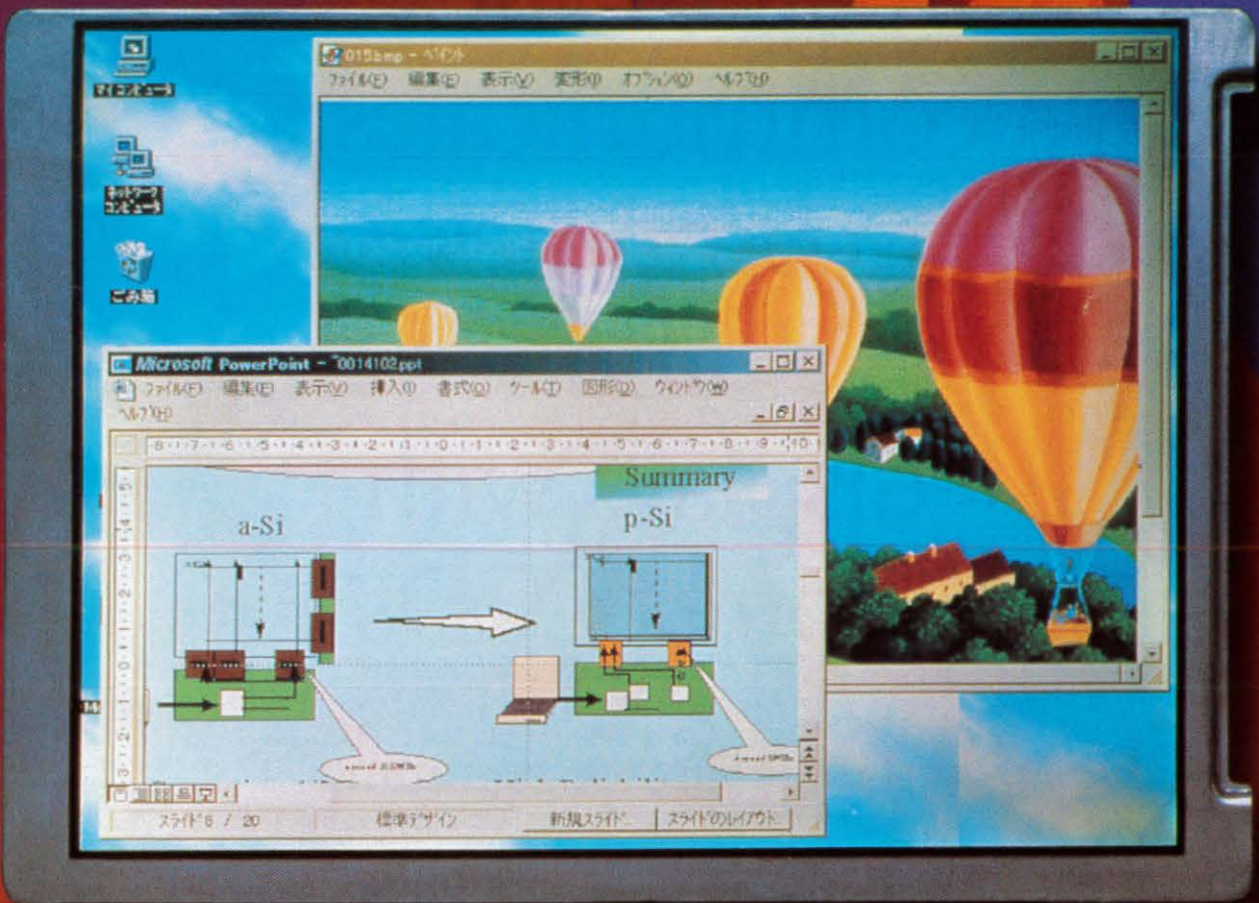


Information

October 1998
Vol. 14, No. 10

DISPLAY


Official Monthly Publication of the Society for Information Display



Reflective Color LCDs: Ready for Low-Power Portable Systems

- ***The "Iron Law" 25 Years Later***
- ***Reflective Color LCDs***
- ***Display Reflections***
- ***Worries at Computex Taipei***

NON-PROFIT
ORGANIZATION
U.S. Postage Paid
Easton, PA
Permit 68



The world
plans, navigates,
measures, monitors,
plays, fishes,
communicates,
computes
and
displays with
Optrex LCDs

And that's just the beginning.

The applications for LCDs keep growing and so does Optrex. Why? Innovative engineering and design support, exceptional quality, and a nationwide distribution network. Our creative design approach allows you to develop new applications and enhance the performance of your existing products. Most importantly, it allows **you** to create the custom or semi-custom LCDs that

turn your bright ideas into reality.

Our customers like that. You will, too.

For more information, call (734) 416-8500, or fax (734) 416-8520 today.



OPTREX
AMERICA, INC.

44160 PLYMOUTH OAKS BLVD. • PLYMOUTH, MI 48170
(734) 416-8500 • FAX: (734) 416-8520
lcdinfo@optrexusa.com

Circle no. 1

COVER: Reflective color LCDs using several different technologies are now good enough to begin filling a growing demand in a variety of applications that require low power consumption, ranging from cellular phones to notebook computers. This is Toshiba's 8.4-in. AMLCD, which uses polysilicon TFTs and integrated drivers.



Credit: Toshiba America

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*

Manufacturing Issue

- Repair and Rework of FPDs
- Electrostatic Discharge
- Flat-Panel Television
- Continuous-Grain Silicon
- Manufacturing Cost Structures

INFORMATION DISPLAY (ISSN 0362-0972) is published eleven times a year for the Society for Information Display by Palisades Institute for Research Services, Inc., 411 Lafayette Street, 2nd Floor, New York, NY 10003; Leonard H. Klein, President and CEO. EDITORIAL AND BUSINESS OFFICES: Jay Morreale, Managing Editor, Palisades Institute for Research Services, Inc., 411 Lafayette Street, 2nd Floor, New York, NY 10003; telephone 212/460-9700. Send manuscripts to the attention of the Editor, ID, Director of Sales: Erika Targum, Palisades Institute for Research Services, Inc., 411 Lafayette Street, 2nd Floor, New York, NY 10003; 212/460-9700. SID HEADQUARTERS, for correspondence on subscriptions and membership: Society for Information Display, 31 East Julian Street, San Jose, CA 95112; telephone 408/977-1013, fax -1531. SUBSCRIPTIONS: Information Display is distributed without charge to those qualified and to SID members as a benefit of membership (annual dues \$55.00). Subscriptions to others: U.S. & Canada: \$36.00 one year, \$5.00 single copy; elsewhere: \$72.00 one year, \$6.50 single copy. PRINTED by Sheridan Printing Company, Alpha, NJ 08865. Third-class postage paid at Easton, PA. PERMISSIONS: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limits of the U.S. copyright law for private use of patrons, providing a fee of \$2.00 per article is paid to the Copyright Clearance Center, 21 Congress Street, Salem, MA 01970 (reference serial code 0362-0972/98/\$1.00 + \$0.00). Instructors are permitted to photocopy isolated articles for noncommercial classroom use without fee. This permission does not apply to any special reports or lists published in this magazine. For other copying, reprint or republication permission, write to Society for Information Display, 31 East Julian Street, San Jose, CA 95112. Copyright © 1998 Society for Information Display. All rights reserved.

- 2 Editorial
Information Displayless
Ken Werner
- 4 The Display Continuum
I Really Need to Go to a Meeting ...
Aris Silzars
- 12 The "Iron Law" 25 Years Later
Are high-performance addressed STN displays breaking the "iron law" of LCD design formulated by Paul Alt and Peter Pleshko nearly a quarter century ago?
Terry J. Scheffer
- 18 Reflective Color LCDs
The market for reflective color LCDs is very active, but which technology will prevail?
Alan Mosley
- 24 The Three Components of Reflection
The ambient light that reflects off a display screen can affect image quality more than the light intentionally produced by the display — but which type of reflection is the most important?
Edward F. Kelley
- 32 Temperature-Compensating Shadow-Mask Mounting
As high-performance CRTs are produced in increasing numbers and in geographically diverse locations, advanced mounting technology is helping CRT makers achieve better images at lower cost.
Keith Wheeler
- 36 It Takes a Worried Man to Sing a Worried Song
Worried songs were sung as the Taiwanese dollar and stock market fell in value daily during Computex Taipei 1998 — but local monitor manufacturers put on a brave face and showed off their new products.
Bryan Norris
- 39 SID Calendar of Coming Events
- 56 Index to Advertisers



Information Displayless

The front-page story of *The New York Times* business section on August 19th was "Entertainment in the Skies; Glitches Still Hurting Video With Wings." "Aha!" said I. "Display issues are finally making it into the general business press."

Well, not exactly. The article covered the entertainment-on-demand systems that are being installed in the first-class and business-class cabins on many

airlines, and focused on the not-yet-reliable systems, which are essentially video-rate LANs. But other than a passing mention of "personal armrest video screens" in Virgin Atlantic's first and business class and a goggle display made by Olympus Optical for Japan Airlines' first-class cabin that "is like watching a 62-in. screen," displays are barely mentioned. In fact, Virgin Atlantic's in-flight masseuse received more coverage than its in-flight displays. (As this was an article on in-flight entertainment systems, I'm not sure what message the *Times* was trying to deliver, but perhaps we should move on.)

So, what the *Times* gave us was an article on information delivery systems with barely a mention of the devices that must be used to deliver the information. Unfortunately, this seems to reflect the attitude of the people who design in-flight entertainment systems, as any frequent flyer can attest.

I have recently been subjected to flop-down LCD panels that were obviously purchased before wide-angle LCDs became commonplace. None of the several panels within my sight were capable of presenting me with an image that was simultaneously large enough, bright enough, and contrasty enough to offer minimally acceptable viewing.

Was I simply being a display snob? I don't think so. A look around the cabin indicated that an unusually large percentage of people were ignoring the in-flight entertainment.

This isn't rocket science. It is simply designing a system that includes the viewer. It is thinking about viewable display characteristics as a function of viewing angle, and subtended angle as a function of viewing angle and distance.

But there are some human-factors questions that may be more subtle. It seems clear that in-flight entertainment is moving toward individual seat-back and armrest displays. (Perhaps first-class passengers can be trusted with \$500 HMDs, but I suspect the cost will have to come way down before the airlines will hand them out to the folks in sardine class.) So, have the people who are proposing 5.6-in. FEDs for seat-back displays made very sure that users think they are large enough? If they aren't, is an 8.4-in. AMLCD large enough? Will a passenger who has just finished using the 13.3-in. display in her notebook PC feel she is being well served with even a 10.4- or 11.3-in. seat-back LCD? Will an FED feel more "cinematic" than an LCD, even if it is smaller? How long will people remain satisfied with VGA/NTSC screen resolution on airplanes after they become used to high-resolution digital TV at home (or at least at the local sports bar)?

The interaction of such human-factors questions with display-design issues and the stringent packaging demands of aircraft installations should keep display people entertained for years to come. Will airline passengers be as lucky?

- Ken Werner

Information DISPLAY

Editor: Kenneth I. Werner
Managing Editor: Jay Morreale
Administrative Editor: Ralph Nadell
Assistant Editor: Dian Mecca
Contributing Editors: Aris Silzars, Bryan Norris, Chuck McLaughlin, Joe Hallett
Advertising Manager: Jay Morreale
Director of Sales: Michele Klein
Sales Manager: Christy Smith

Regional Associate Editors

Allan Kmetz (**Americas**)
Lucent Technologies
Murray Hill, New Jersey

Shigeo Mikoshiba (**Asia**)
University of Electro-Communications
Tokyo, Japan

Alan Mosley (**Europe**)
Central Research Laboratories
Hayes, Middlesex, U.K.

Advisory Editors

Ken Compton
Clinton Electronics Corp.
Rockford, Illinois

Carl Machover
Machover Associates
White Plains, New York

Peter Pleshko
PEMM Services
Kingston, New York

Alan Sobel
Consultant
Evanston, Illinois


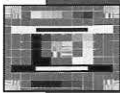
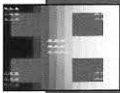
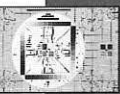


Webster E. Howard
FED Corp.
Hopewell Junction, New York

The opinions expressed in editorials, columns, and feature articles do not necessarily reflect the opinions of the editor or publisher of *Information Display Magazine*, nor do they necessarily reflect the position of the Society for Information Display.

Powerful New Video Generators. The Smart Choices.

STANDALONE

ASTRO VG-851/854

-  Dot Clock to 400 MHz
Horizontal Scan to 300KHz
-  Extremely easy operation from front panel or PC
-  Highest Available Performance
-  256 Levels at all Frequencies
-  Fully compatible with all HDTV-formats-even 1080p
-  Accepts Bitmap-Files




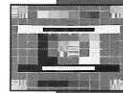




Standalone Units from **\$2950**

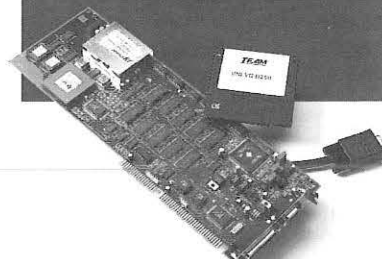
400 MHz for true 2K x 2K resolutions; Storage of more than 1000 Timing/Pattern Programs in Flash Memory and EEPROM; Fully PC-compatible with "Bitmap" capability; direct access to any parameter from front panel or through PC-programs. And any of the (E)EPROM you used in earlier units can still be used.

That's what we call High Performance, Flexibility and Ease of Operation!

PC-BASED

Team VG-530pc UNI VG-D300pc

-  PC-based Performance
-  Dot Clock to 300MHz
Horizontal Scan to 250KHz
-  Fully Programmable Patterns
-  Fully DDC Compatible
-  Accepts Bitmap-Files
-  UNI VG-D300pc Units with Win 95 & Win NT 4.0



PC-Based Units from **\$2500**

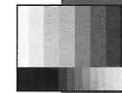
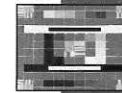
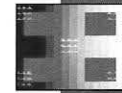


300 MHz gives you ample margin if you work with Display Systems up to a 1600x1280 resolution. Its full "DDC" capability is an increasingly important asset in service and manufacturing applications.

Both PC-based units allow VESA-D.P.M.S. testing and the ability to import preset .pcx data files from other sources as "test patterns".

The user interface is DOS- and Win 95 & Win NT 4.0 respectively.

DIGITAL

ASTRO VG-826A

-  True "Digital" Video Generator
-  Dot Clock to 75MHz / 150 MHz
-  Operated directly from a PC or with "Remote" Frontpanels
-  Very Compact & Lightweight
-  8 Bits resolution/pixel/ color



Digital Units from **\$5950**

Service, repair, evaluate or engineer FPDs? The Astro VG-826A is the Digital Generator for you.

It's small and light, yet has the performance to drive any single or multiplexed Flat Panel Device with a resolution of 24 bits per pixel up to a multiplexed frequency of 150MHz.

