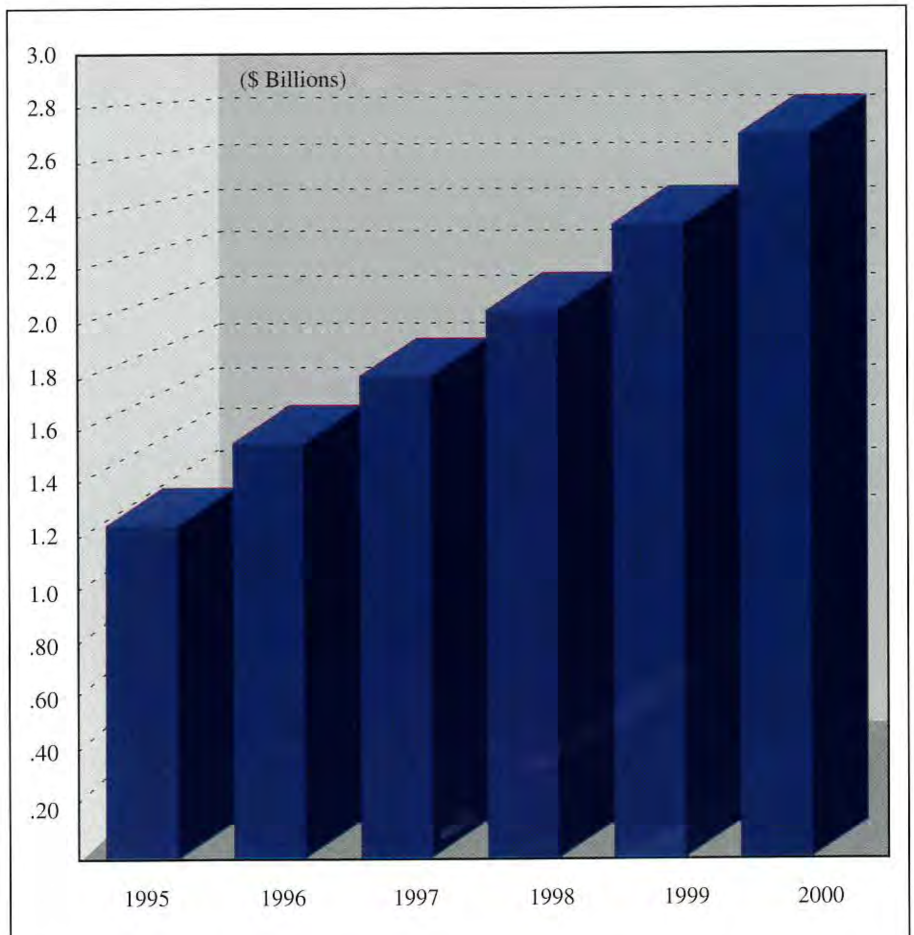


Fig. 1: The North American industrial operator-interface (OI) market – of which the industrial touch-screen market is a part – continues to grow rapidly. (Source: Frost and Sullivan)

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Fig. 2: The combination of a touch screen and graphical user interface (GUI) offers a powerful vehicle for system control.

replaced with an advanced CRT or flat-panel display, and a keyboard or custom keypad array for entering desired changes in machine parameters. Many of the control systems behind these interfaces are PC- or workstation-based, and a touch screen can replace or complement the keyboard/keypad.

Complementary Technologies

A growing trend among system OEMs in the industrial sector is their increased use of PC-based systems for supervisory control and data acquisition (SCADA), as well as for HMI applications. This has opened up new possibilities for the OI - particularly for touch screens.

An inherent part of most of these PC-based systems is a graphical user interface (GUI) based on an operating system such as Microsoft Windows™. The GUI/touch-screen combination offers a powerful vehicle for system control. Complex machine-status and process information can be presented through easy-to-understand graphics. Operators simply touch what they want and the system responds (Fig. 2). And, unlike mechanical controls, these control systems can be easily debugged, updated, and enhanced via software.

Given the advantages of the GUI/touch-screen approach, companies that develop factory- and manufacturing-automation software are adopting it in increasing numbers. "[This] has broken new ground for developers of automation software," says Jack Scruggs, marketing manager for National Instruments' Lookout™ industrial-automation software system. "Our software allows users to build graphically rich, customized SCADA and HMI applications, and offers a natural fit for those OEMs who are contemplating using a touch-screen input device in their operator interface." (See Fig. 3.)

What to Watch For

The touch-screen approach for SCADA and HMI is attractive, but to fulfill their potential the various touch-screen technologies must be carefully evaluated for each application and the appropriate technology well integrated into the system.

In general, there are three key factors: the pointing device used, the contaminants that might come in contact with the touch screen, and the complexity of the information being presented on the display screen.

In an industrial environment, the operator's finger may not be the only thing used as a pointing device, and certain touch-screen technologies have strict requirements for an acceptable stylus. We will say more about this shortly.

In many manufacturing environments, it is possible for chemicals to come into contact with the touch screen, and they may do so not only as solids or liquids but also as vapors or aerosols. These possibilities must be investigated and the touch-screen material selected for its resistance to any chemicals it may encounter. Even when chemical interactions are not an issue, dust, dirt, liquids, or other contaminants may require that the touch screen be sealed.

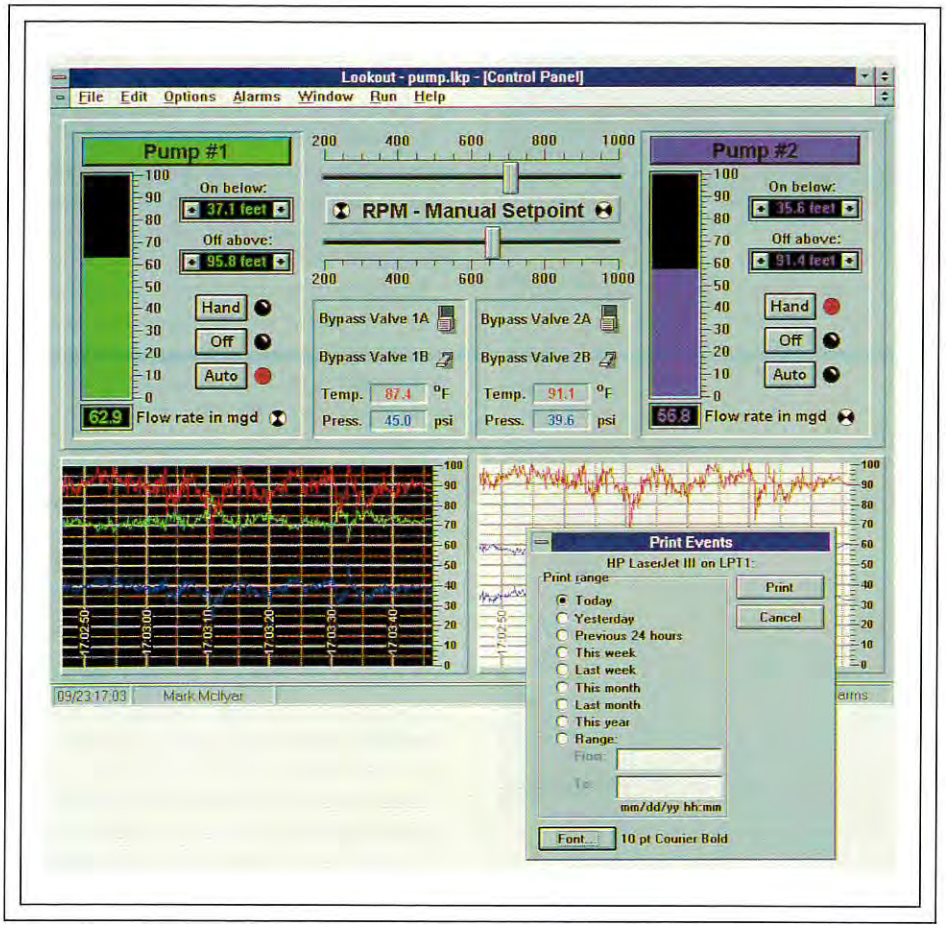
Some touch-screen technologies mount directly onto or in front of the display screen. Therefore, light transmission, parallax, and the minimum size of the touch zone all come into play when designing a graphically represented process- or machine-control OI.

Technologies and Applications

The most widely used touch-screen technologies include capacitive, resistive, surface acoustic wave (SAW), and scanning infrared.

A ***capacitive*** touch screen offers excellent light transmission, low parallax, resistance to scratches, and resistance to most general contaminants, such as dust, dirt, and chemicals. It is constructed of hardened glass with a conductive coating, and has circuitry that develops an electric field across the screen. When the operator's finger touches the screen, the electrical field is affected, and the accompanying touch-screen controller and software determine the contact location. A gloved finger or other insulated pointing device won't work unless it is made conductive. The resolution of capacitive touch screens is very good.

A ***resistive*** touch screen can accommodate virtually any type of pointing device. It uses a special overlay material on a conductive glass substrate. Touching the screen completes an



National Instruments

Fig. 3: Industrial-automation software allows users to build graphically rich, customized human–machine interfaces.

electrical connection between the overlay and the conductive coating on the glass. The touch-screen controller and software establish the x-y coordinates, thereby determining the point of contact. The technology resists dirt, dust, and many chemicals found in industrial settings, but sharp objects can damage the polymer screen. Because several layers of material are used, light transmission is reduced. On the positive side, parallax is not a problem, and the high touch-screen resolution is excellent for complex graphics.

A ***SAW*** touch screen has extremely low parallax and excellent light-transmission characteristics. It is constructed of a solid piece of glass without an overlay, which makes it highly resistant to scratches and contact contaminants. Affixed to the corners of the touch screen are transducers that generate sound waves that travel across the screen's surface. When the screen is touched, the reduction in acoustic energy is detected, and the contact point is determined by the touch-screen controller and software. Because the pointing device must be able to absorb acoustic energy, metal and other hard objects can not be used. On the other hand, contaminants such as sprayed liquids and large amounts of dust or dirt on the screen can absorb acoustic energy and either create false readings or make the touch screen insensitive to legitimate ones. SAW touch-screen resolution is very good for high-information-content graphics.

The ***scanning infrared*** touch screen takes a different approach. It has no effect on the quality of the displayed image because it mounts around the periphery of the display, not in front of it. The touch screen consists of an array of light-emitting diodes (LEDs) that generate an intersecting pattern of infrared light between 0.25 and 0.5 in. above the display screen's face.

A "touch" is made when the intersecting beams are broken by any opaque object of sufficient thickness. The controller and software calculate where "contact" occurred. Because the light beams ride invisibly above the display screen, the operator's viewing angle becomes critical. Parallax (the apparent displacement of an image when the viewing angle is changed) can cause an operator to miss the intended touch target. In addition, the resolution of an LED touch screen is much coarser than that of the other approaches discussed. Infrared touch screens can be sealed, and fare well in harsh environments, provided the LEDs and sensors are kept clean of dust and debris.

Controllers

A touch screen's controller and associated software provide the intelligence and communications capability needed for a complete interface. The controller generally comes in two varieties: bus-dependent and serial (either internal or external). Bus-dependent controllers reside directly in the host computer system, taking up a card slot. The serial version connects to one of the host system's COM ports and communicates via an RS-232C protocol. Serial-interface controllers may either be external to the system or incorporated in the display monitor.

Most touch-screen manufacturers offer software drivers that emulate a mouse in such standard operating systems as DOS, Windows, and Macintosh OS. Systems such as UNIX may not be directly supported by the touch-screen manufacturer. Support for platforms running such systems can generally be obtained from independent applications-software providers.

Cost Advantages

Touch screens can offer much greater flexibility than "fixed" input methods. When a touch-screen interface is part of the product design, the form and function of the application can be changed, enhanced, or updated through software. Cost advantages derive from the elimination of keypad retrofits, button-panel retrofits, and process-specific overlay masks – which are generally not cost-effective unless produced in significant quantities. Presently, the average cost of a touch screen, its controller, and supporting software ranges from $700 to $900 per installation, excluding labor.

Another cost-benefit advantage of touch-screen input systems stems from their common use of the standard serial communications interface. Integrating a touch screen designed for compatibility with standard PC platforms into the OI design is nearly as simple as "integrating" a computer keyboard or mouse input device.