It can be programmed/operated from a PC, the RB-646A "Remote". Frontpanel or the RB-614C Controller.

Make the *Smart Choice*... Contact Team Systems

Call us: **1-800-338-1981** Visit us: **www.team-systems.com**

TEAM
systems



I Really Need to Go to a Meeting ...

by Aris Silzars

It was a few minutes after 3:00 p.m. and I was trying my best to finish up a phone call. I didn't want to be late for the three o'clock staff meeting. While completing my telephone conversation, I did some multi-tasking and prepared my folder with the spreadsheets. I thought I might need to have along in case some financial issues came up. At 3:04, I dashed out of my office and did a walk-jog down the hallway to the designated conference room at the far end. I knew that with luck and if no one tried to grab me for a "quick question" I could make it in just over a minute.

And once again, I accomplished my objective. It was 3:06 as I entered the room and I was *on time*. Actually, I was maybe even a bit too early. Of the approximately dozen expected attendees, there were only two in the room – and one of them was the finance person, who was permanently on the schedule as the first speaker. Boss-person had not arrived yet and the only other signs of civilization were a few notepads and "daytimers" left by attendees who presumably were planning to return shortly – right after taking care of just one more vitally important piece of business.

Over the next several minutes, there were more seemingly random entrances and exits, and more notepads were placed at various spots around the table. The finance person had by now adjusted the overhead projector at least six times and positioned and repositioned the first overhead to absolute perfection. Observing this behavior made me wonder if finance people in general have a difficult time with disorder and are slow learners, or if this only applied to the one standing at the front of this room.

Two colleagues and I were the only ones seated at the conference table when boss-person entered at roughly ten minutes after the hour. By now, most of the spots around the table had been "marked" by their future occupants, who were now making their reappearances with increasing frequency and apparent urgency. However, for most of them, after a cursory apology, the first stop was not the spot they had chosen at the conference table but the corner table where the coffee and cookies had been laid out. Finally, after some by-now familiar comments from boss-person regarding how we all need to try harder to get these meetings started on time, the finance person turned on the projector, the lights were dimmed, and the meeting was launched. The time was 3:18. I resolved that next week I would try to do better – no point in being *this* much too early.

By 30 seconds after 3:18, my carefully trained and conditioned psyche had entered that part of the mind-world known to everyone as meeting-land. Meeting-land is unquestionably the greatest blessing bestowed upon us all by the modern corporation. Where else can one go where the mind is so free to wander as during a staff meeting – or any other kind of meeting that involves more than four or five people? It can be mathematically proven that meetings of six or more participants asymptotically approach meeting-land nirvana, and any number above ten participants is a sufficient condition to allow one to be within epsilon of nirvana (the existence of the meeting being the necessary condition).

Even as my physical body assumed that well-trained attentive look and I occasionally nodded with a knowing and approving look toward the screen being

continued on page 44

SID Executive Committee

President: A. C. Lowe
President Elect: A. Silzars
Regional VP, Americas: R. Donofrio
Regional VP, Asia: C. Lee
Regional VP, Europe: B. Needham
Treasurer: A. R. Kmetz
Secretary: R. L. Wisnieff
Past President: W. E. Howard

Directors

Bay Area: H. Sherman
Beijing: S. Ding
Belarus: A. Smirnov
Canada: T. Schmidt
Delaware Valley: J. W. Parker III
France: F. Maurice
Greater Dayton: R. Holmes
Hong Kong: C. C. Chang
Japan: A. Iwamoto
Korea: M. Oh
Los Angeles: P. Baron
Metropolitan Detroit: V. Cannella
Mid-Atlantic: D. Ketchum
Mid-Europe: R. Mauch
Minneapolis/St. Paul: V. Born
New England: W. Hamilton
Pacific Northwest: J. Rupp
Russia: M. Tomilin
San Diego: R. Ruff
Taipei: F. C. Luo
Texas: Z. Yaniv
U.K. & Ireland: A. Mosley
Ukraine: V. Nazarenko

Committee Chairs

Academic: C. J. Summers
Archives/Historian: R. C. Knepper
Bylaws: C. Infante
Chapter Formation: H. Uchiike
Convention: P. M. Heyman
Definitions & Standards: R. Miller
Honors & Awards: A. I. Lakatos
Long-Range Planning: J.-N. Perbet
Membership: J. W. Parker
Nominations: W. E. Howard
Office Liaison: D. Pinsky
Publications: A. Silzars
Journal Editor: A. Sobel
Information Display Editor: K. I. Werner
Communications: J. Rupp

Chapter Chairs

Bay Area: J. Larimer
Beijing: H. C. Hu
Belarus: E. Kaloshkin
Canada: A. Kitai
Delaware Valley: L. Bryner
France: H. Brettel
Greater Dayton: J. Erskine
Hong Kong: H. S. Kwok
Japan: S. Mikoshiba
Korea: M. Oh
Los Angeles: M. Kesselman
Metropolitan Detroit: J. Erskine
Mid-Atlantic: M. Brennesholtz
Mid-Europe: M. E. Becker
Minneapolis/St. Paul: D. Theis
New England: S. Atwood
Pacific Northwest: T. Yuzuriha
Russia: S. Darevsky
San Diego: R. Ditzik
Taipei: H.-P. D. Shieh
Texas: D. McFarland
U.K. & Ireland: C. Williams
Ukraine: V. Sorokin

Office Administration

Executive Director: Dee Dumont
Executive Assistant: Jenny Needham

Society for Information Display

31 East Julian Street
San Jose, CA 95112
408/977-1013, fax -1531
e-mail: office@sid.org
http://www.sid.org

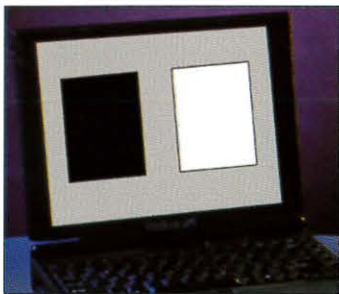
Just when you thought it couldn't get any better...



We made it 60x better.

The PR-705 spectroradiometer. It's the latest in the long line of SpectraScan® instruments. The standard for accurate light and color measurement. The portable PR-705 is 60X more sensitive than its predecessor, to allow testing of instrument panels, LCDs and other FPDs at light levels as low as 0.003 cd/m².

Use it stand-alone to measure displays inside automobiles and cockpits. Measure CRTs, LEDs, flash lamps and light sources in the lab with easy-to-use SpectraWin® software. Or control the PR-705 remotely by sending ASCII commands over a RS-232 interface.



No matter what your application, the PR-705 is the best choice.

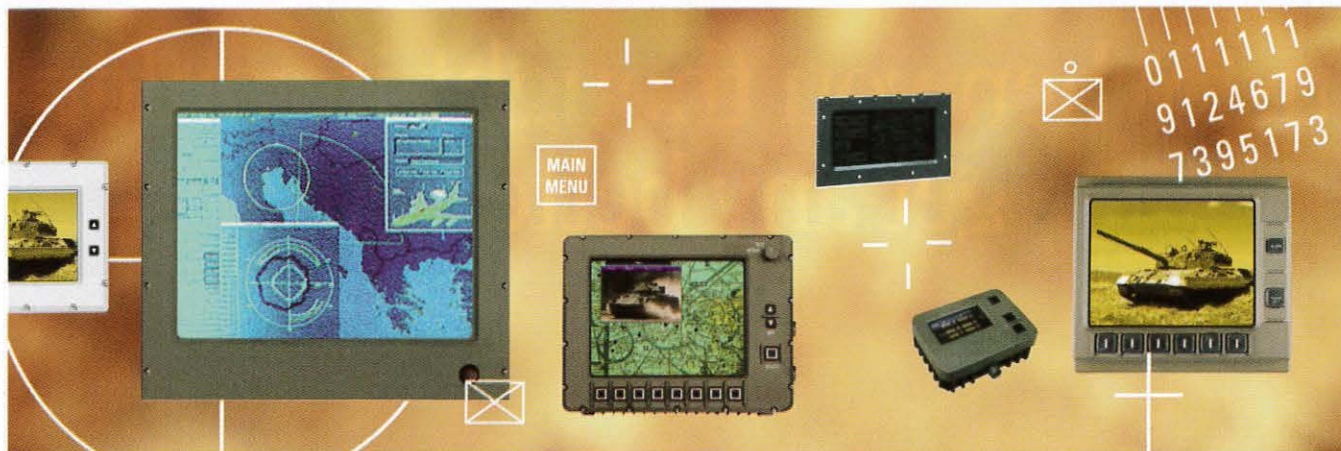
- The highest sensitivity and accuracy are guaranteed by a cooled detector, low-noise electronics and NIST-traceable calibration.
- Six apertures and patented Pritchard® optics make it possible to measure targets down to 0.02 mm with bandwidths as small as 2.5 nm.
- Optics are designed for precise display measurements with low acceptance angles and minimal errors due to lens flare and polarization.
- Built-in floppy drive and parallel printer port eliminate the need for an external computer.

The PR-705 is the solution for all your brightness and color quality problems. Call us today for a demonstration.



PHOTO RESEARCH, INC.

9731 Topanga Canyon Place, Chatsworth, CA 91311-4135, USA
Phone: 818-341-5151 ■ FAX: 818-341-7070
<http://www.photoresearch.com>
e-mail: sales@photoresearch.com



A resolution for all your problems.

▶ Mission is nothing without vision. Whatever your operational need we have a display to fit. Our full line of combat proven, in-service displays including electroluminescent gray shade and Active Matrix Liquid Crystal flat panels have earned us a dominant position as a military displays supplier. Come to the world leader in display solutions for land, sea and air applications.

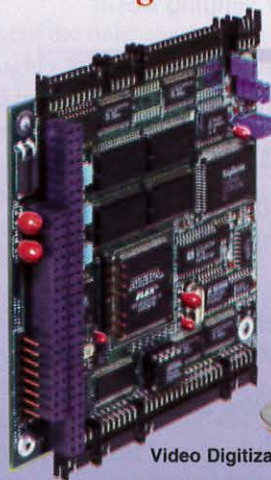
For more information please contact us at:

3785 Richmond Road,
Nepean, Ontario, Canada K2H 5B7
Tel: 1 (613) 596-7009 Fax: 1 (613) 596-7697
floyd.bosko@cdott.com
website: www.computingdevices.com/fpd

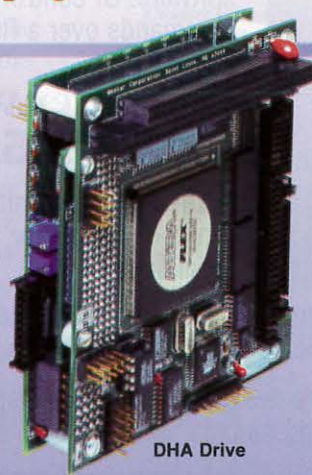
Computing Devices Canada Ltd
A GENERAL DYNAMICS COMPANY

Circle no. 4

Westar's LCDcube™ Drive Electronics solves the integration challenges in developing AMLCD-based displays



Video Digitization



DHA Drive

- ✓ Accepts standard video inputs and drives avionics AMLCDs
- ✓ Reduce development time and cost with standard off-the-shelf solution
- ✓ Shrink overall display outline dimensions with the smallest possible form factor: PC/104
- ✓ Apply to any CRT retrofit application without redesign



Westar is a leading supplier of modular drive electronics and flat panel display test systems to the aerospace, computer, and FPD product industries. Contact us in the US at (314)298-8748, ext.286, or visit our website at www.westar.com/id

Copyright ©1998, Westar Corporation Trademarks are property of their respective owners.

Circle no. 5



BM-SERIES ILLUMINANCE COLORIMETERS

SEE COLOR AND LUMINANCE IN A WHOLE NEW LIGHT...

Work smarter, not harder.

The Topcon BM-5A/BM-7 are fully integrated photometer/colorimeters that automatically read Luminance and Chromaticity coordinates, Color Temperature, or CIELAB and CIELUV values, in a single measurement. Manual operation of filter wheels, recording data and computing Chromaticity values are things of the past. The fully automatic BM-5A and BM-7 make laboratory work more accurate and efficient. All information is instantly available on a backlit rear panel LCD.

GP-IB or RS-232C interface options allow data to be easily exported to a personal computer. With easy selection of field aperture sizes, advanced design, and available accessory options, the BM-5A/BM-7 are ideal photometric tools capable of handling many diverse industry applications.

- Complete evaluation of color displays
- Reflected light measurements
- Automotive/ Avionics panels
- FPD and LCD testing
- SAE chromaticity measurements with optional software and hardware
- Production testing where high volume data recording is necessary
- Outdoor and remote operation with battery pack

Topcon has been a world-wide leader in electro-optical instrumentation standards for over 65 years. And we're committed to providing you with superior instruments, built to the highest standard of quality.

Call today at **1-800-223-1130**
and make Topcon your partner in quality
photometric instrument requirements.



Topcon America Corporation
37 W. Century Rd., Paramus, NJ 07652
Tel. 201-261-9450 • Fax 201-262-1504
Visit us at: <http://www.topcon.com>





THIS MAKES BATTERIES
LAST LONGER

KENT ChLCD™ No Power Displays

Ready to get unplugged from the energy-robbing LCD displays you're now using? KENT Displays' ChLCD (Cholesteric Liquid Crystal Display) technology offers a solution for your electronic products.

BREAK THE BATTERY-DRAIN BARRIER

Since ChLCD reflective and transparent textures are both stable states, an image can be displayed indefinitely without consuming battery energy – for seconds, hours, weeks, months or even years.

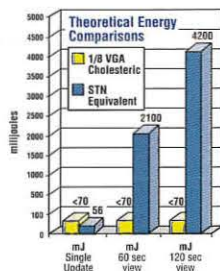
EASIEST TO READ REFLECTIVE TECHNOLOGY

Compared to conventional LCD technologies, ChLCD displays offer better reflectivity, 360 degree viewing cone and exceptional daylight contrast, even in direct sunlight, all without backlighting.

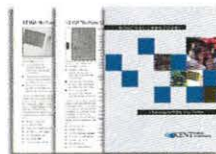
ASK FOR THE FACTS

To learn more about this technology that enables you to do more, ask for this package today.

Circle no. 7



Unlike STN displays which use power to continuously refresh images, ChLCD does not require refreshing to keep energy usage to a minimum.



KENT DISPLAYS
INCORPORATED

A MANNING VENTURES BUSINESS UNIT

Kent Displays, Inc. • 343 Portage Boulevard • Kent, OH 44240 • Phone: 330.673.8784 • Fax: 330.673.4408

Internet: <http://www.kentdisplays.com> • E-mail: sales@kentdisplays.com

Products and technologies of Kent Displays, Inc. are protected by the following patents: United States: 5,453,863; 5,437,811; 5,384,067; 5,251,048; People's Republic of China: 9210/951.2; Israel: 101,746; Taiwan: 801409531; PCT (EP, Canada, Korea, Japan and Norway): 92/01504; 92/09367; Other Patents Pending.