Ongoing maintenance support is generally minimal after initial setup and calibration. Durability ratings of 30 million touch activations at the same screen point are typical among the overlay-type touch-screen technologies. This level of durability would be very difficult to achieve with a mechanical-action switch.

Touching for Control – and Dollars

From semiconductor-manufacturing equipment to medical diagnostic systems, touch screens have offered system operators a level of intuitive input control not available through other conventional methods. Now, touch screens are migrating rapidly from such industrial and scientific markets to fulfill the computer-input needs of an ever-widening range of commercial applications.

In the banking and client financial-services area, touch screens are being used in conjunction with keypads in many newer ATMs. One of the newest gaming machines to hit the entertainment market has replaced mechanical levers and buttons with a touch screen. Fast-food (and other) restaurants are using touch-screen-based point-of-sale terminals. An increasing number of state motor-vehicle departments are using touch-screen-equipped computer-based training terminals to administer their written driver's-license tests.

The number of touch screens found where the public gathers for business or pleasure is growing rapidly. Information kiosks are popping up in shopping malls, airport terminals, and libraries. These stand-alone enclosures typically house a touch-screen-equipped monitor, a PC, and sometimes a printer and/or magnetic-stripe card reader. These systems provide the public with access to a wide variety of custom services, such as dispensing travel or entertainment information, completing a purchase transaction, or even accessing the Internet.

In such applications, touch screens provide more than mere system input. Early in the development process, kiosk designers discovered that traditional input devices - such as keyboards and mice - frequently intimidate potential users who are unfamiliar with computer operation. Touch screens solve this problem while allowing users to accomplish their desired tasks easily.

Touch screens have been redefining the way in which people interact with automated systems for more than 25 years. They have increased productivity by offering a new level of flexibility in operator control while increasing accuracy and reducing training time. Although touch-screen technology itself is quite stable, display-system, control-system, and OI designers are creatively expanding its useful range of applications to serve increasingly diverse user groups. ■

Still Crazy after All These Years

Not only do CRTs constitute a huge business, but they still provide fertile ground for technical development.

by Joe Hallett

THE CATHODE-RAY TUBE (CRT) is generally considered to be a mature product. But as with other mature products, such as the automobile and the telephone, designers continue to innovate so they can meet competition, satisfy customer needs, and reduce manufacturing costs.

CRTs are used in a variety of important applications, with much sharing of technologies, materials, and processes - and new developments occur where the money is. The CRT industry is clearly expected to improve its productivity while keeping up with evolutionary product improvements, such as larger screens, wider aspect ratios, and improved resolution. CRT historian Peter Keller says, "My impression is that very little [R&D] is going on in the U.S. ... some refinements in the Far East ... no more new devices ... no innovation anymore." But Keller was at Tektronix during the glory years of custom-CRT design, and his standards are high. Others still manage to find innovation in the industry, even if it is of a more modest sort.

CRT Market Still Growing

George Aboud, who covers the CRT industry for Stanford Resources, Inc., a market-information company headquartered in San Jose, says, "[The CRT market] is still growing, not declining with the advent of LCD products, except in portable and some special applications. The CRT's price/performance is still very difficult for flat-panel and future technologies to match, particularly as the CRT grows in size, in both desktop-computer and television applications. TVs are getting bigger, with good growth in 31- and 32-in. sizes."

Back in the Laboratory

Manufacturers of television picture tubes and CRTs for desktop computers serve huge markets. Major product changes - such as the conversion during the 1970s from delta-gun to in-line-gun configurations with self-converging deflection yokes - do not happen often. And even changes of this magnitude may hardly be noticed by the average end user, despite massive development costs to the CRT's maker and the makers of the TV sets or monitors that use it. For example, one result of incorporating the in-line system was to stabilize product costs and improve reliability. This has produced the paradoxical situation of TV sets that don't ever seem to wear out, while the replacement cost often drops below the original purchase price. Today, with a number of competing display technologies waiting in the wings, it seems unlikely that the whole industry would again make such a major changeover.

R&D by large CRT makers seems focused on reducing costs through design improvements and improved yield. As Keller observed, the basic product doesn't change very much, except for cosmetic changes and incremental improvements in resolution at larger screen sizes. "Certainly, in color CRTs there is still a lot of manufacturing engineering - and tolerancing analysis - going on to improve electron guns and resolution, and for cost reduction," said retired Tektronix CRT specialist Ken Hawken.

When manufacturers worry about market share and profitability, they aren't likely to talk publicly about R&D expenditures that mainly impact their competitive strength. So if there is a breakthrough technology in somebody's R&D lab, it's probably a secret.

Wide-Aspect-Ratio CRTs

But even incremental changes can make a difference. Wide-aspect-ratio display screens - needed for HDTV and some digital TV formats - have the potential to create major changes in the entertainment market for CRTs. The current installed base of CRT-based television sets may look very old in a few years, in much the same way as a whole generation of early TV sets was re-positioned by the introduction of flat, square-cornered screens. And wide-screen computer monitors can't be far behind.

According to a July 1997 report issued by Stanford Resources, Inc., the number of CRTs sold worldwide will grow about 30% by the year 2003. Most of this unit growth is projected to be in tubes for consumer-television applications. Changes in performance requirements to meet digital and high-definition system requirements will make these CRTs look more like the computer types of today. This trend is evident in the rising average price of consumer CRTs. The average price of computer-display tubes - while still higher than that for consumer types - shows a declining trend over the same period.

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New Technology for CRTs

The development of CRT technology is still active and interesting. Here are some examples of CRT research-and-development activities, adapted from material provided by Stanford Resources, Inc.

- A digitally controlled focus-adjustment system using built-in ultrasonic motors for high-resolution CRT monitors. Developed by Hitachi, Tokyo, Japan.
- A flat-faceplate CRT which uses a slot-type pre-stretched mask, a newly developed electron gun that produces a small horizontal spot size at the screen periphery, and a self-converging yoke enabling the "pure flat" tubes to be used in multi-scanning monitors. Such monitors have appeared on the market within the last few months. Developed by Matsushita Electronics Corporation, Osaka, Japan.
- An "in-neck yoke" that is mounted *inside* a 21-in. color CRT. Developed by researchers at Southeast University, Nanjing, People's Republic of China.
- A three-layer anti-reflective anti-static screen coating that is less expensive to apply than traditional coatings, which require chemical vapor deposition or physical vapor deposition. Developed by researchers at Chunghwa Picture Tubes, Taiwan.
- A new color-CRT design that employs a striped-phosphor-screen construction and a super-fine slot-type shadow mask in conjunction with an optimized electron-beam configuration. Currently in production. Developed by NEC Kansai, Ltd., Shiga, Japan.
- A 15-in. screen that reduces monitor power by 10% by using a CRT optimized for 20-kV operation. Developed by Philips Components BV, Eindhoven, The Netherlands.
- A CRT using an elliptical-aperture dynamic-focus electron gun and a horizontal mask pitch of 0.22 mm. Developed by Hitachi, Tokyo, Japan.
- A 24-in.-diagonal widescreen Trinitron® tube and a multi-scan monitor that can be switched between widescreen (16:9 aspect ratio) and conventional (4:3 aspect ratio) modes. Developed by the Sony Corporation, Tokyo, Japan.

Computer Displays: A Strong No. 2

Displays for computers have been able to use refined versions of TV picture tubes since the beginning, and this relationship still seems to work. Computer displays give the CRT maker an early start on developing technologies such as the fine-pitch masks and higher-resolution electron guns needed for future television tubes, while experience with television makes it possible to provide the computer-display maker with a product that is more mature in areas such as colorimetry and visual image quality.

"The one basic thing is reduction of cost," said Sony's Tei Iki. If one tracks color-CRT cost and price erosion, performance keeps getting better but cost is declining. Right now, monitor requirements are getting closer to TV's. If one were to track the cost per pixel of color CRTs, one would see a dramatic improvement. A lot of CRT R&D is not glamourous but a matter of survival!

"My opinion is that the requirements for R&D are different in various regions. [For example,] the absolute-flat CRT is very popular in Japan, but the jury is out in the U.S. People are working on absolute-flat CRTs – 16:9 is the direction for high end. Whenever something like that is done, performance gets more difficult. Although these are incremental improvements by themselves, [they become] substantial when [they are] all put together. [For example,] corner focus must be okay without increasing the size of tbe CRT. [Now] that video clips [are being shown on] monitors, more brightness [better cathode performance] is needed. [With] multimedia, many formats – [such as] bright video clips, legible small characters, and graphics – get displayed on the same device, without distortion on a flat face.

"PC customers don't care how hard this is and don't want to pay either. The aperture-grille structure has merit for information density and uniformity, but part of the cost is the damper wire. Workstation people understand physics [and the cost of providing performance] but PC customers say, 'that's your problem.' [Although the business is difficult,] people are still investing in CRT capacity [for a very basic reason:] the cost/performance of the CRT really can't he beaten because it's a moving target."

Iki would also like to see more emphasis on understanding the display needs of end users. One of the industry's problems, he says, is that LCD people describe the merits of LCDs *vs.* their perception of CRTs. Meanwhile, each technology progresses. "Analyzing the merits of types of displays – LCDs, FEDs, CRTs – needs attention in a more scientific way," said Iki. "I hope to do some of that, maybe working with a university."

Niche Markets – and a Few Question Marks

Instrumentation provides a special applications environment for CRTs, in which the CRT itself can be a part of the measurement system. Although such applications have been significantly diminished by the growth of fast digital signal-processing electronics and compact display panels, some types of measurements, particularly in nuclear instrumentation, still need the very high speed and sensitivity that a CRT can provide.

A few years ago – before the development of high-quality flat-panel displays (FPDs) – the CRT was a contender for systems to be used in automobiles. Navigation and status monitoring could be done by computer, with visual output on a display somewhat like that used in aircraft.

But the market opportunity appears to have passed by. Although some CRTs were used in cars up to about 1992, it will be FPDs – not CRTs – for autos from now on, predicts Robert Donofrio, principal at Display Device Consultants (Ann Arbor, Michigan). And FPDs have made big inroads in the truck industry for GPS and driving aids, he said.

Thomas Electronics

Fig. 1: The CRT projector provides a combination of favorable cost and high image quality well-suited for displaying video. This is a recent high-brightness 9-in. model.

While CRTs continue to serve an important subset of projection-display products, much of the market growth appears to be fueled by new light-valve technologies. Although a projection CRT derives its basic form from direct-view types, it requires much more attention to high-power attributes - brightness, life, screen burning, safety, and cooling - that are not normally as severe as in other CRT applications.

Planar Advance continues to deliver avionic CRTs in accordance with existing contracts, but isn't doing anything in R&D. "We have [CRT] production problems that we have to fight down, but all of our new efforts are flat panels," said Tom Long, Director of Programs at Planar Advance.

But special CRT applications abound. Clinton makes a CRT with a window on the back of the funnel. "Then we affix sensors and circuits to report screen luminance," said Don Hirsh of True Image (St. Louis, Missouri). "We can make a measurement that is exactly proportional to total screen luminance. When the gun is turned off, the measurement reports ambient light falling on the screen; thus [we can measure] contrast. I hope that our principles work out for hi-res monochrome/medical applications. They may also apply to color applications."

Projectors using CRTs have been squeezed by serious competition from high-light-output light valves at the high end, and from low-cost LCD products at the low end. But the CRT projector is still a serious competitor in the middle, where it provides a combination of favorable cost and high image quality well-suited for displaying video (Fig. 1).

There is still money being put into projection-CRT technology. According to Clinton Electronics' Ken Compton, CRT-based units provide format flexibility for both the business and entertainment industries. Although the market for projection-TV sets with 4:3 aspect ratio is flattening, the potential exists for HDTV/wide-aspect-ratio projectors as new DTV standards are introduced. Increasing the standard from 4:3 to 16:9 would force the adoption of larger projection CRTs and changes in gun design to meet brightness and resolution needs, Compton said.