New Redesigned Infosign™

1997 ★★★★★
Product of the
Year Award
ELECTRONIC
PRODUCTS MAGAZINE



Kent Displays' next generation of Infosign products, this Three-Panel Infosign is available with or without a controller. A single "Three Panel Infosign" with controller can control up to 9 additional displays for a total of 12. This means that you can combine individual Info-Strips with Three-Panel Modules in any combination to fit your particular signage needs. Like the original Single-Panel Infosign, this Three-Panel can be updated quickly from a remote computer with the Windows 95 compatible software that is included. Options include wall mount and floor stand enclosures in silver, black and gold, with or without battery pack, in 3, 6 or 12 display configurations.

Infosigns are ideal for point-of-sale displays, door signage, battery-powered signage, kiosks, airport- and bus-terminal signage and more.

Infosign displays feature ChLCD technology for high contrast and wide viewing angle. They are available with a standard resolution of 20 dpi and an active viewing area of three, 12 in. x 1.5 in. panels. Display color combinations of yellow/black, yellow-green/black, green/black and blue/white are available.

KENT Displays, Inc., 330-673-8784

E-mail: sales@kentdisplays.com

Circle no. 8

1/4 VGA "No Power" Displays



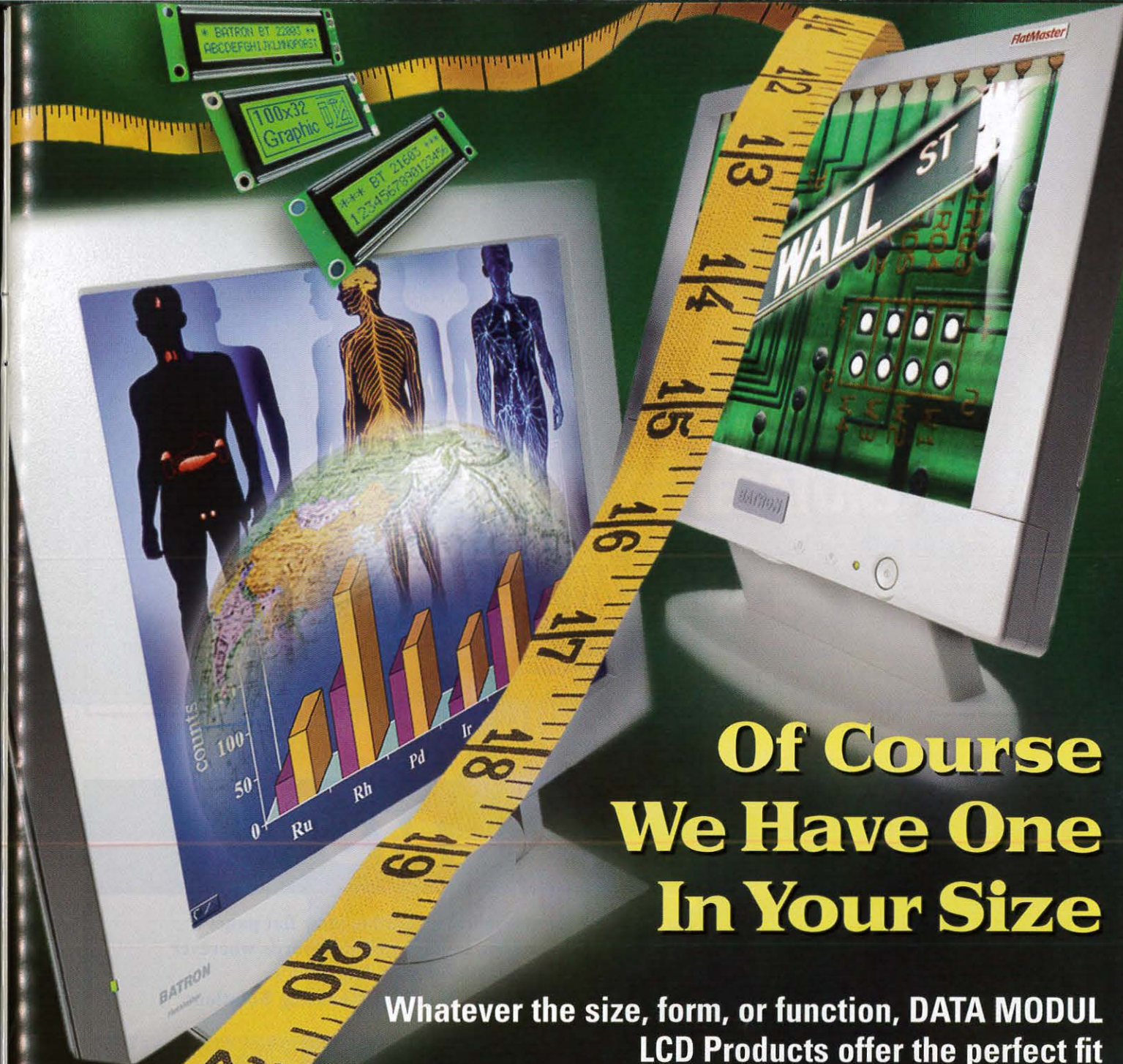
Kent Displays' 1/4 VGA ChLCD "No Power" design not only provides exceptional readability but also requires no power to maintain displayed images, only to change them. Because power isn't constantly being drawn upon to retain the image, expect exceptionally long battery life. As such this display is ideally suited for portable battery-operated applications as well those information display projects where the display must be easily readable at any angle even in direct sunlight.

The 1/4 VGA format is ideal for portable communication devices, data collection products, global positioning systems and more. Available with or without an on-board controller, in 4 color combinations yellow/black, yellow-green/black, green/black or blue/white and featuring an imaging area of 4.48 in. x 3.36 in. with a pixel resolution of 72 dots per inch.

KENT Displays, Inc., 330-673-8784

E-mail: sales@kentdisplays.com

Circle no. 9



Of Course We Have One In Your Size

Whatever the size, form, or function, DATA MODUL LCD Products offer the perfect fit

DATA MODUL's Batron line of LCD products offers high-performance, cost-effective, application-specific solutions to meet your every requirement.

THANKS TO DATA MODUL, THE WORLD IS FLAT AGAIN. Consider our biggest innovation—we were one of the first to introduce the space-saving 20" LCD multi-sync color monitor, with a viewable image area equivalent to a 23" CRT. Powerful, high resolution, razor-sharp images that dazzle the eye with a full spectrum of brilliant colors.

Or take a look at some of our smaller feats—LCD

modules with character heights as small as 3mm, wide-viewing angles and a choice of colors. As a LCD technology leader, DATA MODUL offers unparalleled innovation. Our ISO 9001 and CE certifications mean we can deliver the highest quality and most reliable products in a broad range of applications.

To find out more about DATA MODUL expertise and capabilities in the world of LCDs, contact us.

DATA MODUL



A leader in customization, our AM-TFT monitors can be modified for customer applications, including panel/rack/wall mounts.



High-contrast and extended temperature range make Batron LCD modules ideal for all environmental conditions.



DATA MODUL's line of video-ready NTSC monitors, available from 5.5" (diagonal) and up, incorporate LCD technology.

DATA MODUL, Inc. 120 Commerce Drive, Hauppauge, New York 11788 Tel: 516-951-0800 Fax: 516-951-2121

Circle no. 10

Flat Panel Testing... FAST & SIMPLE!

The SS220 is the easiest and quickest way to test your flat panels! The system is portable and compact, fitting easily into your test area. No integration or mechanical fixturing is required. A simple click of the mouse and your test suite is on its way to completion, providing accurate display measurements AUTOMATICALLY!

FAST & SIMPLE!

The SS220 Flat Panel Test System:

- Fully Automatic Off Axis Measurements
- Spectrometer Based - Luminance & Chromaticity Measurements
- Automatic Measurements to VESA, ISO 13406 & TCO 95 Standards
- Complete Turnkey System
- Panel Drive Electronics

Measurements:

- Chromaticity vs. Viewing Angle
- Contrast vs. Viewing Angle
- Luminance & Color Uniformity
- Spectral Plots
- Contrast Ratio Plots
- Back Light Characterization
- Reflectance (BRDF)



MICROVISION

550 High St., Auburn, CA 95603
Tel: (530) 888-8344 Fax: (530) 888-8349
Email: sales@microvsn.com



Visit our Website at:
www.microvsn.com

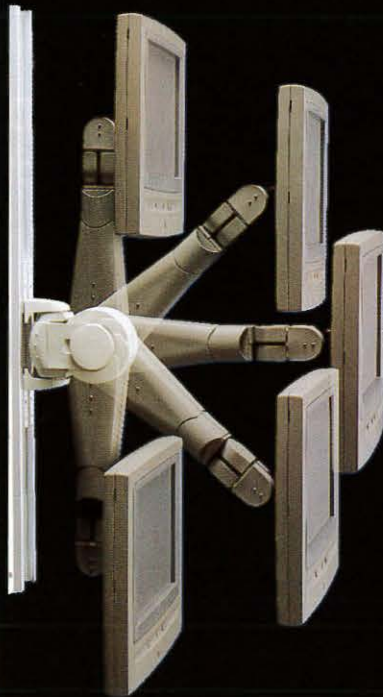
SOMEWHERE ON THE SPECTRUM BETWEEN EXCELLENCE AND PERFECTION...

Circle no. 11

Flat Panel Monitor ARMS™

Call: 1.800.888.8458

Ergonomically position your flat panel monitors, laptops and keyboards wherever you need them—with Ergotron's Adjustable Rotating Mounting Solutions



Mobile Solutions



Wall Mount Solutions



Custom Mount Solutions



Laptop Mounting Solutions



ERGOTRON®

1.800.888.8458 <http://www.ergotron.com>

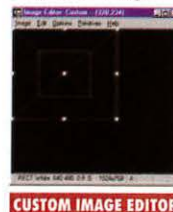
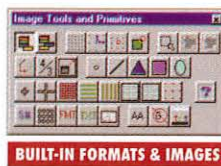
Circle no. 12



INCLUDED

A Quantum Data exclusive. The VGM™ (Video Generator Manager) is a Windows-based (9X, NT) user-friendly interface that becomes a virtual control panel for operation and programming. All functions are included. Format and image selection. Sync and video gating control. The help file is context sensitive and also provides error code explanation, character codes, technical detail and

an on-line users manual. VGM software makes your work easier, saves you time and improves the quality of testing. Find it in a wide array of Quantum Data products. Ask about our multiple language versions, too. Just contact Quantum Data for more information.



The Art of Technology
QUANTUMDATA

2111 Big Timber Road, Elgin, IL. 60123
 Phone: (847) 888-0450 Fax: (847) 888-2802
 Website: <http://www.quantumdata.com>
 E-mail: sales@quantumdata.com

Circle no. 13

The "Iron Law" 25 Years Later

Are high-performance addressed STN displays breaking the "iron law" of LCD design formulated by Paul Alt and Peter Pleshko nearly a quarter century ago?

by Terry J. Scheffer

THE QUALITY of the passive-matrix displays found in the current crop of notebook computers has improved remarkably. These 12.1-in. SVGA screens follow the cursor with little or no smearing and are virtually free of crosstalk, mimicking a TFT display of 3 years ago. Most of these recent improvements are a consequence of high-performance addressing (HPA). HPA does not apply to any single addressing technique, but was adopted by the major Japanese display manufacturers to represent new addressing implementations that enable contrast ratios of over 50:1 and combined rise and fall times of less than 150 ms. How do these new schemes work? Have they found a way to break the "iron law of multiplexing"?

A Brief History of Multiplexing

The emergence of the CMOS LSI process in the early '70s made it practical to consider replacing LED, vacuum fluorescent, and EL displays with LCDs in various applications. Watch manufacturers were the first to seize this opportunity, using 3½-digit static-drive LCDs. In these displays, each of the 23-odd-segment electrodes and the single common backplane electrode were connected to their own dedicated drivers.

Terry J. Scheffer is Chief Scientist at In Focus Systems, Inc., 189 Paukaa Dr., Hilo, HI 96720-2234; telephone 808/961-3732, fax 808/961-3732, e-mail: terrys@hilo.net. Please direct MLA licensing inquiries to Tim Carlson, In Focus Systems, Inc., 27700B SW Parkway Ave., Wilsonville, OR 97970; telephone 503/685-8742.

While feasible for simple watch displays, static drive was impractical for 8-digit calculator displays because of the sheer number of drivers required, not to mention electrode routing complexity and fine interconnect pitch. In order to reduce the number of drivers required, manufacturers developed multiplexing techniques for LCDs based on the 3:1 selection scheme used for driving EL displays, which was modified with alternate-frame voltage inversion to eliminate damaging net dc voltages.

In the multiplexed EL display, the matrix rows are sequentially selected or pulsed from zero voltage to an amplitude $S = 2D$, while the columns are driven with control voltages of $-D$ or $+D$, depending upon the data. On- and off-pixels receive pulses of $3D$ and $\pm D$, respectively, hence the name 3:1 selection. If the voltage D is adjusted to be at, or just slightly below, the EL threshold voltage, then only the on-pixels light up during their selection interval.

This multiplex drive scheme worked reasonably well for multiplexing a few lines of

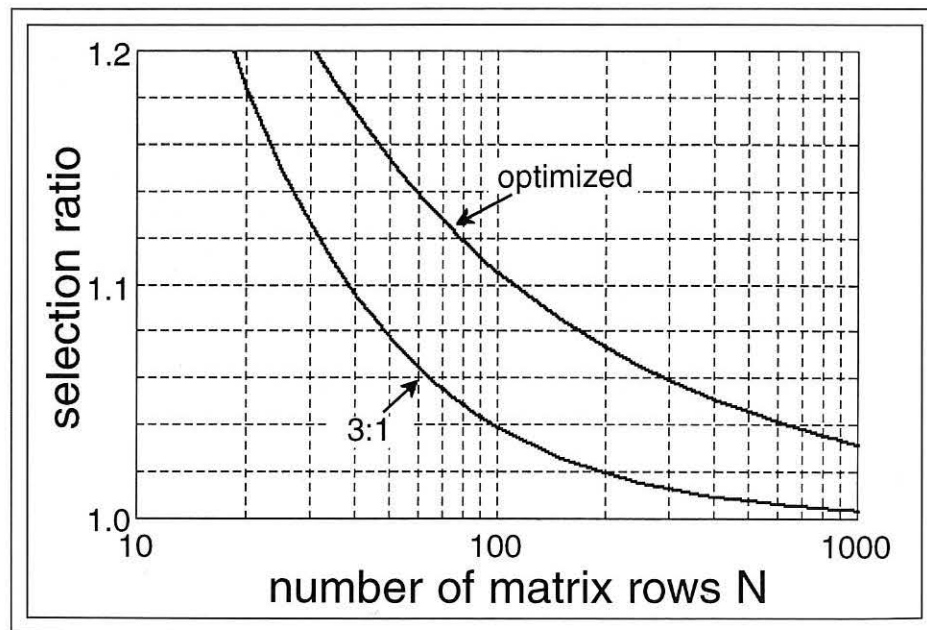


Fig. 1: Alt and Pleshko addressing provided a higher selection ratio compared with the 3:1 selection scheme.

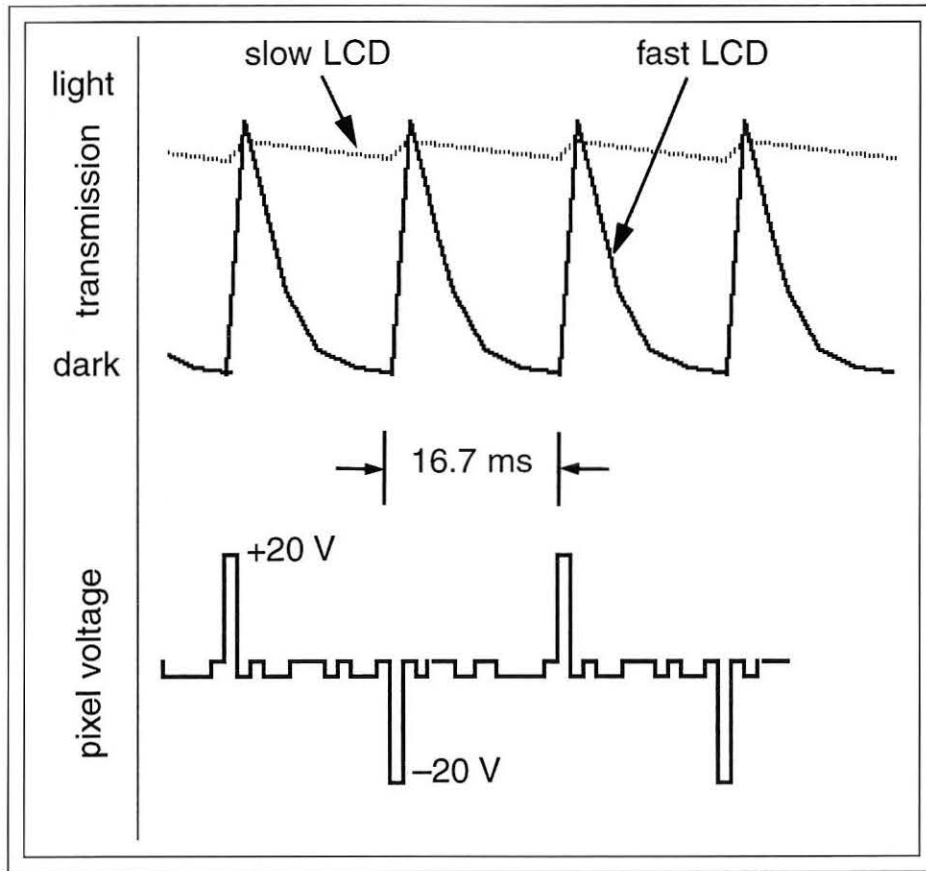


Fig. 2: The on-pixel waveform of a conventionally addressed slow-responding STN display drives the pixel to a constant "white" state. But in a video-responding STN display the rapid decay of transmitted light intensity after the select pulse results in significantly less brightness.

dynamic-scattering-mode (DSM) LCDs, but there was a significant loss in contrast ratio when attempts were made to multiplex the greater number of lines that were usual for the LED and EL displays of the time. In order to understand this performance falloff, Kawakami and co-workers at Hitachi undertook some experiments to investigate the fundamental differences between the response of EL and DSM displays to multiplex drive signals.

Applying a series of pulses to a DSM cell, these researchers expected to see rapid response to each individual pulse, but instead were surprised to see what they referred to as "accumulated pulse response." To learn how the DSM effect responded to actual multiplexing waveforms, they built simple matrices with differing numbers of rows N and then drove them with the 3:1 selection technique. By slowly increasing the supply voltage U

and noting the threshold values, $U_{th_{on}}$ and $U_{th_{off}}$, where the on- and off-pixels first turned on, they were able to establish the empirical expression

$$U_{th_{off}}/U_{th_{on}} = (1+8/N)^{1/2}.$$

These experiments were repeated using the newly reported twisted-nematic (TN) effect with the same results. Attempting to understand this relationship led them to discover that the same expression could be obtained by assuming that the liquid crystal (LC) responded to the root-mean-square (rms) voltage of the pixel waveform. It was only many months later that they realized that they could optimize the selection ratio of on- to off-pixel rms voltages, $\langle V_{on} \rangle / \langle V_{off} \rangle$, and derive what is now known as the "iron law" expression

$$\langle V_{on} \rangle / \langle V_{off} \rangle = [(N^{1/2}+1)/(N^{1/2}-1)]^{1/2},$$

where S/D is now equal to $N^{1/2}$, a function of the number of multiplexed rows N , instead of the fixed value of $S/D = 2$ for 3:1 selection. Closer examination of the optimized drive reveals that the instantaneous pixel voltage during the selection time of an off-pixel is higher than the LC threshold voltage, but the pixel does not turn on as it would in an EL display because of the LC's slow response.

Several semiconductor manufacturers developed chips first for $N = 2$ and then for $N = 3$ after lower-threshold LCs and higher-voltage CMOS processes had evolved. The increase in contrast ratio and brightness for $N = 2$ and $N = 3$ displays using the optimized scheme was actually quite small. The real significance of optimized addressing came later when matrices with much larger values of N were used in high-information-content (HIC) displays. A first step in this direction came in 1978 when Hitachi developed an optimized driver LSI (HD44100) which was used in TN modules with 16 characters and $N = 16$.

Also in the early '70s, Paul Alt at IBM's T. J. Watson Research Center in Yorktown Heights, New York, was independently investigating what factors controlled the electro-optic (EO) behavior of single-pixel and small-matrix DSM displays. Although IBM had no LCD products planned at the time, there was the sense that LCDs could become important. At that time, there were confusing and conflicting ideas about multiplexing LCDs, one of the more popular beliefs being that the limits of multiplexing were determined by the ratio of the LC fall time to the rise time. Alt did not agree with this assessment and was eager to make a fresh start in the laboratory.

Alt began his investigations with DSM cells of different materials, geometries, and temperatures, and measured their EO behavior with a wide variety of voltage excitations, including single unipolar pulses, single bipolar pulses, multiple pulses, dc with pulses, and so on. In looking over the data taken with the different excitations that produced the same EO result, it became evident that the cells were responding to the rms value of the excitation voltage. Alt then addressed the pixels with actual multiplexing waveforms and used the rms response to correctly predict the EO behavior, realizing that the pixel voltage over the whole frame period - not just the instantaneous voltage when the pixel is selected - had to be considered.

LCD technology and history

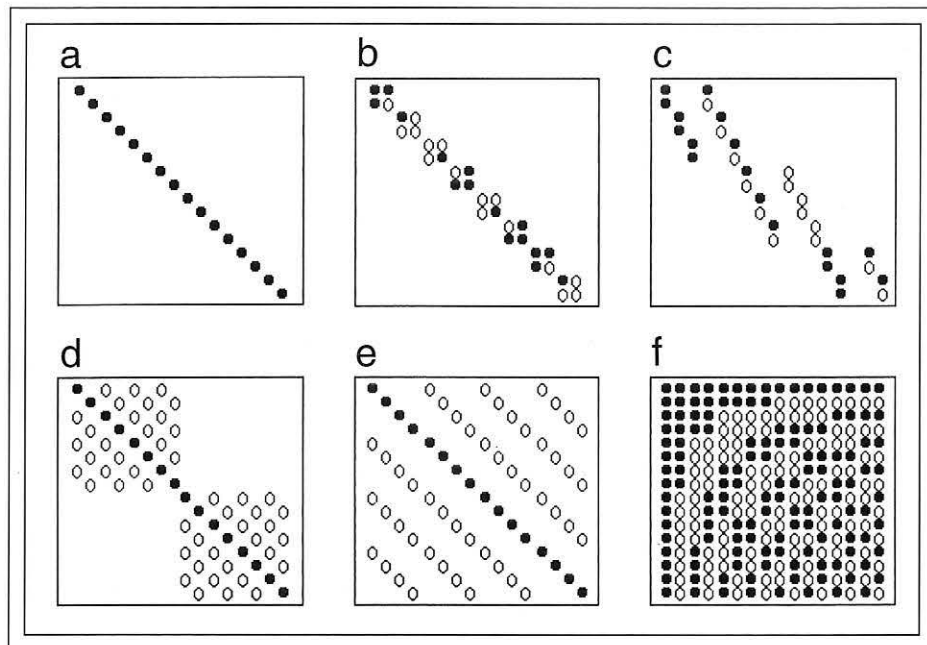


Fig. 3: Orthogonal row functions for driving a simple 16-row matrix include (a) Alt and Pleshko, (b) two-line selection, (c) Enhanced Hi-Addressing, (d) HC-Addressing, (e) four-line MLA, and (f) the Walsh function. In these examples, the horizontal axis represents row number and the vertical axis, time. The symbols \bullet and \circ indicate positive and negative selection voltages. Blank regions indicate where the row voltage is zero.

How to write the general equations for the on and off rms voltages across a pixel then became obvious, and the parameters for maximizing the contrast ratio emerged (Fig. 1). Alt's group soon built a 40×40 -matrix display, and it worked wonderfully.

Strangely enough, Alt found the final result rather disappointing. Anticipating writing a lengthy scientific paper with many complex equations, it was difficult for Alt to resign himself to the fact that the EO response of such a complex electro-hydrodynamic system – with charge flow, light scattering, and electrical and optical anisotropy – could be reduced to the same rms response as the heat from a resistor. The idea of writing a paper was shelved for some time.

Fortunately, Peter Pleshko – Alt's manager at the time – had a better perspective of just how un-obvious this result was. He convinced Alt to write the paper, and contributed to it himself. The result was the classic 1974 paper "Scanning Limitations of Liquid Crystal Displays." After the paper was published, conventional passive-matrix addressing forever became known as Alt and Pleshko addressing.

Breaking the Iron Law?

In investigating a simple two-line matrix and relaxing the condition that the column signal be determined only by the desired pixel value of the selected row, Nehring and Kmetz were able to obtain a selection ratio of 3.0, which was significantly higher than the value of 2.414 obtained by Alt and Pleshko addressing. This discovery raised a whole set of new questions. For a given matrix size N , what was the real optimum selection ratio? Could the selection ratio be made large enough to significantly improve the performance of a high-resolution TN matrix display, and what would these addressing waveforms look like?

These and other questions were answered in Nehring and Kmetz's pioneering paper "Ultimate Limits for Matrix Addressing of rms-Responding Liquid-Crystal Displays." Nehring and Kmetz proved that the Alt and Pleshko selection ratio could be exceeded whenever the number of multiplexed matrix rows was not a perfect square – 4, 9, 16, and so forth – but that the increase was negligible for matrices with more than three rows. At this point, the Alt and Pleshko selection-ratio equation became known as "the iron law of

multiplexing." This result of Nehring and Kmetz meant that researchers would have to look elsewhere to improve the performance of HIC LCDs. The iron law could not be broken.

In their generalized matrix analysis, Nehring and Kmetz also proved that iron-law performance could be achieved with any set of orthogonal functions driving the matrix rows, not just the sequential Alt and Pleshko block functions. In this general case, the column voltages are determined from an inner-product computation of the row voltages and the pixel input data. This proof opened up a new research area known as multiple-line addressing (MLA).

Multiple-Line Addressing

A requirement for rms response is that the characteristic response time be much longer than the frame period of the display. For typical 60-Hz frame rates, this rms behavior breaks down in a display with a characteristic response time short enough to display video images. This breakdown is manifested by a phenomenon known as frame response, in which the liquid crystal reacts strongly to voltage changes occurring within the frame period (Fig. 2). Frame response can significantly reduce the brightness and contrast ratio because of the rapid decay of the optical transmission that occurs after each high-voltage select pulse in the pixel waveform.

Frame response is clearly related to the Alt and Pleshko row-selection pulse. New addressing techniques have been developed that replace this single high-voltage selection pulse with a number of lower-voltage selection pulses distributed over the frame period to minimize frame response. The lower voltage reduces the intensity of the frame response, and the distribution prevents the optical state of the pixel from significantly decaying before it receives another selection pulse.

According to the generalized matrix analysis, any set of orthogonal row functions may be used to address the matrix rows and still preserve the iron-law selection ratio. A subset of these will have the qualities that effectively reduce frame response. An important consideration in choosing functions from this subset is the hardware complexity associated with their implementation. Not only must the row functions be generated, but they also must enter into the determination of the column

voltages through the inner product computations. Examples of sets of orthogonal row-selection waveforms for MLA of a 16-row matrix are compared in Fig. 3.

The first Active Addressing™ prototype developed by Motif used bi-level Walsh-function waveforms [Fig. 3(f)] that selected all the matrix rows all of the time. These functions were very effective in eliminating frame response, but their use required a high degree of computational complexity. Furthermore, this type of function required double-buffering the input image data because a complete frame of input data had to be stored unchanged for an entire frame period in order to correctly compute the inner product.

During this time, another memory buffer had to be simultaneously present to store the incoming image data stream for the next frame. This implementation became too costly in a market of drastically reduced TFT prices, and Motif ceased to be an active player. Motif has, however, retained the intellectual property rights to this technology and is now managing a successful MLA licensing program.

Asahi Glass independently invented the four-line MLA scheme [Fig. 3(e)], whose computational complexity is considerably reduced over that of the Walsh-function

approach, yet frame response is still strongly suppressed because the selection pulses are uniformly distributed over the frame.

At IDRC '97, Sharp presented the four-line MLA scheme called High-Contrast Addressing [Fig. 3(d)]. According to Sharp's presentation, the single matrix is divided into two equal sections, with the four selection pulses distributed in the first half of the frame for the upper display section and in the second half of the frame for the lower display section. A big hardware advantage of this scheme is that it only requires a single frame-buffer memory because the information in the memory portions corresponding to the upper and lower display sections can be alternately discarded after only half a frame, and these memory portions can then be reused to load the next frame's data for the other panel section.

In the two-line MLA schemes developed by Hitachi, referred to as Hi-Addressing [Fig. 3(b)] and Enhanced Hi-Addressing [Fig. 3(c)], the additional hardware complexity of MLA is kept to an absolute minimum, requiring only line buffers for additional memory, since the two selection pulses are separated by only one (b) or two (c) selection intervals. Because the selections are not uniformly distributed, this method is less effective at reducing frame response, so the frame frequency

must be increased. For comparison, Fig. 3(a) shows the Alt and Pleshko row-function matrix, which is identical to the unit matrix. Displays using the MLA schemes shown in Fig. 3 have contrast ratios and response times that are significantly improved over conventionally addressed displays.