Medical imaging - another growing market for CRTs - is forcing continued improvement in image quality in large monochrome tubes. Higher resolution, freedom from screen defects, and better-defined spots are needed for medical applications such as mammography. With images that commonly exceed 4 million pixels, detectable defects - in the 3-15-mil range - are a big factor in CRT yield. "If the same standard were applied to TV, you couldn't afford it," said Compton. Anything that will reduce screen defects is important.

The synergy between projection and medical applications may benefit R&D programs for better electron guns and improved yoke performance. "Projection and medical imaging are looking for the same things," said

Compton. "They complement each other. Both need to deliver a good beam at high beam currents. We are accustomed to using 29-mm necks on projection CRTs, even on high-output 9-in. types. Adoption of wide-aspect-ratio TV images will force CRT neck sizes up to 36 mm," he said. "We are now seeing improved deflection yokes for 36 mm with equivalent performance to 29 mm."

Thomas Electronics is one of several manufacturers of CRTs for avionic displays, medical monitors, photo-imaging products, projectors, and other specialized applications. "We are still dealing with tradeoffs among efficiency, geometry, and phosphors. CRT R&D is very incremental," said Doug Ketchum, Thomas VP and head of R&D. "From what I've seen, prices have been flat year after year. Yields are up, the industry has been healthy, and players who are in for the long haul are still adding capacity."

The growing use of digital technology in photography is expanding opportunities for the CRT. Digital images abound, coming from digital cameras or scanners. CRTs can be used in scanners, and they can also be used to print images to film. "The CRT offers the best price-performance relationship for photo imaging," according to Ketchum.

The CRT is the dominant technology and is getting wider application in such places as photo booths and high-volume mini-labs. The same people who provide paper/film transfer through the optical path are now looking at digital exposure. The monochrome CRT that is used in digital imaging is generically like a projection CRT except for lower writing speed. Cost is a tradeoff, but the CRT is a plus where photorealism is important.

Similar R&D applies to projection and film recording, including phosphor (colorimetry), match to film, speed, accurate geometry, high brightness, and uniform exposure. "Tradeoffs relate to efficiency, geometry, phosphors...," said Ketchum. "CRT projection still is important. There is nothing tremendously new and exciting, yet the dominant market is still CRT-based."

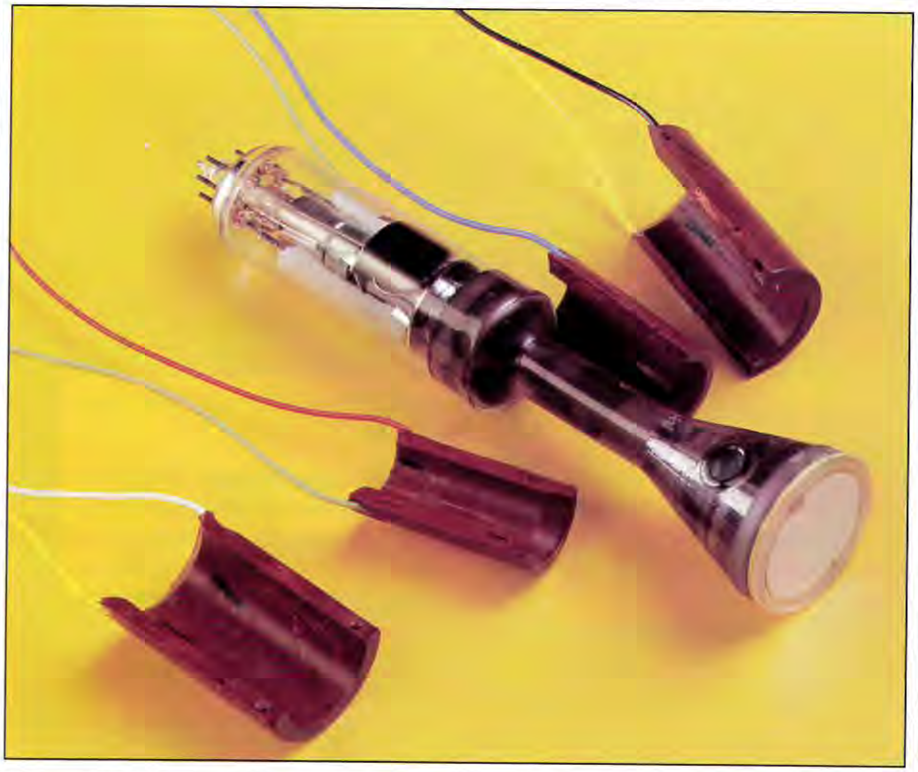

WinTron, Inc.

Fig. 2: A recent innovative CRT development is the neck-down CRT, which seems to provide the best of two worlds: the neck diameter is large in the focusing region to help spot size and small in the deflection region to minimize power.

Tiny CRTs are important too. "We are very busy with up to two CRTs for head-mounted displays used for flight simulation [an alternative to dome projectors] and for cockpits. High brightness [is needed] in cockpits for full daylight viewability," said Ketchum. "We will do anything to take weight out of the helmet. We try to minimize weight and physical diameter.

"Power is also a concern, particularly for field-sequential-color systems that must operate at very high horizontal scanning rates. We are trying to get 1000 lines - a spot size of 15-18 μm - which requires the largest possible focus lens. But as the tube gets smaller, focus lenses get worse," said Ketchum.

"The only thing that strikes me as unusual [in CRTs today] is the neck-down CRT used with a clamshell yoke," said historian Keller. Developed by yoke-maker WinTron, the special clamshell yoke and a CRT that has a stepped-down neck area (see *Information Display,* November 1997) achieve the best of both worlds, since the neck diameter is large in the focusing region to help spot size, and small in the deflection region to minimize power (Fig. 2).

"We are also busy with large sizes for use in medical imaging," said Ketchum. "For me, the key will be applying color technologies such as dynamic astigmatism and tube-coil matching to monochrome products. There is interest in 23-25 in. for full-chest x-rays, using projection-like gun technology. The challenge is lots of brightness and contrast, which means big 36-mm necks and high-current guns. The [medical] business is getting more real now," said Ketchum. "In the longer term, it will migrate the same way as other CRTs to offshore manufacturing."

Into the New Millennium

While new technologies threaten the CRT in all of its major applications, there seems to be a common view that the useful life of the CRT will extend well into the next century. The big bucks are still in entertainment applications, with computer displays running a strong second. Unfortunately, there do not appear to be any new CRT applications that could come forward to pick up the slack.

The CRT as we know it will eventually go away - but not soon. Continuing R&D expenditures will ensure that the venerable CRT continues to be a moving target for competing display technologies well into the future. ■

conference report

News from Toronto: The First "Glass Chassis" May Not Be Glass

The IDRC in Toronto was a solid research meeting with only a few surprises, but those surprises were aces.

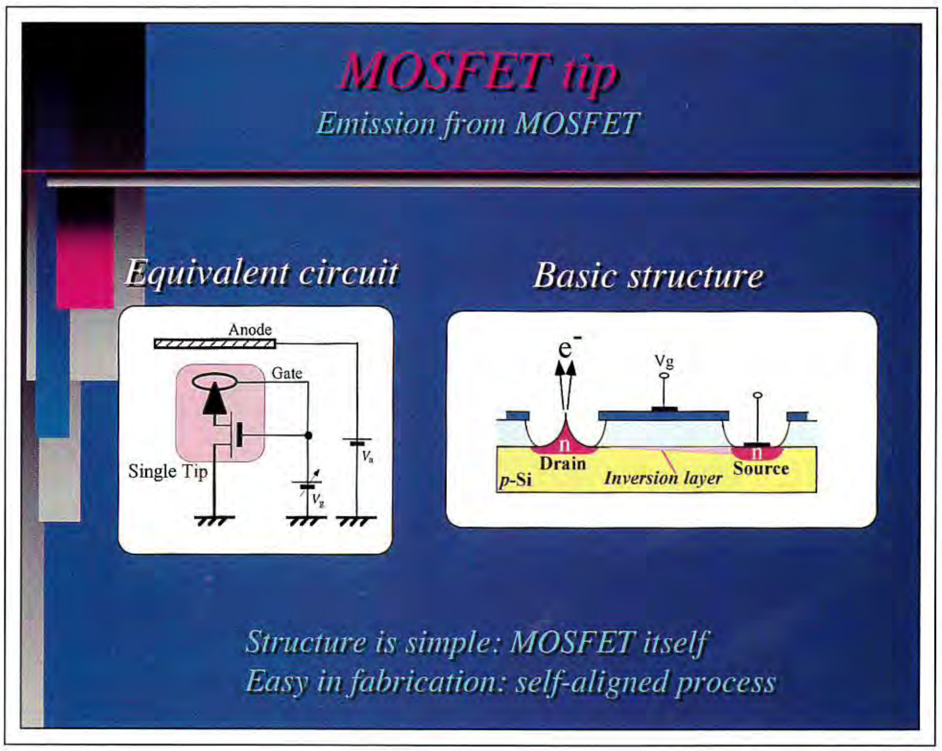
by Ken Werner

IT WAS THE LAST PRESENTATION of the 17th International Display Research Conference and its associated International Workshops - held September 15-19, 1997, at the Sheraton Centre Hotel in Toronto, Canada - that packed the biggest punch. Late in the morning of Friday, September 19th, Junji Itoh and Seigo Kanemaru of The Electrotechnical Laboratory, Ibaraki, Japan, presented their paper, "An Intelligent Field-Emission Display Based on a New-Generation Field-Emitter Array," as part of the Invited Symposium on FEDs.

Itoh and Kanemaru described an intelligent FED (*i*-FED), in which an n-type silicon emitter tip is fabricated on the drain of an otherwise standard MOSFET (Fig. 1). The MOSFET gate then acts both as a conventional extraction gate and as an FET gate controlling the drain current supplied from the source to the tip through the inversion layer. The result is a dramatic improvement in emission-current stability both over time and spatially over the tip's surface, as shown in a videotape demonstration. And the MOSFET tip maintains current stability in a far less rarified vacuum than do conventional silicon tips - 10^{-5} torr rather than about 10^{-8} torr.

Extensions to the MOSFET structure make things even more interesting. Add a second gate to the MOSFET, and a control voltage V_c applied to that second gate can determine the saturation current through the emitter as V_g increases. With such a dual-gate MOSFET tip, the emission current can be fully controlled by a voltage of less than 20 V. If the typical control voltage drops from 50 to 10 V (a factor of 5), the power consumption in the drive circuitry can drop to as little as 4% of its original value. (In today's FEDs, about half the power is consumed by the drive circuitry; the other half goes to accelerating the electrons emitted by the tip so they can excite the phosphors.)