Combating Crosstalk

The trends toward higher resolution, larger size, and faster response in notebook-computer displays all exacerbate crosstalk effects. Crosstalk occurs when the optical states of individual pixels in a display are collaterally affected by the optical states of other pixels, and generally appears as vertical and horizontal streaks emanating from displayed patterns. Crosstalk can be traced to non-ideal conditions, such as the finite sheet resistance of the transparent ITO electrodes and output impedance of the row and column drivers. These impedances act in combination with the pixel capacitance to distort the addressing-voltage waveforms and cause pixel voltages other than the desired ones.

The first multiplexed LCD matrices used frame inversion to prevent damaging net dc voltages on the pixels. These panels exhibited particularly intense vertical streaking above and below horizontally striped patterns. This crosstalk was traced to the panel's low-pass filtering action, which rounded off the sharp voltage transitions in the column-drive waveforms. The round-off would not cause visible artifacts if it occurred to the same degree at every pixel, but the degree of rounding off is pattern dependent. Thus, the pixel voltages in a nearly all "on" column will be very close to their expected values because there are few transitions in the column waveform to be rounded off. However, in a column displaying a dotted pattern, there are many on and off transitions, and the round-off distortion will noticeably decrease the rms pixel voltages, causing the streaking under these patterns. The streaking has been reduced in conventional displays by inverting the polarity of the row and column waveforms more frequently than once per frame. This has the effect of making the number of transitions in the column waveforms less dependent upon the image pattern.

In order to reduce the voltage required of the row drivers, the Alt and Pleshko method was initially modified by applying an offset voltage to both row and column electrodes

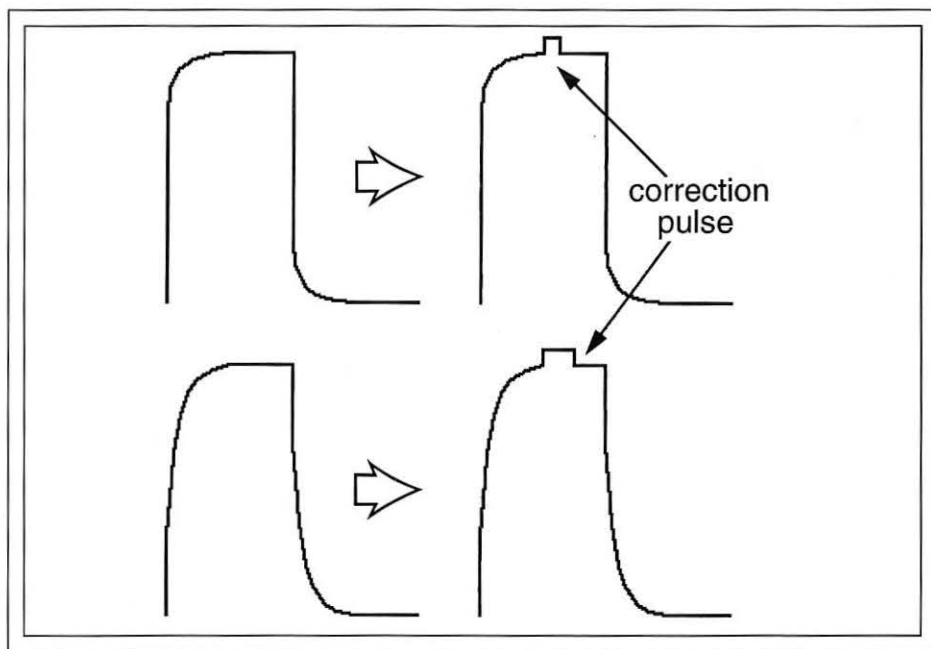
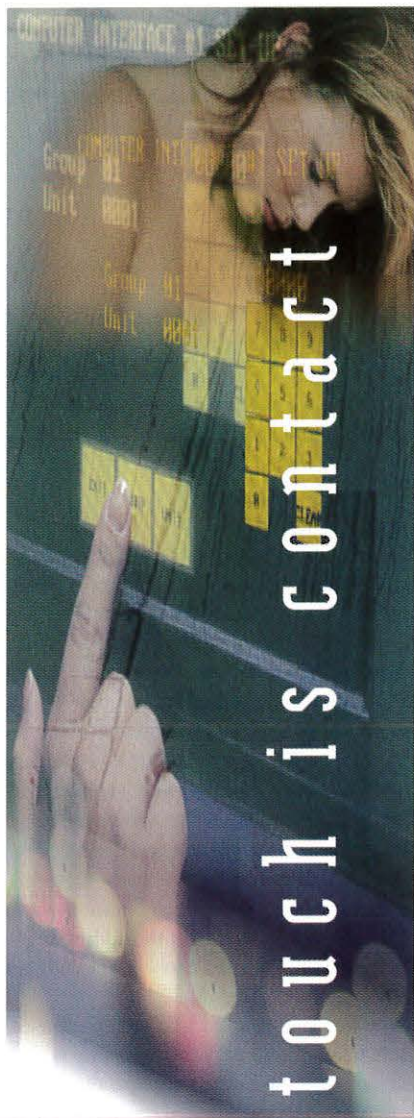


Fig. 4: Horizontal shadowing can be eliminated by compensating for variable distortion of row-selection pulses, as described by Hitachi at IDRC '97.



Apogee-One

Apogee Touch/LCD System is the turn-key solution to your man-machine interface needs. Bright and crisp color-TFT integrated with digital resistive touch screens is the most reliable touch solution you could ever find.

It's that simple!

Get in touch with CyberTouch.



CyberTouch

Touch Screens • Touch Monitors • Touch Systems

805.499.5000 • Fax 805.499.5888
sales@cybertouchusa.com
www.cybertouchusa.com

LCD technology and history

during one phase of their polarity sequence. This became known as the Improved Alt and Pleshko Addressing Technique (IAPT). An undesirable consequence of this method was the introduction of transient voltages on the pixels, which degraded the contrast ratio. Sanyo was first to remove this "improvement" with their "Smart Addressing," which used tri-level row drivers capable of a $2S$ voltage swing instead of the traditional bi-level row drivers with the lower $S + D$ voltage requirement. The added cost of the high-voltage drivers in the Sanyo approach can be partially offset with cheaper, lower-voltage column drivers. It seems that the IAPT method cannot meet the performance targets of HPA.

To achieve acceptable image quality in notebook screens, it has been necessary to develop more-sophisticated crosstalk-elimination schemes. Recently, Hitachi, Sharp, and others have published elegant methods that actively eliminate crosstalk, as opposed to the conventional passive methods described above. At least three different origins of crosstalk have been identified: vertical stripe shadowing, vertical block shadowing, and horizontal shadowing.

The cause of vertical stripe shadowing was discussed earlier in connection with the frequent polarity inversions. Sharp has developed an active method that corrects for this particular distortion, rather than having it apply to all images. The method determines whether or not there is a voltage transition on the column by comparing the image data of the selected row with that of the previous row. If a transition has occurred, a small correction pulse is applied to the column voltage in a specially developed column-driver chip to compensate for the loss in rms pixel voltage associated with the rounding off of that transition. If there is no transition, then no correction is applied. Thus, virtually all stripe shadowing is eliminated, while at the same time the contrast ratio appropriate to the iron-law selection ratio is restored.

Vertical block shadowing is caused by voltage switching transitions on the column electrodes inducing waveform-distorting voltage spikes on the row electrodes via the differentiation effect of a series RC circuit. This is a global coupling phenomenon, where the same distortions are simultaneously induced on all the row electrodes. These voltage transients can become particularly large if many column electrodes simultaneously switch in the same

direction, as can easily happen if the display shows a similar pattern across many columns. Several schemes are now in use which detect these global transients upstream at the row-driver voltage source and apply an appropriately sized counter-pulse to compensate for the transients (Fig. 4).

Crosstalk associated with both vertical stripe shadowing and vertical block shadowing concerns waveform distortions that occur the majority of the time, when the pixel is not selected. Horizontal shadowing, on the other hand, is introduced by distortion of the row-selection pulse, which occurs during the relatively short period of time when the pixel is selected. The pixel capacitance in a super-twisted-nematic (STN) display depends upon the orientation of the liquid crystal because its dielectric constant is anisotropic. An on-pixel could have three times the capacitance of an off-pixel, so a matrix row with many on-pixels will round off the selection pulse more strongly than a matrix row with only a few on-pixels. Counting the number of on-pixels in the selected row and applying an appropriate compensation voltage to the selection pulse eliminates this type of crosstalk.

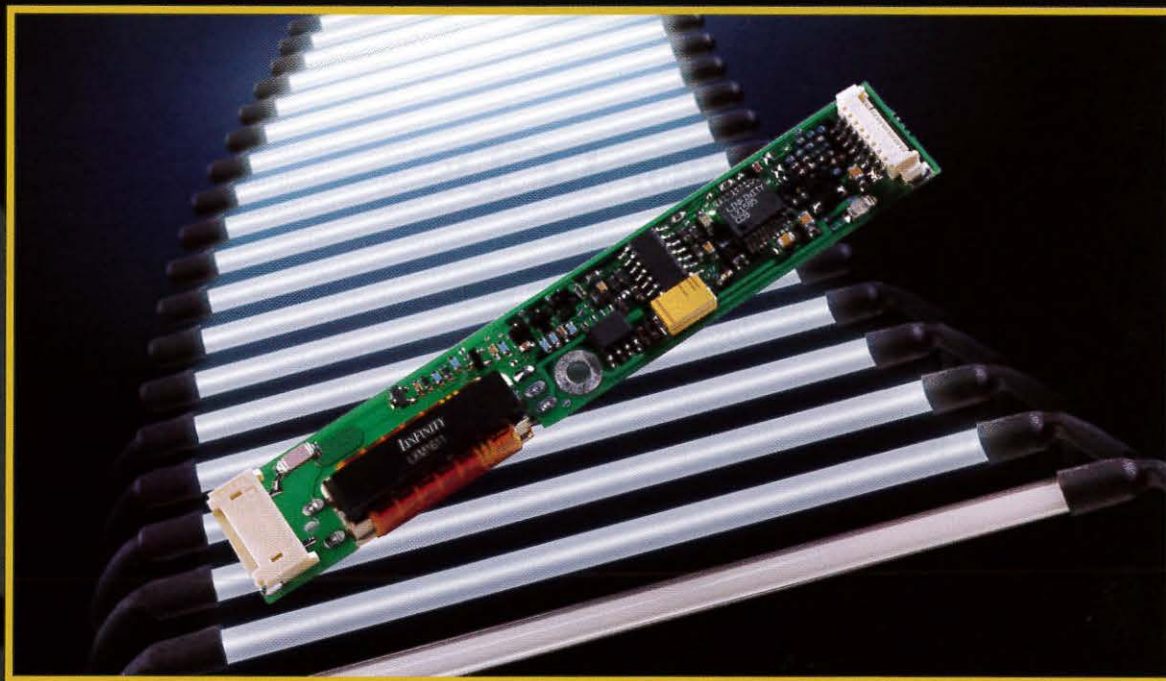
Outlook

HPA schemes have kept STN displays viable in the notebook-computer market. Because of their simpler construction, STN displays will always be cheaper to manufacture than their thin-film-transistor (TFT) counterparts. STN displays are therefore likely to dominate in price-sensitive areas for the foreseeable future. The emergence of LCD desktop monitors presents a new opportunity for STN displays because of the ease at which they can be adapted to larger sizes compared with TFTs. The availability of larger STN panels at significantly lower costs than TFTs will be a strong driving force for this new market.

HPA will also be widely applied to mobile applications using reflective STN-LCDs because of its significantly lower power dissipation compared with conventional addressing. ■

Please send new product releases or news items to Information Display, c/o Palisades Institute for Research Services, Inc., 411 Lafayette Street, 2nd Floor, New York, NY 10003.

SAVE POWER! SAVE MONEY!

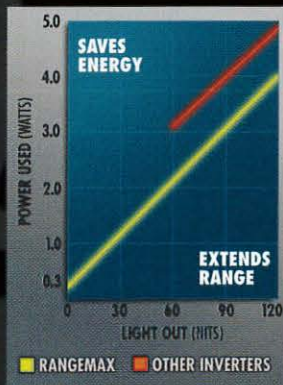


ONLY RANGEMAX™ INVERTERS GIVE YOU 1,999 LIGHT LEVELS BETWEEN BLACK AND BRIGHT.

RangeMAX inverters combine breakthrough 2000:1 digital dimming with exclusive controlled-strike waveform features to help you extend lamp life, battery life and reliability.

Here's jitter-free, full featured backlight performance designed to exceed your every expectation. RangeMAX inverters are available for single, dual or quad LCD display applications. All delivered in space-saving modules, as small as 10mm x 6mm x 135mm.

If you design LCD backlit displays, let RangeMAX sharpen your competitive edge. For twice the technology at half of what you'd expect to pay, call us, fax us or visit Linfinity's web site today.



THE INFINITE POWER OF INNOVATION

Linfinity Microelectronics
800-LMI-7011
Fax: 714-372-3566
www.linfinity.com

ACI Electronics 800-645-4955, All American 800-573-ASAP, FAI Electronics 800-677-8899,
Future Electronics 800-388-8731, Jan Devices 818-757-2000, Arrow/Zeus Electronics 800-52-HIREL

©1998.™ RangeMAX is a trademark of Linfinity Microelectronics Inc. Patents pending.

Circle no. 14

Reflective Color LCDs

The market for reflective color LCDs is very active, but which technology will prevail?

by Alan Mosley

BACKLIT color active-matrix LCDs (AMLCDs) and supertwisted-nematic liquid-crystal displays (STN-LCDs) are widely used in notebook computers and are now being introduced as displays for desktop monitors. The present value of the worldwide markets for these two backlit technologies is around \$10 billion and is predicted to grow to around \$25 billion by 2003.

Almost since the introduction of STN-LCDs and AMLCDs in the late 1980s, manufacturers have continually sought to reduce the power consumption and bulk of their display modules. Although they have achieved remarkable reductions in both areas – typical values of power consumption and depth are now 3 W and 7 mm, respectively – there is still a demand for further improvements. It is now recognized that in order to meet the demands of the marketplace for reduced power consumption and bulk, it will be necessary to remove the backlight from the display module.

These market demands are centered around the large range of handheld computing and telecommunications products, including palm-top computers, mobile phones, pocket orga-

Alan Mosley is the Technical Director of MicroPix Technologies, a new company spun out of CRL to exploit miniature liquid-crystal-on-silicon displays; MicroPix/CRL, Dawley Road, Hayes, Middlesex UB3 1HH, U.K.; +44-1-81-848-6400, fax +44-1-81-848-6653, e-mail: amosley@crl.co.uk. He is also a Regional Associate Editor of Information Display and Director of the U.K. & Ireland Chapter of SID.

nizers, and personal digital assistants. Until recently, the LCDs used in these products were reflective monochrome supertwisted displays. These display modules are thin (about 5 mm) and have a very low power consumption (about 0.3 W), but their functionality – and market value – is limited by the absence of color. To overcome this deficiency, LCD manufacturers have begun to develop reflective color LCDs.

The first examples of this class of displays, which operate in the electrically controlled birefringence (ECB) mode, are already in the marketplace. Presently, the optical performance of these displays is limited because they are only able to provide four to eight colors, including black and white. In view of the

present situation, many LCD manufacturers, particularly in Japan, are developing new types of reflective color LCDs. Some of the various approaches that have been reported will be described below.

Technologies

The ideal reflective color LCD would have multicolor single pixels, since this would avoid the light losses associated with dividing each pixel into red, green, and blue sub-pixels, each of which transmits (and subsequently reflects) only one-third of the entering light. But this ideal approach is very difficult to implement because each pixel must provide a range of colors and gray levels. A technique that avoids this difficulty is to use a stack of



Fig. 1: Sharp's reflective HR TFT-LCDs deliver enhanced performance despite using polarizers and color filters.

Sharp

three displays, with each display providing a single primary color. The main disadvantage of this method is the cost of three displays.

Consequently, some manufacturers are continuing to use color filters, but are finding ways in which to increase the brightness of the LCD. An obvious approach is to use a liquid-crystal effect that does not use polarizers, such as the dye phase-change, also known as the guest-host effect. In spite of this analysis, some manufacturers – most notably Sharp – have developed reflective color LCDs that employ both polarizers and color filters (Fig. 1).

Reflective Color ECB STN-LCDs

Simple reflective color ECB-type STN-LCDs – such as the 80 × 64-pixel plus icons, four-

color displays produced by Varitronix – are already in the marketplace (Fig. 2). The technology results in multicolor single pixels that not only enhance the brightness of the display but also remove the need for expensive color filters. However, typical optical performances are relatively poor:

- Contrast ratio, 2.5:1
- Viewing angle in the vertical direction, ~30°
- Reflectivity relative to white paper, ~20%
- Number of colors, 4

The operation of these displays is based on the electrical control of the effective birefringence of the liquid-crystal material.

The wavelength of the light transmitted by an ECB STN-LCD having essentially crossed polarizers depends on the birefringence (Δn), thickness (d), and twist angle of the liquid-

Table 1: Performance Specifications of the Sharp Polarizer-Based Reflective Color LCD

Dimensions (W × H × D)	210.7 × 152.8 × 2.4 mm
Pixels	[640 × RGB] × 480
Reflectivity	30%
Contrast Ratio	10:1
Viewing Angle for CR > 2:1	100° (V), 120° (H)
Number of Colors	260,000
Response Time	50 ms
Power Consumption	0.3 W
Weight	190 g

crystal layer. In a reflective color ECB STN-LCD, the effective value of Δn is changed by varying the data voltage applied to a particular display column, leading to a change in the peak wavelength of the transmitted light. The value of the product $\Delta n d$ is chosen so that the peak wavelength transmitted in the non-select voltage state is in the red part of the visible spectrum.

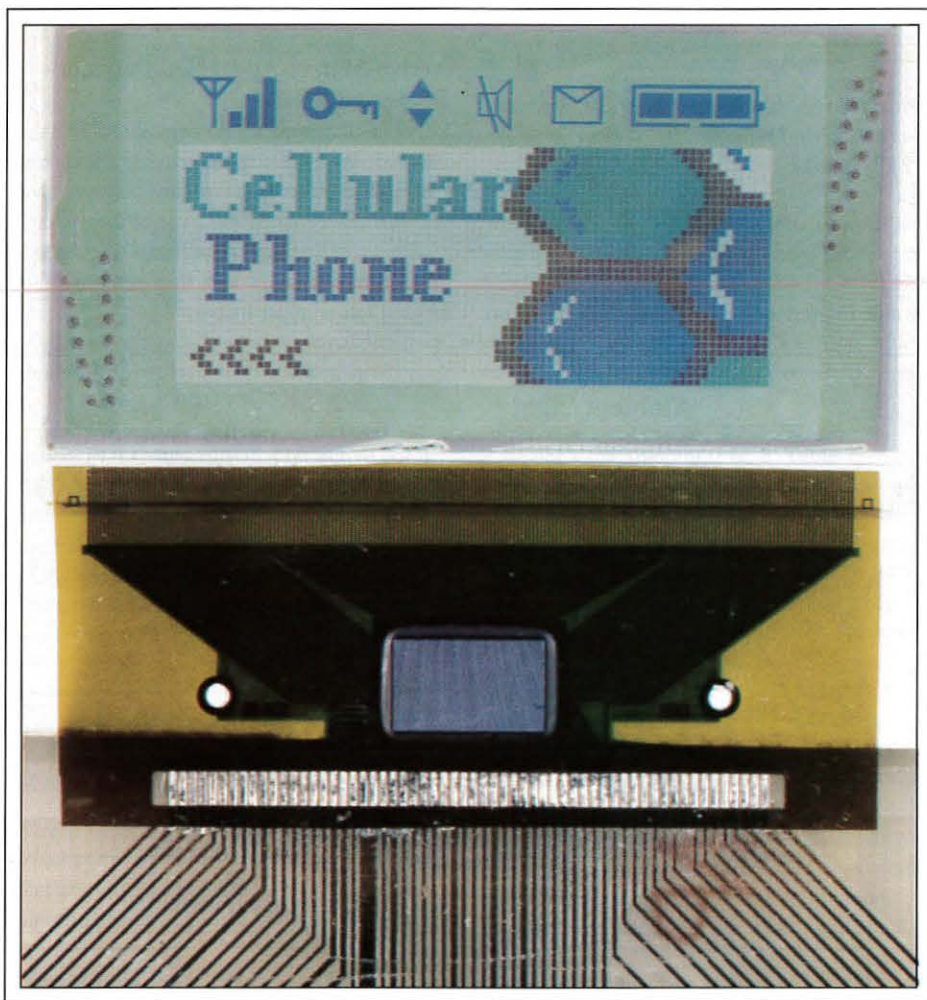
As the data voltage is increased, the effective value of n decreases, which decreases the peak transmitted wavelength, moving it toward the blue end of the spectrum. Applying the maximum permissible data voltage produces a black pixel.

At present, it is hard to see how reflective color ECB STN-LCDs will be able to produce more than eight colors and acceptable values of contrast ratio and viewing angle. On the other hand, they are relatively low in cost and are already in the marketplace, generating revenue for their manufacturers. Nevertheless, it must be concluded that these reflective color STN-LCDs are unlikely to survive and will be replaced by one or more of the other reflective color LCD technologies that are now under development.

Reflective Color AMLCDs

The great power of active-matrix addressing is its ability to address a wide variety of liquid-crystal materials. The only limitation is that these materials should have very high resistivities, typically $10^{14} \Omega\text{-cm}$.

A key parameter of every AMLCD technology is its aperture ratio, the percentage of the nominal pixel area through which light can pass. The larger the value of this ratio, the brighter the display. In reflective AMLCDs,



Varitronix

Fig. 2: The first examples of this class of displays, which operate in the electrically controlled birefringence (ECB) mode, are already in the marketplace.

LCD technology

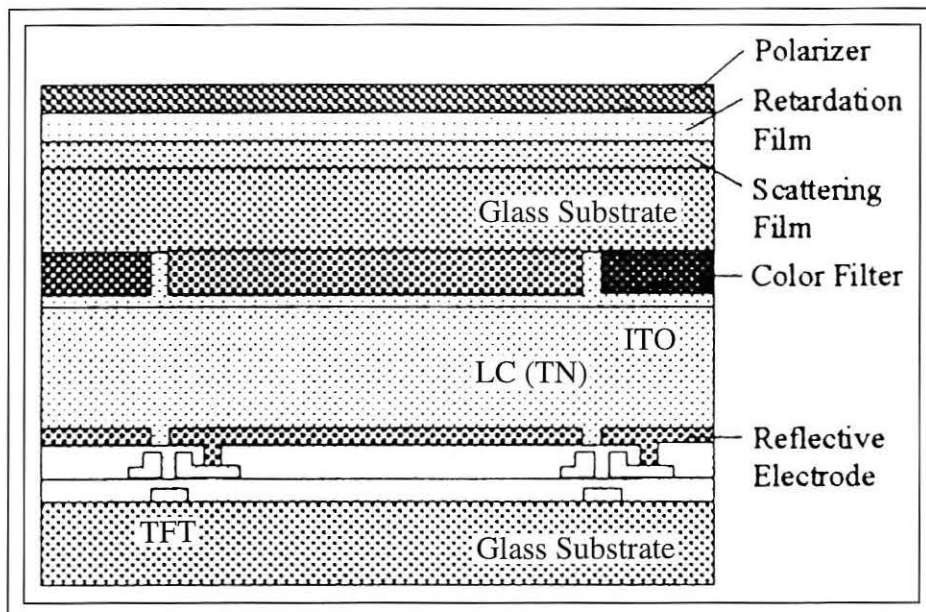


Fig. 3: In reflective AMLCDs, it is possible to increase the value of the aperture ratio dramatically by using a planarized electrode that also acts as an internal reflector. [Courtesy of Ogawa et al., SID Intl. Symp. Digest Tech. Papers, 217 (1998).]

it is possible to increase the value of the aperture ratio dramatically – from 60 to 85%, for example – by using a planarized electrode that also acts as an internal reflector (Fig. 3).

Current work on reflective color AMLCDs can be divided into three areas: AMLCDs with polarizers, active-matrix-addressed dye phase-change displays, and active-matrix-addressed polymer-dispersed LCDs.

AMLCDs with Polarizers

One of the first approaches to reflective color LCDs was simply to use twisted-nematic (TN) displays with less efficient, and hence more transmissive, polarizers and less absorbent color filters – which is possible because in a reflective LCD the light passes through the color filter twice. But these displays were far too dark and led to the development of displays with internal reflectors, high aperture ratios, and a single polarizer.

Then, Sugiura and Uchida of Tohoku University improved the performance of the internal reflector by building a microstructure into its surface. This led to the fabrication of acceptable reflective color LCDs, such as Sharp's 8.4-in. VGA display (Table 1).

The advantage of this technology – a single polarizer with color filters and an internal reflector with a microstructured surface – is

that it uses materials and processes very similar to those used for more conventional transmissive AMLCDs. But, ultimately, we should be able to produce a superior display based on

a liquid-crystal effect that does not use polarizers.

Active-Matrix-Addressed Dye Phase-Change Displays

Dye phase-change LCDs, which were first reported around 1970, can provide bright images in a reflective display because they do not require polarizers. By blending appropriate red, green, and blue dichroic dyes, we can produce a black-on-white display that can be combined with RGB color filters, an internal reflector, and active-matrix addressing to provide a reflective color LCD.

The main problem with this approach is that it is difficult to obtain dyes with high resistivities, and low-resistivity dyes lead to low holding ratios and increased power consumption.

Active-Matrix-Addressed Polymer-Dispersed LCDs

Polymer-dispersed liquid-crystal (PDLC) displays are well known and provide a polarizer-free optical effect that switches between clear and scattering states. Because of these characteristics, PDLC materials have been used in projection systems, where they can provide a bright high-contrast image.

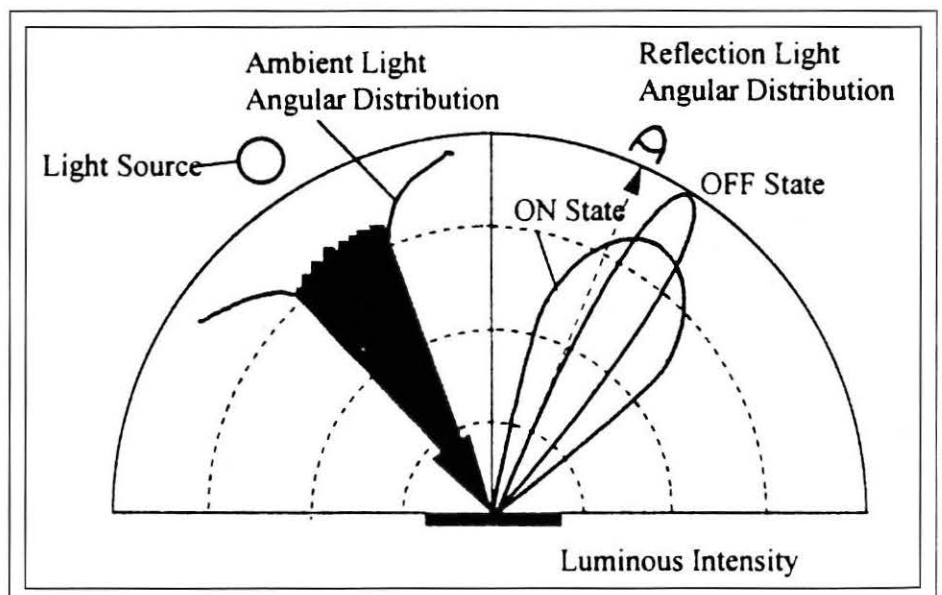


Fig. 4: In the PDLC display's non-select state, the PDLC material scatters light into the eye of the viewer. In the selected (high-voltage) state, the material is transparent, so incident light is specularly reflected from a mirror-like internal reflector and passes beyond the viewer's line of sight. [Courtesy of Sonehara et al., SID Intl. Symp. Digest Tech. Papers, 1023 (1978).]

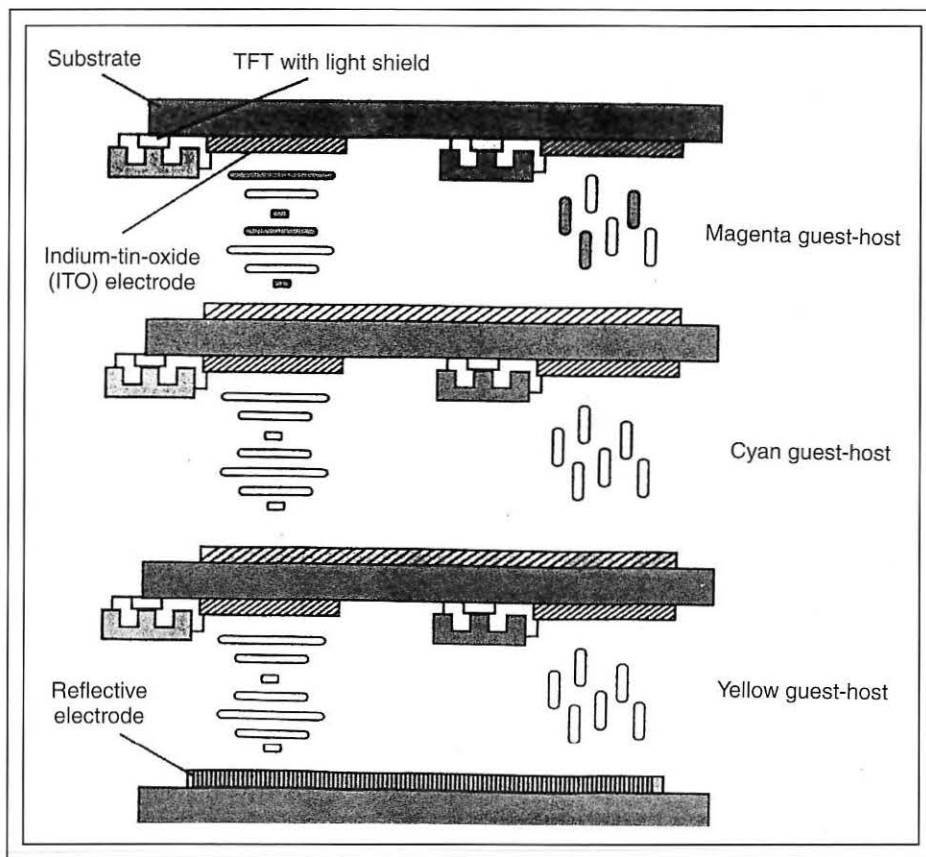


Fig. 5: In a triple-layer dye phase-change display, the dyes are subtractive rather than additive and parallax is reduced by selecting the order of the dye layers. (Courtesy of Toshiba.)