Extend the MOSFET to a three-gate structure and things get more interesting yet. The voltages on the three gates are V_c, V_x, and V_y, and the tri-gate MOSFET acts as an AND gate: the tip emits electrons only when both



Electrotechnical Laboratory

***Fig. 1:** In an "intelligent FED," an n-type silicon emitter tip is fabricated on the drain of an otherwise standard MOSFET. The result is a dramatic improvement in emission-current stability.*

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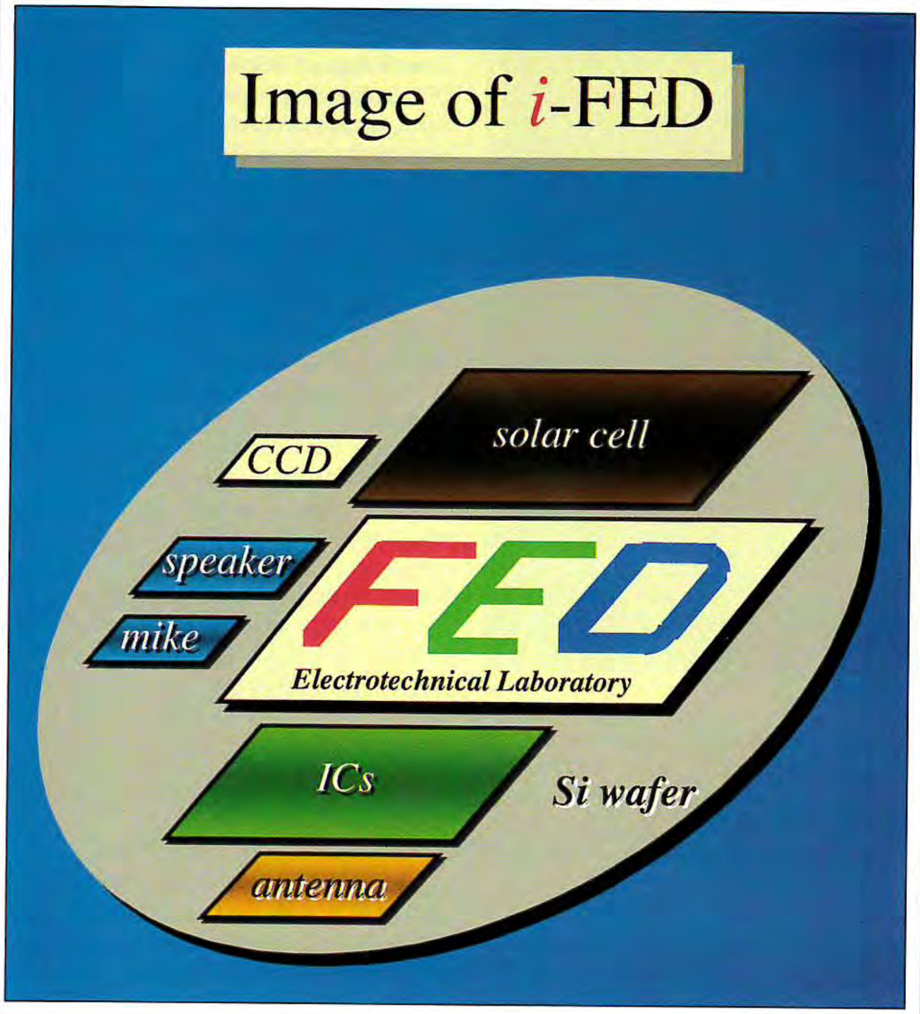


Electrotechnical Laboratory

Fig. 2: A three-gate MOSFET emitter tip functions as an AND gate and permits the MOSFET tip to be directly connected with other TTL devices. Such a device can be monolithically integrated on the same silicon substrate to make a fully integrated system.

the x and y signals are positively biased. This permits the construction of an active-matrix FED and lowers the voltages V_x and V_y to TTL-logic levels.

This not only reduces power consumption compared to conventional passive-matrix FEDs using metal-tip field-emitter arrays (FEAs), but it also permits the MOSFET tip to be directly connected with other TTL devices such as CPUs and memory. These devices, along with solar cells, CCDs, and speakers and microphones (with the help of micromachining), can all be monolithically integrated on the same silicon substrate (Fig. 2).

The authors noted that such a display would be limited by the sizes of standard silicon wafers, but implied that there were many applications for integrated systems with a 5-in.-diagonal display or less. Even without integration with other components, MOSFET tips would give FEDs a substantial power advantage over AMLCDs - an advantage they do not enjoy today.

In the lively Q&A session, Peter Brody of Active Matrix Associates congratulated the authors "on a brilliant piece of work," and asked if the authors were suggesting that *i*-FEDs would use single-tip pixels. "No," answered Itoh, "but because they are more regular, we can use many fewer: tens rather than thousands."

Fred Kahn of Kahn International (and the General Chair of the conference) asked if polysilicon could be used. The answer was that the logic could be implemented without doping of the bulk material, but with the greater device sizes necessary with polysilicon, "the high-level intelligence capability would be sacrificed."

For many of the approximately 50 people in the room, it was clear that the developments described in the paper were a significant surprise. When *Information Display* commented on this to a knowledgeable person, his response was that although the developments had been kept confidential, several other laboratories were also working on these ideas and that a product based on them could be available very shortly.

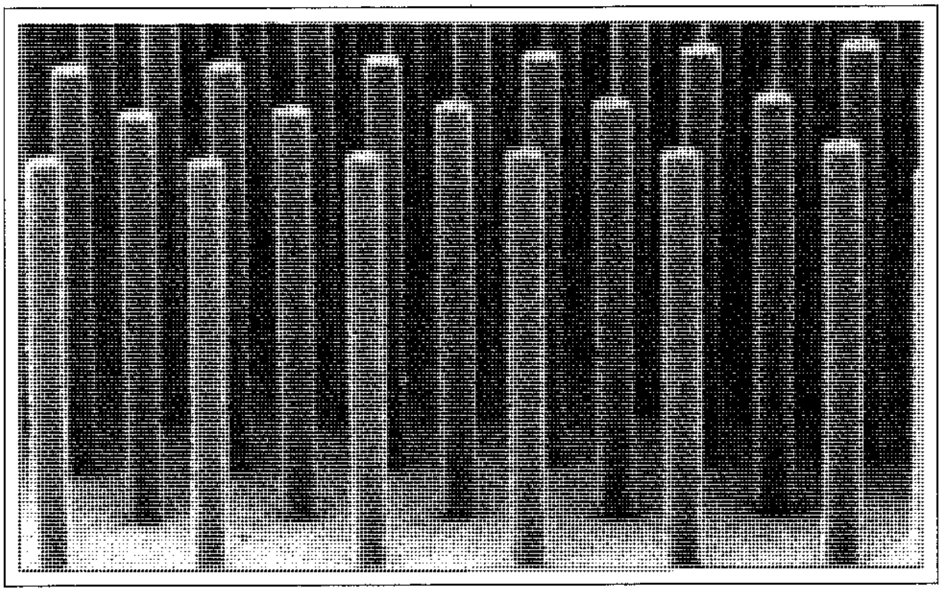
FEDs Sally Forth

In fact, the small Invited Symposium on FEDs provided more than its share of interest, even though only four invited papers were scheduled. (Raytheon withdrew its lead-off paper on high-voltage, high-brightness FEDs, and Chris Summers of the Phosphor Technology Center of Excellence filled in with a talk on phosphor developments.)

Robert Smith, Manager of Electronics Development for Motorola's Flat Panel Display Division, Tempe, Arizona, discussed "Drive Approaches for FED Displays." Two of the challenges are that drivers must go to about 2 cents an output to compete with LCDs and that it's hard to make a small, cheap 5000-V power supply.

Today's FEDs use a resistive layer to protect the emitter tips by preventing current runaway and to help attain increased emission uniformity. The ballast sets the current, so a ballast must be picked that provides enough current for the desired luminance at practical voltages. That value is not generally high enough to effectively enhance emission uniformity by feedback.

Smith noted that the row connections of an FED are typically connected to the extraction gates, while the columns are the cathode connections. During each row-select period, intensity information is communicated to the pixels through the column drivers, and there are several techniques for doing this: amplitude modulation (AM) of either voltage or



Micron Display Technology

Fig. 3: Micron Display Technology has fabricated glass-post spacers 350 μm tall and 25 μm in diameter. These posts have been attached to the anode in the black-matrix region of the display, where they do not interfere with the display image.

current; pulse-width modulation (PWM) of voltage, current, or a combination of the two; and a combination of AM and PWM. Smith described grading criteria and applied them to the various drive techniques. He concluded that some form of PWM voltage drive is best suited for today's cathode technology, but in the long run an AM-current drive approach is likely to offer an optimum combination of power consumption and display uniformity. However, problems with pixel defectivity must be solved first.

During the Q&A period, Smith was asked if he bad observed differential aging in FEDs. His answer was succinct: "We've observed it. We're not far enough along to worry about it. It's going to be a problem."

In the other FED Symposium paper, J. Browning and a group from Micron Display Technology (MDT), Boise, Idaho, discussed the issues involved in scaling FEDs beyond 10 in. on the diagonal. Micron has fabricated 14-in. baseplates using chemical mechanical polishing, and has packaged 12.1-in. baseplates in spacerless packages. MDT is currently fabricating 12.1-in. color XGA displays, but the most interest was generated by the authors' description of their glass-post spacers.

MDT has adopted the "medium voltage" (2500 V) approach to FED design for acceptable phosphor efficiency without the need for a focusing electrode. This voltage requires spacers greater than 375 μm tall. MDT has fabricated glass-post spacers made from glass fibers, which are attached to the anode in the black-matrix region of the display, where they do not interfere with the display image. The authors showed a photomicrograph of spacer posts 350 μm tall and 25 μm in diameter (Fig. 3), and another photomicrograph of posts 2400 μm tall and 40 μm in diameter. An array of 70,000 350-μm posts were tested under compression, and supported 1450 lbs. before failing. The authors stated, "The post-application process is self-aligning, and the posts can easily be placed on any size display, including sizes of 60 in. on the diagonal." The authors did add that the run-ont for very-large high-resolution displays is a concern.

In the Q&A, Ernst Lueder of the University of Stuttgart asked how the authors fabricated the spacer posts. Browning's answer: "I can't tell you." Motorola's Bob Smith asked if the posts were bulk-conductive or coated. Browning: "We're looking at a variety of approaches, but we'll probably coat."

Information Display: "When do you expect to have an operating panel with spacers?"

Browning: "I can't answer."

Privately, an MDT executive has told *Information Display,* "We've solved the spacer problem."

First Commercial OEL Display Announced

Teruo Tohma of Tohoku Pioneer Electronics' OEL Engineering Division in Yamagata, Japan, discussed recent progress in developing a dot-matrix organic electroluminescent (OEL) display module. A prototype module has 256 × 64 dots, a luminance of 100 cd/m^2, a CR of greater than 100:1 at 500 lux ambient, and emits in the green. Modifications to the driver ICs permit a four-level gray scale and 32-level dimming despite the display structure's parasitic capacitance.

The prototype was demonstrated publicly at the conference for the first time, and Tohma announced that a commercial version would be introduced in October in a Pioneer car audio product. Seminar Chairman Ching Tang, whose path-breaking 1987 paper initiated OEL development, congratulated Pioneer "for developing the first commercial OEL display."

In their paper on integrated organic light-emitting-diode (OLED) structure using doped polymers, J. C. Sturm and C. C. Wu of Princeton University commented that the heat generated in OLEDs is large and polymers are thermally insulating. It is therefore possible to literally melt a display in the pursuit of high luminance.

During the break, Roger Stewart of Sarnoff Corp. noted that there's a two-order-of-magnitude difference between basic OEL luminous efficiency and overall system efficiency, so there's a lot of work to be done.

LCDs

Shin-ichi Hirano, recently retired from IBM Japan, led off Monday's Invited Symposium on AMLCDs by describing the expected requirements for TFT-LCD performance and production processes in 2005, relying heavily on the conclusions of the UCS TFT-LCD technical committee. Hirano observed that the current 10–13 deposition layers must be reduced to 7 or 8. "We must exchange our complicated Big Mac hamburger for a simple ham-and-cheese sandwich."

The UCS committee has recommended a standard substrate size of 960 × 1100 mm, which is probably as large (or larger) than manufacturing engineers would want to handle, and which would efficiently accommodate displays of the sizes consumers are most likely to want, from 40-in. 16:9 displays 2-up through 19-in. 4:3 displays 8-up to 12-in. 4:3 displays 16-up.

In processing, the average time for a process step must be reduced from 60 to 90 sec per display to 30–45 sec. Such a requirement is non-trivial. In the case of a resist coater, it implies high speed and acceleration that would require a 50-kW servomotor to attain!

One aspect of display performance that requires improvement is a basic one: TFT-LCDs can not match CRTs in displaying NTSC television.

Because of the high cost of realizing its program and because of the need for international agreement on standards, the UCS committee is proposing to the Japanese Government that a Japanese and international consortium be formed.

In "Single-Crystal Silicon for High-Resolution Displays," IBM's Paul Alt predicted that the rapid change in display formats will slow because XGA is a good solution for many current applications, but ultimately we will need more pixels. Alt made a careful argument, concluding that projection displays based on reflective light valves with single-crystal backplanes should be very strong contenders for a variety of applications. There are difficulties, but marvelous displays are within reach, "such as multi-megapixel displays illuminated with solid-state lasers for detail and color never seen before in an electronic display… . Lasers will allow small silicon light valves to be illuminated efficiently."

Alt described and showed photos of a prototype 20 × 20-in. 4-Mpixel rear-projection monitor. The monitor uses a 100-W arc lamp, and the pixels have an aperture ratio of 82%. The light reflected from the three 1.94-in. light valves produces 100 pixels/in. and an average luminance of 100 cd/m^2 on the low-gain surface-diffusion screen, for images that have far more impact than the numbers might suggest.

Alt predicted that x-Si and OLEDs would be a very powerful combination.

Six authors from Lawrence Livermore National Laboratory led by Paul Carey announced the fabrication of polysilicon TFT-LCDs on low-temperature plastic substrates, a trick performed by using pulsed-laser processing that kept deposition temperatures to 100°C or less. The authors reported channel mobilities up to 7.5 cm^2/V-sec and I_{ON}/I_{OFF} current ratios up to 1×10^6. The talk began with an acknowledgment of Peter Brody's early work at Westinghouse, in which CdSe TFTs were fabricated on a variety of flexible substrates.

Ken Werner

The 17th IDRC was held at the Sheraton Centre Hotel in Toronto, Canada.

Hiroyuki Mori of Fuji Photo Film and Phil Bos of the Liquid Crystal Institute at Kent State University discussed the applications of negative-birefringence films, which "will be a key optical component in future LCDs to obtain a wide viewing angle." The authors propose using a pi-cell with a discotic film - a liquid crystal with negative birefringence that has been polymerized to form a film. This combination provides excellent viewing angle and optical response that is fast enough for full-motion video. (Pi-cells are ten times as fast as TN-mode displays, the authors said.)

David Wortman described 3M's reflective-polarizer technology. The company's dual-brightness enhancement film (DBEF) passes light of the proper polarization and reflects the rest. When the DBEF is used in place of the standard rear polarizer in a backlit LCD, the reflected light then reflects off the walls of the backlight cavity, its polarization becomes randomized, and - after a few iterations - a large percentage of the light passes through the polarizer. In this and other applications, the film can be used to make displays brighter and more efficient.

In the lively panel discussion that concluded the AMLCD Symposium, Paul Alt asked, "why put a system (or part of it) on glass?" And answered his own question by: "… to reduce the number of wires to the display panel." But you can't put something as complex as a Pentium processor on the glass. "For fully integrated systems, the display-on-silicon makes more sense."

Roger Stewart added, "You can also reduce bandwidth to the display by putting MPEG or Firewire on the panel.

Webster Howard (FED Corp., Hopewell Junction, New York, and President of the Society for Information Display): "Yes, but chip-on-glass is the way I'd go."

Roger Stewart: "If you want it large you do it on glass. That's what's making life interesting. There's a real place for each approach."

Paul Alt: "Polysilicon may have advantages over reflective silicon-backplane displays in VGA middle sizes… . With very large displays poly-Si won't work, and with very small displays the aperture ratio is too small."

Color EL … Again

Also on Monday, the Westaim Corporation of Calgary, Alberta, Canada, held an elaborate press conference at the Sheraton Centre to announce the development of a stable blue EL phosphor and demonstrate early-prototype full-color EL displays using the phosphor in conjunction with the company's thick-dielectric electroluminescent (TDEL) display technology.

Westaim has been using its TDEL technology to produce nice alphanumeric modules and small graphics displays. The development touted in Toronto was real enough, though overhyped to the apparently receptive audience of Canadian stock analysts and (mostly young) Canadian business reporters. (An uncritical report appeared the next day in the business section of the *Toronto Globe and Mail.*) The few old display hands in the audience, however, asked questions of the engineers and muted their praise.

Westaim is pursuing the color-by-white approach for EL that was pioneered by Planar. The new phosphor is used to pump up the blue output of the company's broad-spectrum mix. But the white-area luminance is currently only 30 cd/m^2, with the blue component only 3 cd/m^2. The quarter-VGA prototype units were shown in subdued light, and the blue was obviously dark. But Westaim expects to double the luminance in 3–4 months, said developer Jing Way.

TDEL is not a high-resolution technology. The full-color pixel pitch on the prototypes was 0.45 mm, which Jing Way said would come down to 0.30 mm. This is good enough to enable the company to make a 10.4-in. (or larger) VGA display, which it intends to do over the next 12 months or so.

Applications Engineer Don Carkner said that the panel's 140-V drivers don't produce enough current to drive the displays fully. Arranging for driver manufacturers to produce higher-current drivers would double the luminance, he said. "We haven't done anything [yet] on optimization of layer thickness, and that should be good for another factor of 2. If we got a reliable desktop monitor with 100–150 cd/m^2 we would go to market." Westaim CEO Kevin Johnson said that he did not expect the technology to produce revenues until at least 1999.

Technical-Program Highlights

The core IDRC technical program opened Tuesday morning in Cinema I, a remarkably shabby movie theatre in a subterranean level of the Sheraton Centre Hotel. A. Lien and his associates from IBM led off by recommending a soluble polyaniline derivative with a conductivity of hundreds of S/cm as a viable replacement for ITO on the TFT-array side of AMLCDs.

R. Saxena and a group from Rockwell Science Center described a compensation system for normally white automotive STN-LCDs using positively birefringent, uniaxial, in-plane, and obliquely oriented retardation films instead of conventional film compensation. The system produces a display that is useable over a temperature range of -27°C to +85°C.

The last paper before lunch made many audience members forget their hunger pangs. Tatsuo Uchida and his colleagues from Tohoku University, Sendai, Japan, described and demonstrated a field-sequential-color (FSC) AMLCD using an optically compensated bend (OCB) cell (pi-cell). The OCB cell exhibits gray scale and switches with a response time of less than 3.5 msec – more than ten times faster than a TN cell, and fast enough for full-motion video with FSC.

This structure has several advantages:

- Needs no matrix color filter (MCF).
- Has five times the transmittance.
- Does not need precise alignment of filter and TFT plate.
- Has only one-third the number of subpixels and drivers of a traditional AMLCD.
- Is good for moving images.
- Has a wide viewing angle.

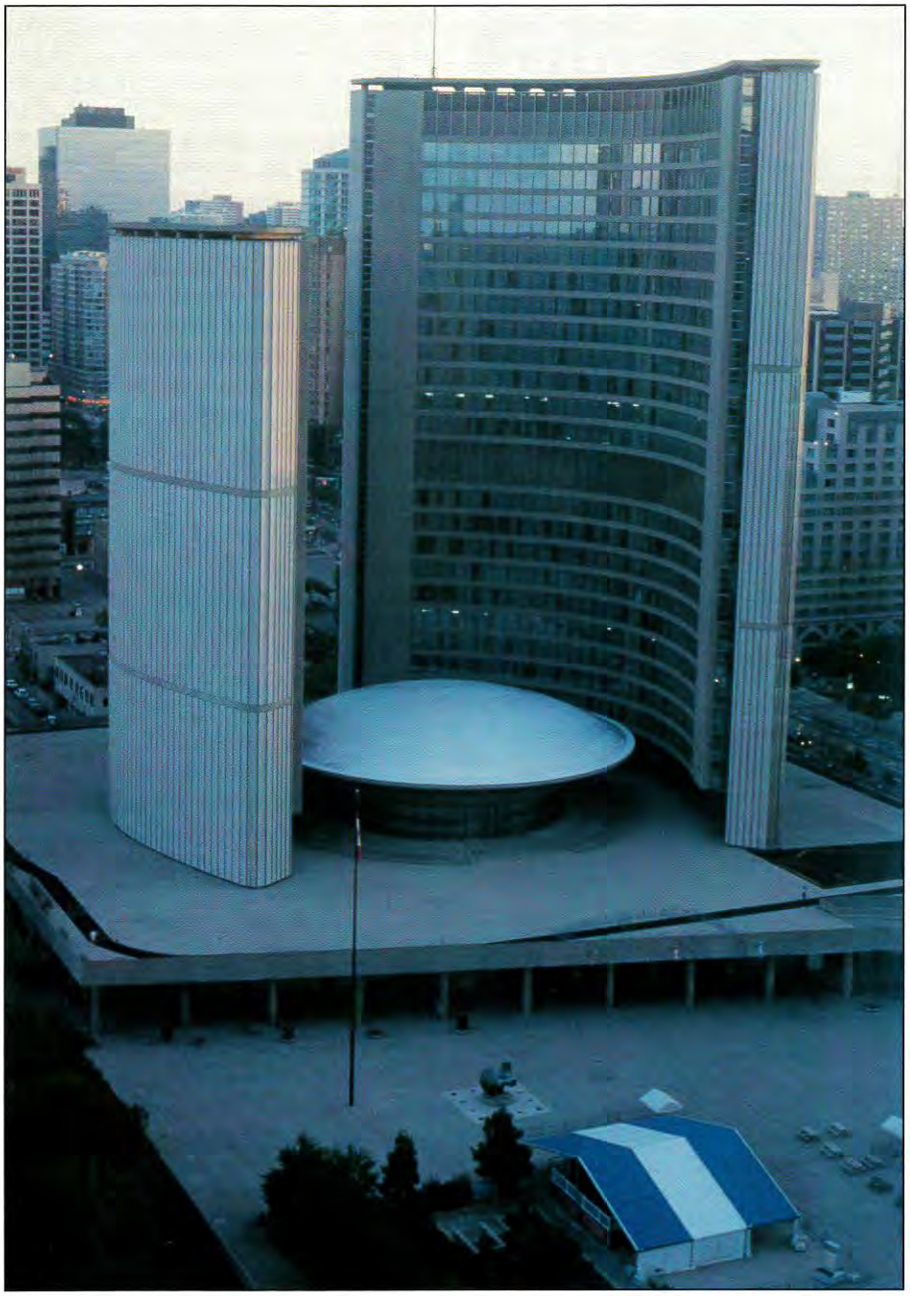
The demo units showed nice color and good viewing angle.

The driving scheme for the display, called Dynamic Excite Drive (DED), was developed by Bright Lab. Co., Ltd., of Tokyo, Japan. Masaya Okita, Executive VP and CTO of Bright Lab, told *Information Display* that DED improves the response time of many types of LCDs by a factor of 10. He showed me an FSC STN display exhibiting a changing pattern of color bars. The original response of the display was 85 msec; with DED it was 8.5 msec, he said. So, he said, DED allows video-rate FSC from AMLCDs as well as OCB cells, and color graphics from STN-LCDs.

The elimination of the MCF improves the luminous efficacy of a typical notebook AMLCD to 0.5 lm/W, Okita said, and the elimination of the need for precision assembly

Ken Werner

Unlike most North American cities, Toronto never abandoned its streetcars.



Ken Werner

Toronto's award-winning City Hall represents the world protected by God's hands. The design funnels the (relatively) warm south wind past the building's windows while blocking northerlies.

means "manufacturing can be done anywhere, not just Japan." He made a point of telling *Information Display* that the STN panel he was demonstrating "was not made in Japan."

Bright Lab is establishing a U.S. subsidiary to manage licensing, and, added Roland Tseng, Bright's VP of Worldwide Marketing, there is substantial licensing interest from major companies.

Back to the IDRC technical session in Cinema I. H. J. Kim and his colleagues from Samsung Electronics' Advanced Technology Group, Kiheung, Korea, described a full-color 2.3-in. projection AMLCD panel with low-temperature polycrystalline TFTs *and fully integrated driver circuits.* Multiple-pulse excimer laser scanning was used to anneal the silicon. The 16:9 panel has 720 × 3 × 464 pixels of 23.5 × 61.5 μm, a CR of 150:1, and a pixel aperture ratio of 60%. Commercial availability: 1999.

In the poster session, N. Ishimaru and a large team from Asahi Glass presented the production technology for making inexpensive color matrix filters by pigment ink-jet printing. The large cluster of people around the presenters, along with their favorable comments, was an indication of this paper's potential significance. The fundamental technology was described in a companion paper by Y. Nonaka and associates in one of the "sit-down" sessions.

Canadian Showcase

The organizers arranged a showcase of Canadian display technology that intentionally did not focus on end-user products. McMaster University showed hybrid EL/LED modules for an "electronic poster" intended for sign and advertising applications. The modules consist of a traditional yellow ZnS:Mn.

EL phosphor in front of red and blue LEDs was used as backlights. Common viewer reaction: "I never would have thought of that."

Westaim showed its full-color EL prototype on the first day; Litton Canada showed its military/aerospace LEDs and the world's only commercially available CdSe LCD; and Computing Devices Canada showed its military systems with thin-film EL displays.