In 1997, Seiko reported using an active-matrix PDLC structure in a reflective color LCD, with MIMs being used as the switching elements. In this display's non-select state, the PDLC material scatters light into the eye of the viewer. In the selected (high-voltage) state, the material is transparent, so incident light is specularly reflected from a mirror-like

Table 2: Performance Specifications of the Seiko PDLC-Based Reflective Color LCD

Size	5.6-in. diagonal
Pixels	[320 × RGB] × 240
Reflectivity	8%
Contrast Ratio	10:1 with collimated light 5:1 with diffused light
Number of Colors	4096
Response Time	50 ms (rise + decay)
Power Consumption	0.12 W

internal reflector and passes beyond the viewer's line of sight (Fig. 4, Table 2).

At present, we do not appear to have a universal method for measuring the reflectivity of LCDs. Therefore, purchasers must be careful when using published figures to judge the performance of reflective color LCDs. Subjectively, the Seiko and Sharp displays appear equally bright.

In its present form, the Seiko display has the disadvantage that it requires high voltages (of the order of 20 V) to switch the PDLC layer, but switching voltages in the range of 7-10 V have been reported elsewhere. Although the Seiko display has the advantage of being polarizer-free, it has the disadvantage that it uses color filters, which immediately reduce the level of the reflected light to 33%.

Multi-Layer Displays

By using a stack of three displays it is possible to produce a display with multicolor single pixels, thereby avoiding the light losses asso-

Table 3: Performance Specifications of a Three-Layer Dye Phase-Change LCD

Size	3.4-in. diagonal
Pixels	240 × 160
Reflectivity	35%
Contrast Ratio	4:1
Viewing Angle	140°
Number of Colors	512
Response Time	?
Power Consumption	?

ciated with using RGB sub-pixels. As stated above, the main disadvantage of this method is cost. Two techniques have been reported: one based on active-matrix-addressed dye phase-change LCDs and one based on the stabilized cholesteric-texture displays developed by Kent State University.

Two significant points concerning a triple-layer dye phase-change display are that (1) the dyes are subtractive rather than additive and (2) parallax is likely to be a problem (Fig. 5). To overcome parallax, Toshiba has used 0.4-mm glass substrates and carefully selected the order of the dyes in the stack. Toshiba found that the lowest level of parallax was obtained by placing magenta at the top and yellow at the bottom. While it appears that the parallax problem is virtually solved, the fundamental problem of the relatively high cost of three displays remains. The performance of a prototype display reported by Toshiba is summarized in Table 3.

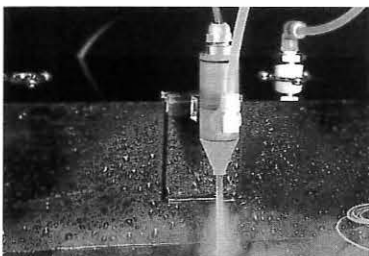
The response time of dye phase-change displays can be long, over 100 ms, because of the increased viscosity of the liquid-crystal material caused by the addition of 3-5% of dye. Toshiba did not provide a value for the power consumption of this display in a paper delivered at the 1997 SID Symposium, but they did report that the dyes had been purified to increase their resistivities.

Multi-Layer Stabilized Cholesteric-Texture LCDs

The polymer- and surface-stabilized cholesteric-texture LCDs developed by Kent State University are able to switch between reflecting a narrow band of circularly polarized light and transmitting all light. The peak wavelength of the reflected light is the product of the pitch of the cholesteric texture and its average refractive index.

A NEW AGE IN FLAT PANEL CLEANING PULSE JET MEGASONIC CLEANERS

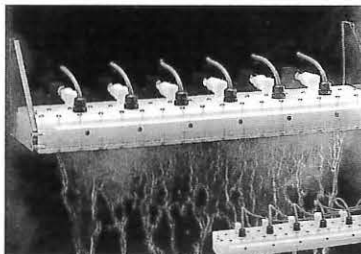
HONDA ELECTRONICS CO.LTD.



W-357-P25

- Designed specifically for Flat Panel Display cleaning.
- Application of megasonic energy to the flowing medium provides effective sub-micron cleaning results.
- Minimize dirt particle restriction due to flowing medium.
- Substrate sizes: from miniature FPDs to very large widths.

- The W357-P25 can be effective method to clean substrate edges.
- TEFLON® or PP nozzles eliminate metal ion contamination.
- Post-Lapping, Pre-Coating, and Pre-Bonding cleaning.
- Easy implementation into production line.



W-357-L5580

Nano-Master carries several other tools relevant to the flat panel industry. Please contact us or see web for more information: Ultrasonic Sound Pressure Meters, Dip Tank Ultrasonic Cleaners, Ultrasonic Mini Cutters, Ultrasonic Flow Meters, etc.



NANO-MASTER, Inc.

3019 Alvin Devane Blvd. • Suite 220 • Austin, TX 78741 • Tel: (512) 385-4552 • Fax: (512) 385-4900
email: main@nanomaster.com • www.nanomaster.com

Circle no. 15

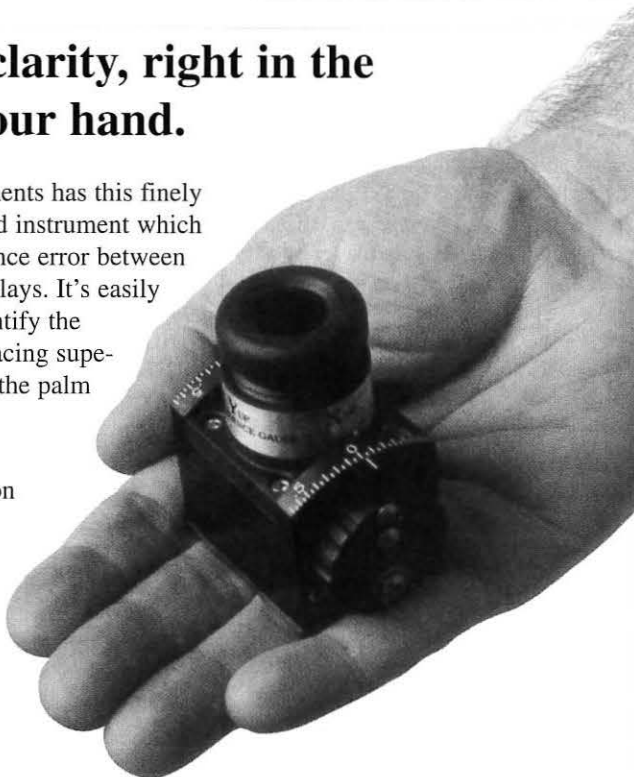
KLEIN Instruments Corporation

**KLEIN CM7AG
Convergence Error Gauge**

Superior clarity, right in the palm of your hand.

Only Klein Instruments has this finely calibrated, handheld instrument which measures convergence error between colors on CRT displays. It's easily manipulated to identify the degree of error, placing superior clarity right in the palm of your hand.

More information on Klein's advanced quality assurance products is just a phone call away. We'd love to hear from you.



Test Equipment for Computer Monitor Displays

ph: 503-245-1012 • fax: 503-245-8166 • www.kleininc.com Portland, OR USA

Circle no. 16

LCD technology

By changing the pitch, we can produce structures that reflect red, green, or blue light. A 3-in.-diagonal 240 × 160-pixel two-layer device consisting of blue and yellow reflecting layers and a black light absorber was described by Kent Displays at the 1997 IDRC in Toronto. Although stabilized cholesteric-texture LCDs are able to show gray scale, the reported display did not have this capability and was therefore limited to four colors: blue, yellow, white, and black.

A Reflective Future – but with What Technology?

There are many different approaches to reflective color LCDs. At the present time, reflective color LCDs derived from ECB STN-LCDs are already in the marketplace, while those based on conventional AMLCDs are about to begin production. This is not too surprising, given the infrastructure supporting STN-LCDs and AMLCDs. It is clear that there is a very strong demand for reflective color LCDs, but it is difficult to predict which of today's technical approaches will ultimately be the most successful. ■

Internet Consulting and Database Research

Get on the "Net." Training, lectures, Web sites, and consulting by the former Executive Director of the Internet Society. Visit the SID homepage at

<http://www.sid.org>

Database research. Patent Searches, Technical Literature, Competitive Analysis, Market Research, Demographics

H.L. Funk Consulting
7 Diane Court
Katonah, NY 10536
Telephone/Fax: 914-232-3530
E-mail:
consult@hlfunk.com

Circle no. 17

From the day we're born,
we go into the world
looking for what we
want with our eyes.



Almost nothing has a bigger impact on product preference than the visual performance of a display. OCLI's image enhancement technology delivers **vivid colors, high contrast** and **crisp resolution** on direct view and projection displays. The difference is an immediately visible improvement that will win over even the most discriminating customers, the moment they see it.

Contact us for more information: www.ocli.com

USA (707) 545-6440 (888) 312-0848 EUROPE (49) 6162-93030 JAPAN (81) 3-3225-8974

Circle no. 18

The Three Components of Reflection

The ambient light that reflects off a display screen can affect image quality more than the light intentionally produced by the display – but which type of reflection is the most important? This is the second in a series of articles from NIST.

by Edward F. Kelley, George R. Jones, and Thomas A. Germer

BEAUTIFUL DARKS IN BRIGHT LIGHT.” That’s another way of saying that reflections from the display surface are under control. Perhaps we will see advertisements making this statement in the future (Fig. 1). But the actual meaning of such claims is vague unless the reflection properties are clearly indicated.

If we were to state only the familiar diffuse and specular reflection properties, would the specifications be adequate? Not really: we might still not know how the display will look to the eye. There are actually three components of reflection with which we must contend in order to properly describe display reflection as it is perceived by the eye.

This is not a criticism of existing reflection-measurement methods and recommended practices. Defining how an electronic display actually appears to the eye may require a more complete description than is needed for fabric or paint.

When considering reflection properties, specular (mirror-like) reflection and diffuse reflection (as seen with surfaces like common copy paper and walls painted with flat, or matte, paint) are often thought of. With specular reflection, the observed luminance in the virtual image is proportional to the luminance

of the source. The luminance of reflected images in a mirror doesn’t depend upon their distance from the mirror, just as the luminance of objects does not vary with distance when we observe the objects directly.

With the so-called diffuse reflection, many people think in terms of Lambertian reflection – the luminance of the surface is independent of the direction from which the surface is

observed and depends only upon the illuminance of that surface. (A nearly perfect Lambertian surface is not common and is difficult to produce in practice.)

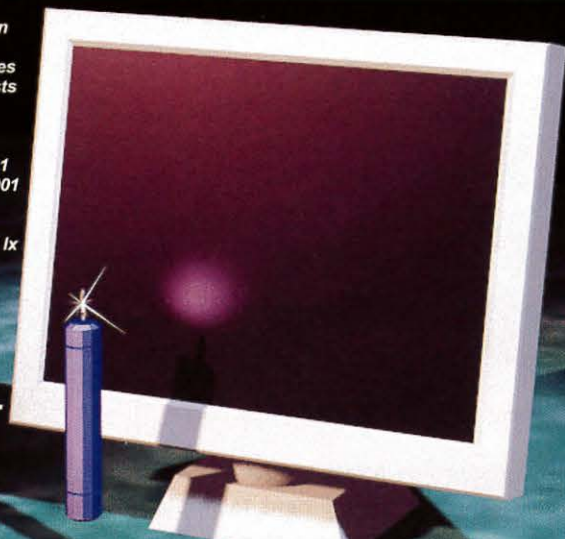
The problem here is that the display industry sometimes think that the terms “diffuse” and “Lambertian” mean the same thing, and that is generally *not* the case for displays.

According to the American Society for Test-

FPD-MAKERS, INC
Beautiful darks in bright light!

Using multi-layer anti-reflection coatings and special surface treatments, our display provides you with extraordinary contrasts even in bright office environments. Note these specifications:

*Specular reflectance < 0.00001
Lambertian reflectance < 0.0001
Haze reflectance = 0.0082
Ambient contrast 150:1
using an illuminance of 500 lx
Luminance: 200 cd/m²*



Introducing...
FPD123
1024 x 768

Edward Kelley

Fig. 1: This fictional advertisement, which specifies three kinds of reflectance, could not honestly be used to describe any display that exists today.

Edward F. Kelley, George R. Jones, and Thomas A. Germer are physicists at the U.S. National Institute of Standards and Technology (NIST), Bldg. 225, Room A53, Gaithersburg, MD 20899; telephone 301/975-3842, fax 301/926-3534, e-mail: kelley@eeel.nist.gov.

ing and Materials (ASTM), a diffuser is a surface that takes light energy away from the specular direction and distributes it in many other directions.¹ The term is not constrained to refer only to a Lambertian surface. So, it makes sense to use the term "Lambertian" for reflectance properties associated with a perfectly diffuse reflection.²

Four different screens showing the same-sized text with a black-and-white metal target on the front surface, to assure they are ren-

dered equivalently in the reproduction, are shown in Fig. 2. The screens are illuminated by a 60-W light bulb in a small aluminum shade, and the bulb has a small opaque black square on its surface.

Figures 2(a) and 2(b) show cathode-ray tubes (CRTs), and Figs. 2(c) and 2(d) show flat-panel displays (FPDs). Figure 2(a) is an older CRT monitor that appears to have a medium-gray screen when turned off; the CRT in Fig. 2(b) appears dark gray when

turned off. When the FPD screens are turned off, the surface of the FPD in Fig. 2(d) will appear darker than that in Fig. 2(c). Unfortunately, the limitations of the camera used and the printing of the images on paper severely restrict the range of contrast that is rendered here for all the displays, especially for the CRT in Fig. 2(b) and the FPD in Fig. 2(d).