Projector and monitor maker Electrohome showed its ShowStar LCD optical system and ALON automatic convergence system for CRT projectors. Also on display was an optical "brightness equalizer" that keeps luminance fall-off in the corners of a projection display to less than 20%.

Featured Speakers

In the keynote address on Wednesday morning, Planar's Jim Hurd reviewed his company's long and painful path to success. Founded in 1983, the company was not firmly profitable until 1990. The six years of deficits "left a scar I will never forget," said Hurd. But with 1997 revenues of $90 million, it is safe to say that success has come.

"Planar is living proof that there is more to displays than just PCs and tanks," said Hurd. "The new applications for displays seem endless." And "there is no best display technology. We must be aware of particular characteristics of a display technology and only sell to customers who need those characteristics for their applications."

In a special plenary invited address, Yoshito "Super" Yamaguchi, Senior Managing Director of Mitsubishi Electric Corp., gave the presentation "Large Screen Displays: Past, Present, and Future." (Yamaguchi earned the nickname "Super" when he took over U.S. sales of Mitsubishi projection TVs from an ineffective U.S. distributor in 1974 and ran $10 million in sales up to $1 billion.)

Mitsubishi's first CRT stadium display was installed in Dodger Stadium in Los Angeles. The luminance was 1000 cd/m^2; there were 192 dots by 128 lines; the screen dimensions were 8.64 m (H) and 5.76 m (V); and the pixel pitch was 45 mm. Mitsubishi's cost for the display was $3 million, but the company sold it to the Dodgers for one dollar! The company's latest stadium display has been installed in Nagoya Dome in Nagoya, Japan. The luminance is 3000 cd/m^2; there are 1792 dots by 512 lines; the screen dimensions are 35.84 m (H) and 10.24 m (V); and the pixel pitch is 20 mm.

There is now substantial interest in outdoor full-color LED displays thanks to Nichia's development of bright blue diodes with high luminous efficiency.

In the area of indoor displays, Mitsubishi will soon have a 46-in. 16:9 PDP with 1280 pixels × 1024 lines for a pixel pitch of 0.79 mm (H)/0.58 mm (V). The "engineer's dream" for the future and target for Mitsubishi is a 100-in. or more display with 4000 × 2000 pixels, a pixel pitch of 1 mm or less, and a luminance of 1000 cd/m^2 or more.

In answer to a question from the floor, Yamaguchi said, "CRTs and PDPs will be the main displays in the home."

Novel and Reflective

The session on "reflective/novel" LCDs opened with a presentation from Kent Displays on its new multicolor, reflective, surface-stabilized cholesteric LCD (Ch-LCD). The display stacks two standard Ch-LCDs to produce four colors. Next will be a stack of three to produce eight colors. A 100-dpi 1/8-VGA prototype shown in the author interviews looked better than the 4:1 CR spec might indicate. Three of the company's goals, said D. Davis and his co-authors, are a 4-stack 16-color Ch-LCD, gray scale, and plastic substrates.

Yashuo Kawata and a team from Toshiba reported the fabrication of a double-layer Ch-LCD that incorporates one LC layer with right-handed helicity and, on the other side of an internal separator, another layer with left-handed helicity. The result is a much brighter display because it reflects incoming light with both left and right circular polarizations, instead of just one.

Tony Lowe of IBM Greenock and Masaki Hasegawa described a novel double-cell guest-host (DGH) nematic display. The structure comes the closest yet to an ideal reflective, quasi-lambertian display for reading text that would have a white-light reflectivity of 0.6 or more, a CR of about 10:1, and a wide viewing angle at high resolution without parallax effects.

K. Klein of the Cambridge University Engineering Department and a team of authors from Screen Technology Ltd. and Merck Ltd. described a novel photoluminescent cholesteric display. In a standard PL-LCD (see *Information Display,* December 1997), an LCD gates the light from an UV backlight, which strikes an RGB phosphor screen in front of the LCD. The variation described in this paper makes use of the fact that the light from the backlight can be narrow band. The light valve consists of a cholesteric mirror and shutter that passes light through the homeotropic texture or reflects it by Bragg reflection from the cholesteric planar texture for a measured CR of 80:1.

Plasma Display Panels

M. Seki and a large team from NHK and Matsushita described developments in PDP fabrication that have made the development of a 42-in. HDTV DC-PDP prototype possible. To increase fabrication precision, the new process uses photolithography instead of screen printing for the main processes: forming the anode bus lines, insulating layer, resistors, phosphor, and barrier ribs. The result is a consistent and stable display with 1920 × 1035 cells and a lifetime of greater than 10,000 hours. Luminous efficiency is 0.4 lm/W and white area luminance is 150 cd/m^2. "A program to produce practical HDTV PDPs has been started based on these technologies," say the authors.

H. Homma and his colleagues in Shigeo Mikoshiba's group at the University of Electro-Communications in Tokyo, along with N. Kikuchi of Noritake, described a new drive scheme for ac-PDPs that extends the light-emission duty factor to 90% and the luminance

Ken Werner

Downtown Toronto mixes 19th- and 20th-century architecture.

to 650 cd/m^2 for HDTV panels. This Address-while-Displaying (AwD) scheme uses signal electrode resistance for an optimized erase pulse. The scheme requires no change in the panel structure, but it does require higher drive voltages. These, however, can be reduced by depositing wall charge.

The system inserts scan pulses between display pulses, requiring no extra address periods. The system can also be applied to dc pulse-memory panels.

In answer to a question from Fujitsu's Tsutae Shinoda, Mikoshiba explained that there was little benefit from using the new system with NTSC panels, but substantial benefit with HDTV panels.

Wrapping Up

"A striking trend of this meeting is the many papers on low-power reflective displays, including – but not limited to – cholesterics," said *JSID* editor Alan Sobel toward the end of IDRC '97. Add to that reports of the significant advances in fast LCDs, LCD compensation, silicon-backplane LCDs, and driver integration; the growing sophistication of the work in FEDs; and the steady march of PDPs toward HDTV-compatible resolution, and this IDRC goes down as one of solid progress – and a few exciting surprises.

It was also slightly larger, with 496 registrants, than the previous IDRC held in North America in Monterey in 1994, which drew 478. Conference Chair Fred Kahn announced at the plenary session that 161 papers were delivered, and for the first time at a North American IDRC, more than half were from Asian companies. The percentage from Japanese companies was down from 1994, however, and one paper in five came from companies located in Korea or elsewhere in Asia.

The next IDRC, Asia Display '98, will be held in Seoul, Korea, September 29 to October 1. ■

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

continued from page 4

computer after doing it all day at work didn't seem all that appealing.

The next morning, while having his breakfast cereal, Andy searched his on-line newspaper for interesting activities he might try to take in over the coming weekend. The weather prediction was for 20°C and mostly sunny – a great weekend for being outdoors. His electronic morning paper gave him the following events: several virtual-reality concerts that he could order on pay-per-view, a special sale at an on-line shopping mall, an on-line crafts fair with 200 booths that he could access from his computer, and a long list of movies, theater performances, and concerts that he could access on his HDTV home-theater-with-surround-sound entertainment system. He would have to make a choice – either go for a quiet hike in the woods or stay inside his living-module and shop or be entertained.

There would be no point in going into town. The center of town was virtually deserted on weekends. Because there were no stores, there were also few people and, consequently, most of the restaurants in the core office-building area were also closed on weekends. Once the workers left, it got real empty and desolate. Even the street people didn't like it anymore.

Andy felt an intense wave of loneliness sweep over him. After sitting in front of his computer screen all week at work, he didn't want to do it at home. He was tired of having to search for everything on-line and not being able to look at a real product before buying it. He wanted to go places and see people. He didn't want to watch his home theater anymore. He wanted to be part of something. Anything. How did the world end up in this electronic mess, anyway?

He was no longer just unhappy. He was heading for a serious depression. How could the Information Age prognosticators have been allowed to get control? How could they have been allowed to ignore what people want and need: to interact with each other? He wanted and needed to belong. He needed to be around other human beings. He needed to see, speak, and touch others like himself. He desperately wanted to rejoin the human race ....

Beep ... Beep ... BEEP BEEP BEEP! Andy's alarm clock just wouldn't give up. Andy turned instinctively, shut off the alarm, and sat momentarily confused on the edge of his bed. Whew! Was it only now that he was really awake? Just to make sure, he looked around carefully. Everything looked normal. My goodness, this dream had been just a bit too real.

After glimpsing this vision of a future that he now hoped would never happen, getting ready for work seemed unusually pleasant. He practically relished reading the morning newspaper while eating his cereal-with-milk-

and-banana. Driving to work, he made sure all the stores were still there and decided to set aside some extra time at lunch to search for that new CD. He also decided that he would take time after work to buy a book on a topic that he would select after browsing for just as long as he wanted. Maybe he would even take time to relax with a cup of latte and a piece of hazelnut torte at the bookstore coffee shop.

For the rest of that day and for several days after, he had moments when memories of his nightmarish dream gave him little jolts, like aftershocks from an earthquake. Maybe what made this dream stick so tenaciously was that it had been based on reading an article by such a well-known Information Age prognosticator. Why do these folks make such awful predictions, he wondered? Are they so technologically driven that they have no clue about why people really go to bookstores, or anywhere else for that matter? Do they not understand that people are not on this earth only to process information like computers? Do they not understand that we don't always know (or care) what information we want to experience next? And don't they realize that staring at the same computer screen for endless hours loses its charm?

All this wondering reminded Andy of one of his first experiences with taking information and using the computer to do the sorting and organizing.

This early experience had occurred about 15 years before, when the GUI was still a twinkle in a few clever people's eyes. Engineers were just beginning to explore the possibilities of localized workstations. Andy had been assigned the task of preparing a demonstration of how an engineer could take all the information normally stuck on a bulletin board above his desk and keep it well organized on his local computer.

Andy had first created the typical bulletin board by looking around at the ones his colleagues were actively using. Typical contents were phone messages, appointment slips, conference announcements, internal meeting notices, a few cartoons, maybe a family picture or two, perhaps a reminder of a project report that was past due, and other action items pertaining to technical project activities.

As for the photos and cartoons, he didn't know how to handle them with early 80s technology. In any case, he decided they were not essential to his demonstration. The rest he organized in a number of files that could be accessed and presented as separate screens. For example, one file would be for phone messages, another a calendar for appointments, yet another for upcoming conferences.

For his demonstration, he assembled a super-messy-looking bulletin board, about two feet by three feet in size, with samples of all these categories of information, and for comparison, had the same data neatly organized using his new multiple-screen computer program.

All of his colleagues and managers seemed properly impressed with what he had created, and he received many compliments on the appearance and usefulness of his new computer program. All, that is, except for one. This one manager kept looking first at the bulletin board and then at his computer screen and then back again. Finally, when everyone else had left, he sat down next to Andy and thoughtfully observed, "Andy, it seems to me that when I look at the messy bulletin board, I have near-instant access to all the information, and I can update anything I want with a quick jab of a push-pin. How quickly can I do the same on your computer screen? And Andy, I can't carry my computer everywhere I go. So, I use these 3 × 5 cards on which I write reminder notes to myself. Do I have to enter all this information on your computer to keep myself organized? And if I do, what is there to serve as a visual reminder for me, like the bulletin board above my desk?"

While the demeanor of the manager was caring and interested, Andy had to admit, at least to himself, that the computer probably did nothing to improve upon the speed or effectiveness of managing the data that one finds on a typical engineer's bulletin board. In fact, there were a number of disadvantages, such as portability, lack of instant overview, and the need for frequent and disciplined old-information deletion and new-information addition. Eventually, this had led Andy to the realization that keeping schedules on a computer is only useful if many others needed to access the same information for purposes of coordinating meetings or remotely filling up a manager's day with previously unknown and unplanned activities.

This experience had also made Andy realize that he would not be enamored with having his newspaper delivered on-line. He especially enjoyed the experience of scanning the pages while he ate his breakfast.

One morning, a day or two after his bad-dream experience, he did a quick calculation of what it would take to replace his newspaper with a computer screen. He noted that his breakfast reverie typically took about twenty minutes and the paper had about sixty pages. Some pages be scanned quickly. On others he would find something unexpectedly interesting and would read an entire article. Part of the fun was the element of surprise and finding something intriguing for which he wasn't even searching. He liked to get an overview of all the happenings in the world.

To get the same content up on his computer screen, it would take at least four screens for each newsprint page. That would mean that he would have to scan one screen every five seconds on the average. And that would mean some of the screens could only be up for one or two seconds. Hadn't he already had a disconcerting experience like this somewhere? Well, of course. This would be very similar to the last time be went to the library and looked up information on a microfiche reader. Using one of those things had made him almost nauseous. Maybe having portions of a newspaper page flash up every few seconds on a computer screen wouldn't be quite as bad, but Andy decided it wouldn't be nearly as relaxing as looking at the equivalent of eight screens at once, positioned at just the right angle to permit him to move food from plate to mouth in the most efficient manner.

That morning, driving to work, Andy decided that he liked the world pretty much as it was. He liked stores, he liked shopping malls, but he also liked mail-order shopping. He especially liked weekend craft fairs that attract large crowds. It was great fun to wander and look at all the stuff and all the people. He liked telephones, and he liked the Internet. He liked all these things and more. What he didn't like was someone trying to tell him that some of the things he liked were going to go away just because they *could* be done on-line cheaper or more efficiently. That was really dumb, he decided. As long as people liked something, technology wasn't going to take it away. "Who's in charge here, anyway," thought Andy, almost out loud. Now he was feeling much better. In fact, be decided that he wasn't even going to bother writing the Letter to the Editor he had been composing in his head. Why bother? Let the Information Age pundits have their fun. It won't hurt anyone. Well, except maybe for an occasional bad dream ....

In keeping with Andy's view of the world, I am available for Information Age encounters using all methods new and old. You can reach me by e-mail at silzars@ibm.net, by phone at 425/557-8850, by fax at 425/557-8983, or by mail at 22513 S.E. 47th Place, Issaquah, WA 98029. If you wish to know what article and what pundit inspired this column, please use one of the above media to convey your wish and I will gladly respond. ■

Note: In the December Display Continuum Column the age of Microsoft was stated as 33 years; it should have read 23 years. We apologize for this typographical error.

Heat-Reflecting Self-Cleaning Oven Doors • Defrosting Refrigerator and Freezer Doors • Solar Heating • Security Systems

• Thin-Film Photovoltaics • Flat Panel Displays • Electrochromic Devices • EMI/RFI Shielding • Anti-Static Coatings • Bar-Code Scanners • Copier Cover Plates • IR Reflecting Windows •

editorial

continued from page 2

Sarnoff Research Center – both for dramatically increasing the display community's poetic output and for selecting *Information Display* to provide the first publication of his work.

– Ken Werner

Gamma and Its Bases
by Michael H. Brill

When voltage in a cathode tube sends slow electrons speeding,
That cause the phosphor dots to glow, the light for TV's needing
Is made according to a law that varies day-by-day.
That law says voltage makes the light with power gamma. Pray
What gamma is the proper one, that heaven handed down?
That number is a vagary that makes grave sages frown.

One group of such, NTSC, declared it 2.2.
The makers of the cameras, and of home receivers too
Agreed, and signed a pact, and went their merry ways, but when
The TV sets themselves belied the hallowed value, then
The sages separately declared two better values. Who
Could argue with the averages or with a purpose true?

Sir Charles[1] announced a purpose, and the value 2.5.
He said the TV watchers and the viewers who're alive
Undo the bloody gamma and retrieve the voltage V:
A marvelous coincidence – a clever fellow, he!
But 2.5 is not quite the inverse of 1 on 3,
The exponent that sages say is part of you and me,
That hammers frightful wattages into benign perception.
But to say we're made for 2.5 perhaps is self-deception.

I much prefer the gamma that Sir Denis[2] claims is true.
That gamma value's 2.3 and holds a secret too.
When input by a voltage in a base Napierian,
This gamma makes a luminance whose value in base ten
Is proportional to voltage in the base "au naturel,"
And serves us folks who work in tens and count on fingers well.

And so I end this essay of the gamma, put to song,
And hope that betas strike me if my tale of gamma's wrong.

[1]Charles Poynton, "'Gamma' and its disguises: The nonlinear mappings of intensity in perception, CRTs, film and video," *SMPTE J.*, 1099-1108 (December 1993).
[2]Denis Pelli, "Pixel independence: Measuring spatial interactions on a CRT display," *Spatial Vision* **10,** 443-446 (1997). The value 2.3 is from this paper, but the log-base interpretation is not his fault!

We welcome your comments and suggestions. You can reach me by e-mail at kwerner@netaxis.com, by fax at 203/855-9769, or by phone at 203/853-7069. The contents of upcoming issues of *ID* are available on the *ID* page at the SID Web site (http://www.sid.org).

european views

continued from page 6

The ***Advanced Substrate Materials*** project will investigate lightweight, ultra-thin glasses and polymer substrates with conductive coatings for use in light-emitting-polymer displays. This will allow development of lightweight, formable emissive displays.

The objective of the ***Fibre Optic Displays Interfaces*** project is to develop and demonstrate the technology for a low-cost noise-immune digital fibre-optic link, from system units to displays that will operate over distances of up to 100 m.

The ***Field Emission Backlight*** project will develop field-emission technology suitable for backlighting applications, such as LCDs or signage.

The ***Novel Optics for Displays*** project will investigate the use of novel optical designs in backlit and reflective LCDs with the aim of achieving higher brightness and improved efficiency in order to meet the demands of the marketplace.

Finally, the ***Advanced Interconnections for Displays*** project will investigate technologies required for high-resolution flexible connectors and "chip-on-substrate" sub-assemblies to compete with the "chip-on-glass" techniques used by the leading Far Eastern manufacturers.

In order to make the DTA a broad forum for the UK-based displays community, other companies and universities will be encouraged to become Associate Members of the DTA. To help achieve this objective, a quarterly newsletter, *Displays Focus,* and a Web site have been established. In addition, workshops covering specific aspects of display technology and other issues, such as better coordination of research activities, will be organised. The first workshop, on light-emitting organics, is being held on the 14th January 1998.

The DTA represents a new initiative that is clearly focused on the needs and strengths of the UK displays community. This focus and the synergy provided by the collaboration of UK companies and universities should lead to the development of new products and components that will benefit the many UK companies that use flat-panel displays in their products. ■

Alan Mosley is Director of Business Development at CRL, and a Regional Associate Editor of Information Display; *telephone +44-1-81-848-6400, fax +44-1-81-848-6653, e-mail: amosley@crl.co.uk.*

Jury's verdict does not end ADS-Kent face-off

On December 1, 1997, after two and a half days of deliberation, a jury in the United States District Court for the Northern District of Texas, Dallas Division, rejected Kent State University's (KSU's) contention that Advanced Display Systems (ADS) of Amarillo, Texas, infringed upon a KSU patent for polymer-free cholesteric liquid-crystal displays and, further, held that KSU's patent 5,453,863 is invalid due to both obviousness and anticipation. According to an ADS press release, "ecstasy and relief were the emotions of the day" at ADS headquarters. The company announced in the press release that it is expediting the completion of its volume production facility in Amarillo, and expects it to be operational in Q2, 1998. Gene Micelli, President and COO of Kent Displays, Inc., to which the KSU patent is licensed, said in a press release, "It is important to note that although the jury has rendered a verdict the court has not issued a final judgment. As such the contested patent remains in force. The Company and KSU remain firmly convinced of the validity of the patent in question and are fully prepared to take all actions necessary to resolve this issue in their favor." Micelli told *Information Display* that the technical issues were very difficult for a jury to interpret and that Kent Displays viewed the verdict as reversible on appeal. Both in the press release and in subsequent conversations with *ID*, Micelli said that "additional evidence" discovered during the trial, evidence illegally suppressed during the trial, and evidence revealed since the trial has opened new possibilites for re-trial [and] appeal.... The allegedly suppressed evidence, which was discovered by Kent Displays attorneys and presented late in the trial, consists of testimony and a photograph supplied by Victor Zhou, formerly an engineer with ADS. The photograph was of a Kent prototype display taken, apparently surreptitiously, when then Kent President Zvi Yaniv had visited ADS in late 1993 or early 1994. According to the testimony, the protograph was apparently taken when Yaniv left the ADS offices with Bao Gang Wu, CEO of ADS, presumably for lunch. Zhou testified to disassembling the prototype at the direction of Jimmy Gao, his supervisor at ADS, so a photograph could be taken. According to the trial transcript, Kent Displays' attorney asked Zhou, "Did he [Jimmy Gao] tell you to hurry?" Zhou's answer: "Yeah. He said, hurry up, but I don't know what's the reason. But he said that." James Lupino, Director of Marketing for ADS, referred *ID* to ADS's attorney for comment. Attorney Kevin Nash of Friedman, Driegert, and Shueh, Attorneys at Law, Dallas, Texas, responded to Micelli's charge by saying, "The Zhou photograph was not suppressed. It was involved in another suit with another company, and was covered by a protective order [issued by a different judge]." Nash said that he had identified the photo on a privileged log as a photograph of circuitry. Nobody suppressed evidence, he said. Rather, Kent's attorneys "failed to examine the privileged log properly." Whether the photograph and Zhou's original testimony were adequately described in the privileged log as ADS maintains or inadequately described as Kent maintains, aren't they damaging to ADS's case? "Whatever relevance, if any, they might have to an action involving trade secrets, they have no relevance to this patent case," said Nash. The Court's final judgment was expected at around the turn of the year.

– Ken Werner

Hughes Lexington acquired

Lexel Corporation has announced the completion of the acquisition of Hughes Lexington, Inc., as of September 30, 1997. The employee and leadership teams of Hughes Lexington have chosen the name of Lexel Imaging Systems, Inc., for the new company. Lexel Imaging Systems is a wholly owned subsidiary of

continued on page 51

HOTEL RESERVATION FORM FOR SID '98

DEADLINE: April 24, 1998

SID
SOCIETY FOR INFORMATION DISPLAY

RETURN THIS FORM ONE OF THREE WAYS:

Mail to:
SID Conference
c/o Anaheim Housing Bureau
PO Box 4270
Anaheim, CA 92803

Fax to:
(714) 776-2688

On the web:
www.anaheimoc.org/housing.html
(Group code: SID)

1.) Rooms are assigned on a first-come, first-served basis as received by the Housing Bureau. If rooms are no longer available in the hotel(s) of your choice you will be placed in the next closest available hotel in your rate preference.

2.) To ensure that your request is handled quickly and efficiently, you must complete the form in its entirety.

3.) NO TELEPHONE RESERVATIONS WILL BE ACCEPTED. If you have not received a confirmation after 2 weeks, please call the housing bureau.

4.) ONLY ONE ROOM MAY BE REQUESTED under each name and only one room per form please.

5.) If you are sharing a room, complete only ONE form with the names of the persons who are sharing; be sure to include all names. Include earliest arrival date and latest departure date.

6.) Allow 1 week for processing. Once your reservation has been processed by the Housing Bureau, you will receive an Acknowledgement Form in the mail or by FAX (only if FAX number is given.) NOTE: THIS IS NOT A CONFIRMATION. You will receive confirmation of your reservation directly from the hotel at a later date.

7.) After April 24, make all reservations, changes and cancellations directly with hotel.

8.) Guaranteed room reservations are required, with your Housing Form, please include a major credit card number. Your credit card will be charged first night room and tax if you are booked at the Anaheim Hilton & Towers. Deposits are returned if cancelled 7 days prior to arrival date. All other hotels will hold your credit card number as a guarantee.

9.) Room rates quoted are subject to a 15% state and city room tax.

PART I. HOTEL INFORMATION

Hotel Choices (by code, see reverse side for codes and rates)

1.____________________ Rate____________________

2.____________________ Rate____________________

3.____________________ Rate____________________

Arrival Date____________________ Departure Date____________________

Number of occupants__________ Occupants' Names____________________

Room Type (see reverse): ____________________

If choosing **Hilton:** ☐ Main Building ☐ Lanai ☐ Towers If choosing **Quality:** ☐ Standard ☐ Studio Suite

Special Requests: ☐ King Bed ☐ Non-Smoking ☐ Handicap-Accesible

PART II. CREDIT CARD INFORMATION

☐ VISA ☐ MasterCard ☐ American Express ☐ Diner's Club ☐ Discover

Card No.____________________ Exp. Date __________ Signature____________________

PART III. SEND CONFIRMATION TO:

First Name ____________________ Last (Family) Name____________________ Title ____________________

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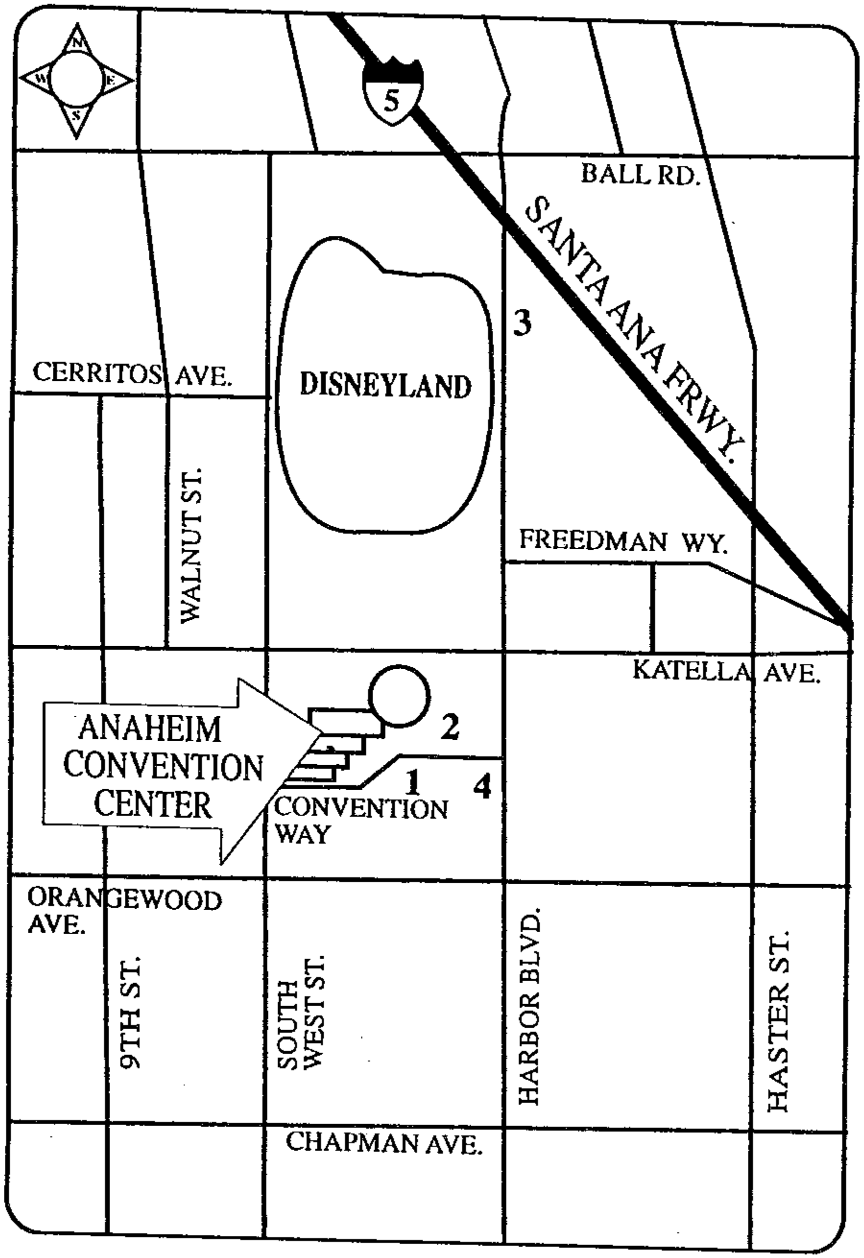

HOTEL RATES AND CODES

1. Anaheim Marriott Hotel (Headquarters Hotel)
Code: MARRI

Single:	$145.00
Double:	$165.00
Additional Person:	$ 20.00

2. Anaheim Hilton & Towers
Code: HILTON

	Main Building	Lanai	Towers
Single:	$150.00	$180.00	$210.00
Double/Twin:	$180.00	$210.00	$240.00
Additional Person:	$ 30.00		

3. Howard Johnson's
Code: HOJO

Single/Double/Triple/Quad: $69.00

4. Quality Hotel Maingate
Code: QUAL

	Standard	Studio Suite
Single/Double/Triple/Quad:	$90.00	$115.00

continued from page 48

Lexel Corp. The new company remains dedicated to serving its customers with world-class products and services that expand its traditional high-performance CRTs, but now also includes electronic assembly, test, and design services. Its employee teams are committed to providing the industry with ever-increasing levels of quality, service, and on-time deliveries. Operations will continue at the company's present location at 1501 Newtown Pike in Lexington, Kentucky.

Clinton Electronics and Orwin Associates combine resources

Clinton Electronics Corp. and Orwin Associates, Inc., have entered into an initial agreement to combine their respective resources. Both firms are privately held and will continue to maintain operations from current facilities. This combination brings together the design and advanced engineering talents at Orwin with the manufacturing capacity and experience of Clinton Electronics. It will provide the medical-imaging market witb a full spectrum of products, from high-resolution custom designs to high-volume clinical displays. Both firms bring digital-control experience together with new concepts in closed-loop control and quality feedback systems for the next generation of medical displays.

Photo war hits the net

The war between Kodak and Fuji Film for the hearts, minds, and dollars of amateur photographers entered the digital domain some years ago with Kodak's Photo CD initiative. (Photo CD never caught on with amateurs, althongh it is highly valued by professionals in the graphic arts.) More recently, sources report to *ID*, Kodak's senior management has lost the conviction that the future of amateur photography is digital (despite an active digital-imaging group within Kodak). Apparently not so at Fuji Film, which has established a digital-photography service at www.fujifilm.net. Participating photo finishers will scan your film and upload the images to the site, where they can viewed or downloaded with a password. Software is available for creating "photo albums" that can be viewed by computer-literate grandparents the world over. In addition to the obvious uses for such images, such as e-mailing them, Fuji Film will also allow you to select an image and have prints delivered anywhere in the U.S. Basic storage at the site costs $4.95/month, but the first 3 months are free, at least for the moment. It's hard to tell how many additional – or larger – displays Fuji's service is likely to sell, but every bit helps.

Color field-sequential illuminators

Teledyne Electronic Technologies, Hawthorne, California, has developed RGB Alphalight™ color field-sequential illuminators (CFSIs), a wide variety of small-aperture (0.25–1.4-in. on the diagonal) RGB backlights that meet the demand for full digital information and video display interfaces for battery-powered hand-held or wearable electronic devices and simpler "green" PC projection monitor CRT replacement units. CFSIs are ideal for creating more efficient, less costly, and more compact VGA-compatible imagers for LCDs and spatial light modulators. CFSIs are now quickly becoming the key enabling technology for many of these applications, are critical to the proliferation of such end products, and will be instrumental in their realization in low-power non-emissive displays.

The LCD industry has focused on making displays of ever-increasing size with integrated, separately deposited color RGB filters. Each "color" pixel is segmented into thirds or fourths, assigning each portion to a specific primary-color site. Third-generation facilities are now producing either two 15-in.- or one 23-in.-diagonal display per "motherglass," with line set-up costs of about $500 million. Fourth-generation lines are now seen as the only way to economically sustain panel-size growth commensurate with decreased costs and increased yields. These new lines cost $750 million to $1 billion.

The color filters used in these products, and their associated yields, are said to cost approximately 40% of the price to produce each panel and render the display able to transmit only 3–4% of the light produced by its fluorescent illuminators, thus wasting much power. CFSIs eliminate color filters and increase existing resolution by a factor of three. Additionally, they would cut power, yield a horizontal viewing angle from 90 to 160%, reduce size and weight, reduce drive, conversion, and address circuitry, and simplify manufacturing manyfold.

Information: Bill Kennedy, Teledyne Electronic Technologies, 12520 Daphne Ave., Hawthorne, CA 90250. 213/777-0077, fax 213/242-1924. ■

sustaining members

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Crystaloid LCDs
Dale Electronics, Inc.
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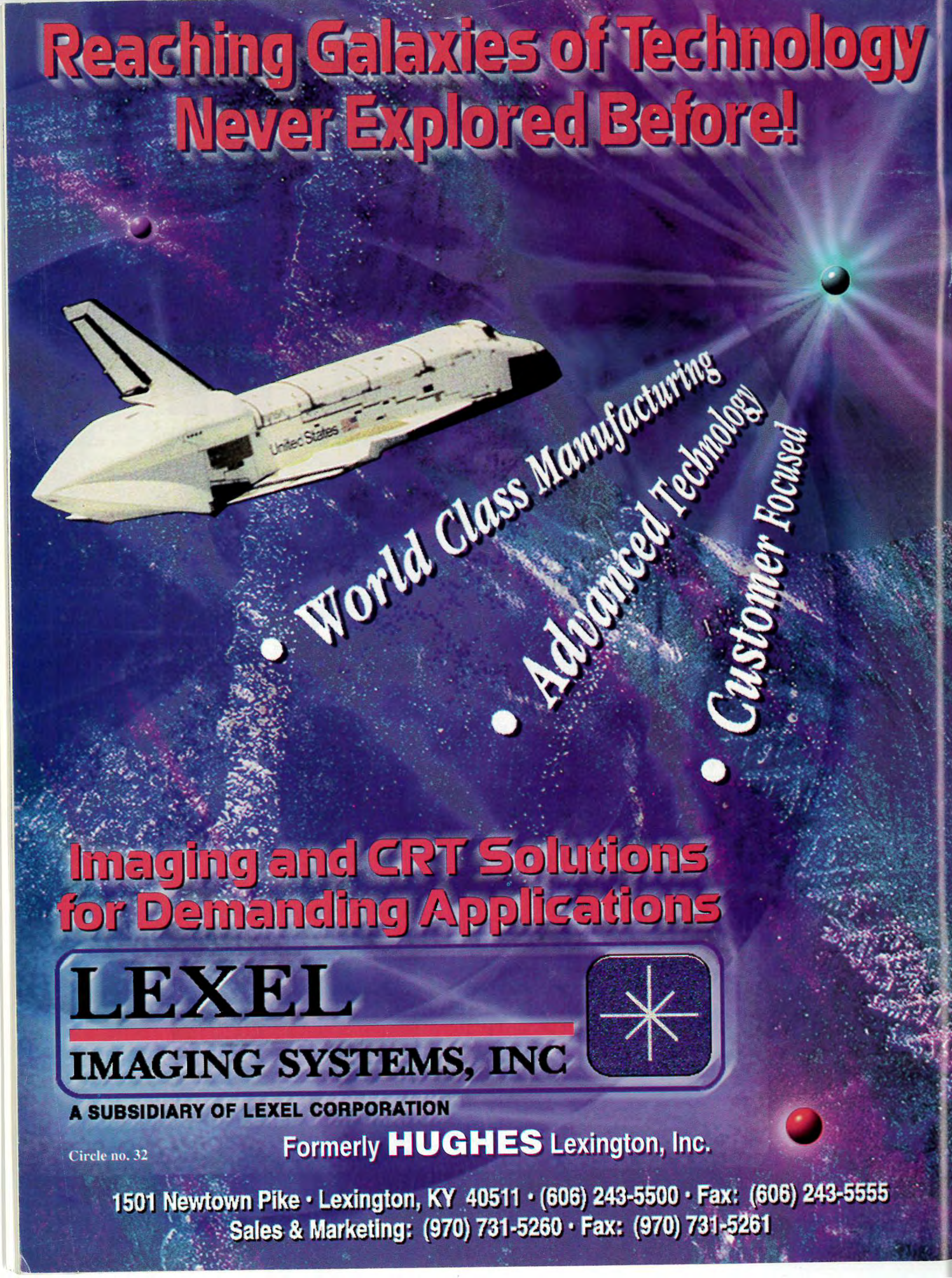
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