How should these reflection properties be described so that we can understand how usable a display would be in a particular envi-

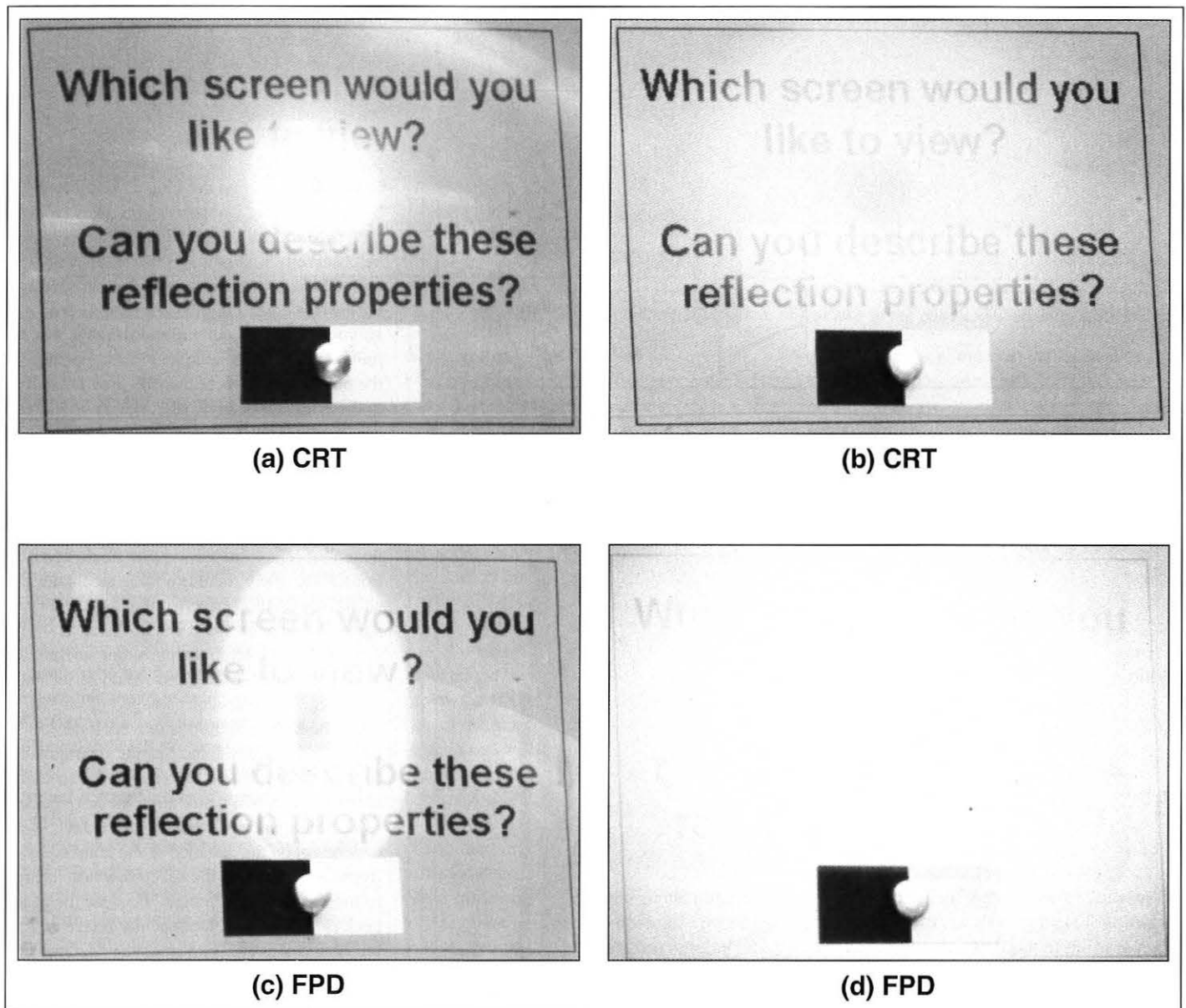
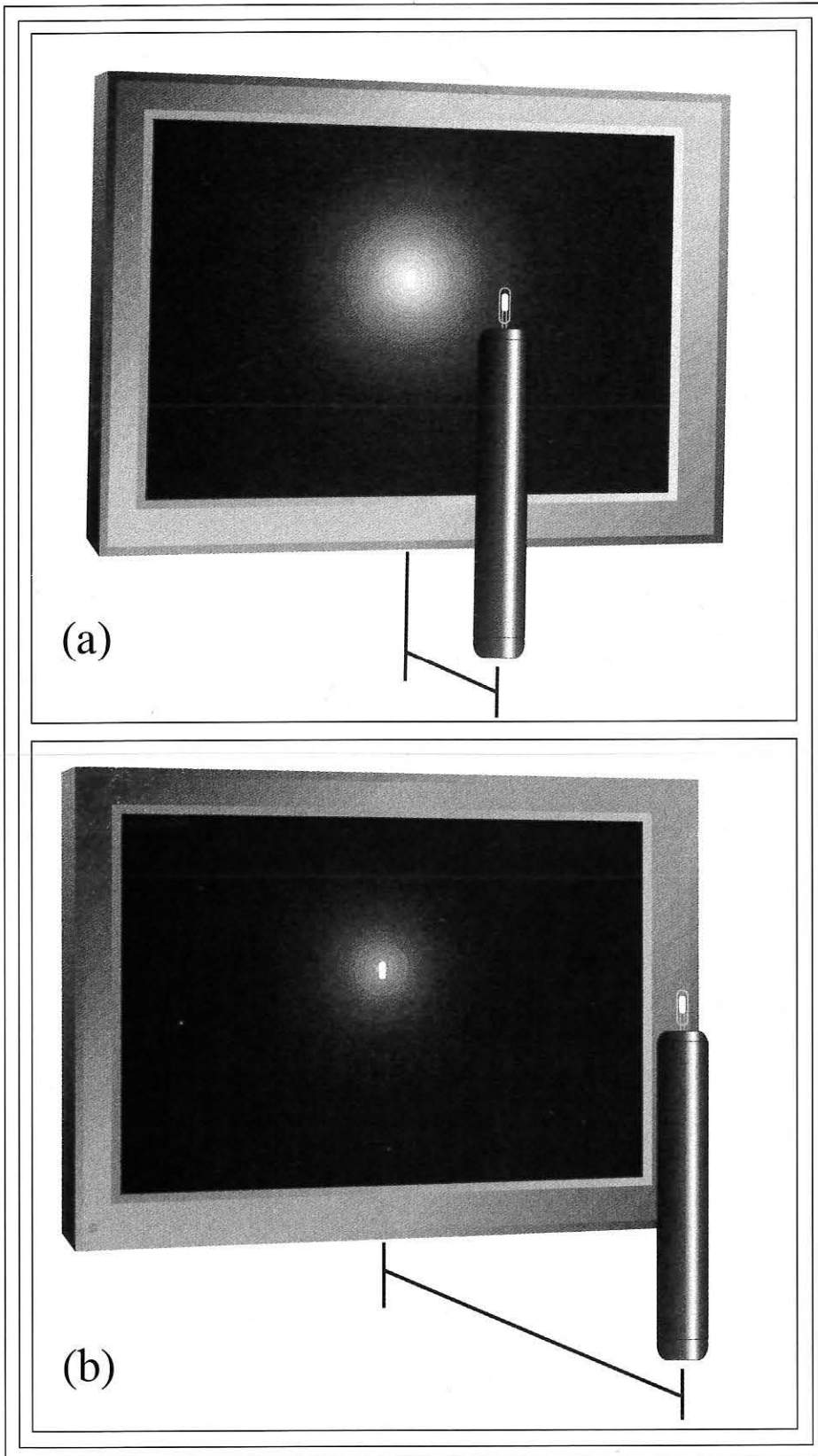


Fig. 2: These four displays exhibit very different reflection characteristics, each one representing a different combination of specular, Lambertian, and haze reflectance.



ronment and how it would appear to the eye? Would specifying the specular and Lambertian (or diffuse) components convey enough information to describe the reflected image? Probably not; something more is needed.

The best way to observe the reflection properties of a display surface is to look at the reflection of a point source of light. (With some flashlights, the head can be removed to expose the small high-intensity bare bulb. This will serve well as a point source of light.) In general, and with most CRT screens, three manifestations of the reflection of the point source can be observed (Figs. 3 and 4).

If there is a specular component, as is the case with most CRT computer monitors, a distinct virtual image of the point source will be observed. The brightness of the virtual-image point source will remain constant as the point is moved away from the screen. A general background gray that persists far away from the virtual image of the point source may also be observed. Again, this is especially true with CRTs, in which that gray background is the surface containing the phosphors. It is very much like a Lambertian surface in that its luminance remains relatively independent of the observation direction and is proportional to the illuminance upon its surface - it will get darker as the point source is moved away from the screen. If the screen has a front-surface semi-diffusing treatment, a fuzzy ball of light that surrounds the specular image can be observed. This is referred to as the haze component of reflection for want of a better term.³ For CRTs, where there is a thick faceplate, a small fuzzy ball of haze without a specular image centered within it can be seen. This haze ball comes from the phosphor surface behind the front surface and would be located to the side of the specular image.

As the flashlight bulb is moved, it can be positioned so that the haze peaks are aligned. If a flat screen is used, decreasing the specular viewing angle will better align the haze peaks.

The luminance of the haze reflection depends upon the distance of the point source from the screen, but the haze reflection itself follows the specular image. Because the haze peak is aligned with the specular image and the luminances add, and since the haze peak

Fig. 3: The reflection of a point source changes depending upon its distance from the display.

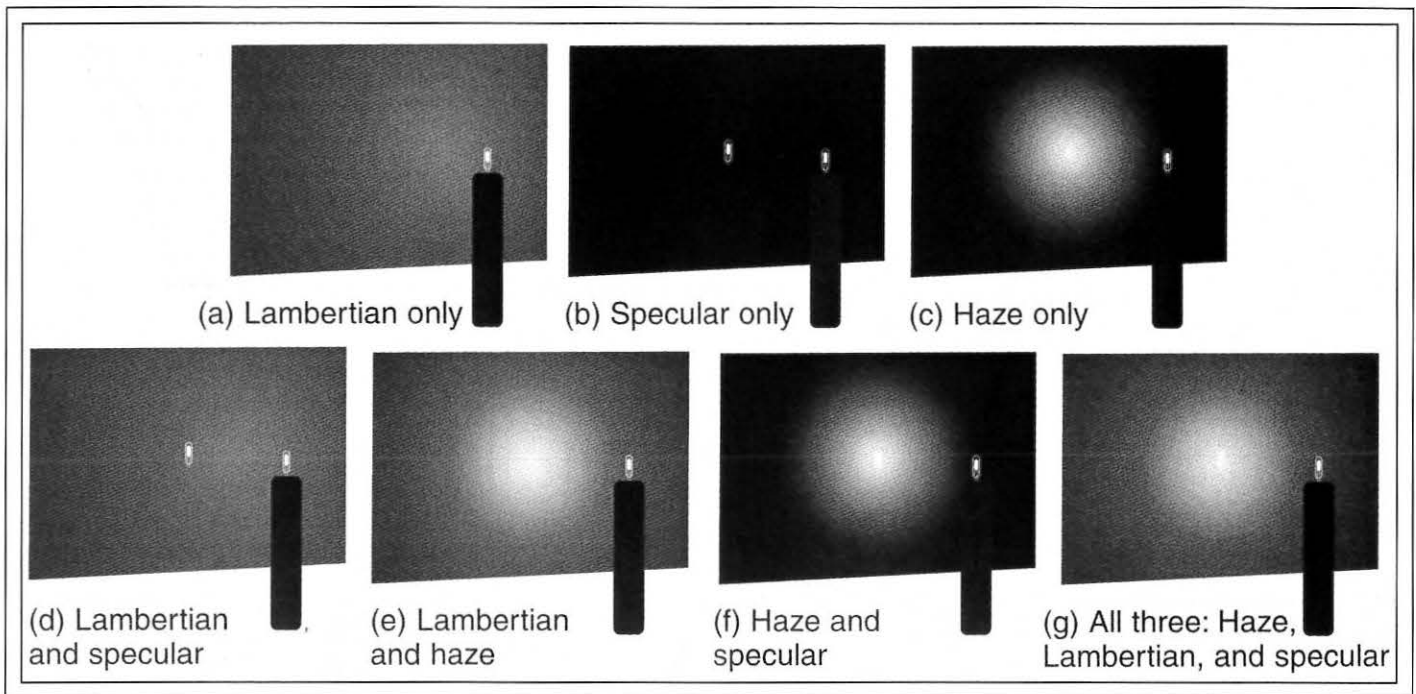


Fig. 4: Displays can have various mixtures of the three different reflection components. Often, one or two of the components can be made trivial.

decreases as the source is moved away while the specular luminance remains constant, a viewer can get the impression that the specular image is decreasing in luminance as the source image moves away, which is not the case.

So three types of reflection associated with displays can be seen: the general background-gray Lambertian component, the specular component having a distinct image of the source, and the haze component - the fuzzy ball of light that follows the specular image. The haze component is like the Lambertian component in that it is proportional to the illuminance, but the haze component is also like the specular component in that it is peaked in the specular direction. The haze is the reflection property that exists between the two extremes represented by specular (with a distinct image) and Lambertian.

Another way to see the three distinct reflection components is to direct a laser beam at the surface and allow the reflected light to illuminate a large white card - all in a very dark room (Fig. 5). The general, usually very soft, illumination of the whole card is the Lambertian component. The sharp point of light is the specular component, and the fuzzy ball of light around the specular point is the haze component.

Measuring What We See

Observing the three reflection components is one thing; measuring them accurately is another matter. If all we had to deal with were the specular and Lambertian components, reflection characterization would be simple. However, the existence of haze requires us to employ more sophisticated methods, such as the bidirectional reflectance distribution function (BRDF).

The BRDF is the directional dependence of the ratio of the reflected luminance to the incident illuminance. Since the observation direction and the illumination direction can be different, the BRDF is a four-dimensional function of the incident and reflection angle. If we were to add wavelength dependence and polarization dependence, the BRDF would become a six-dimensional function.

When we look at the reflected luminance distribution of a point source or observe the reflected distribution of a laser beam on a white card, we are viewing a geometrical distortion of the BRDF. It is obviously possible to look through a small-aperture viewing tube fixed in space (to make sure we only look at the same point on the screen) and move a point light source around (Fig. 6). Suppose we constrain our apparatus so that the tube and source are in the horizontal plane.

If the eye could measure the luminance and all three components of reflection that were present, we could measure the in-plane BRDF and get results similar to those shown in the plot of Fig. 6. As the point source approaches the specular direction, the luminance dramatically increases as we move up the haze peak - note the log scale - until the bright specular image of the bulb comes into view. To turn this conceptual apparatus into an instrument, we would need to replace the eye with a detector, calibrate the apparatus, and apply a cosine correction to the point-source illuminance as it is moved away from the specular direction.

But using a point source is not the best way to measure the BRDF. If we can account for (or avoid) the effects of veiling glare in a camera system, a photograph of the reflection of a point source might be a useful way to supply a measurement of the shape of the BRDF. The best methods, however, use lenses and practical light sources.⁴ If these goniophotometric methods are not followed carefully, however, the result of the haze measurement may be ambiguous because the result can depend upon the distances of the source and detector from the screen, apertures of the source and detector, and the foci of the detector and source.

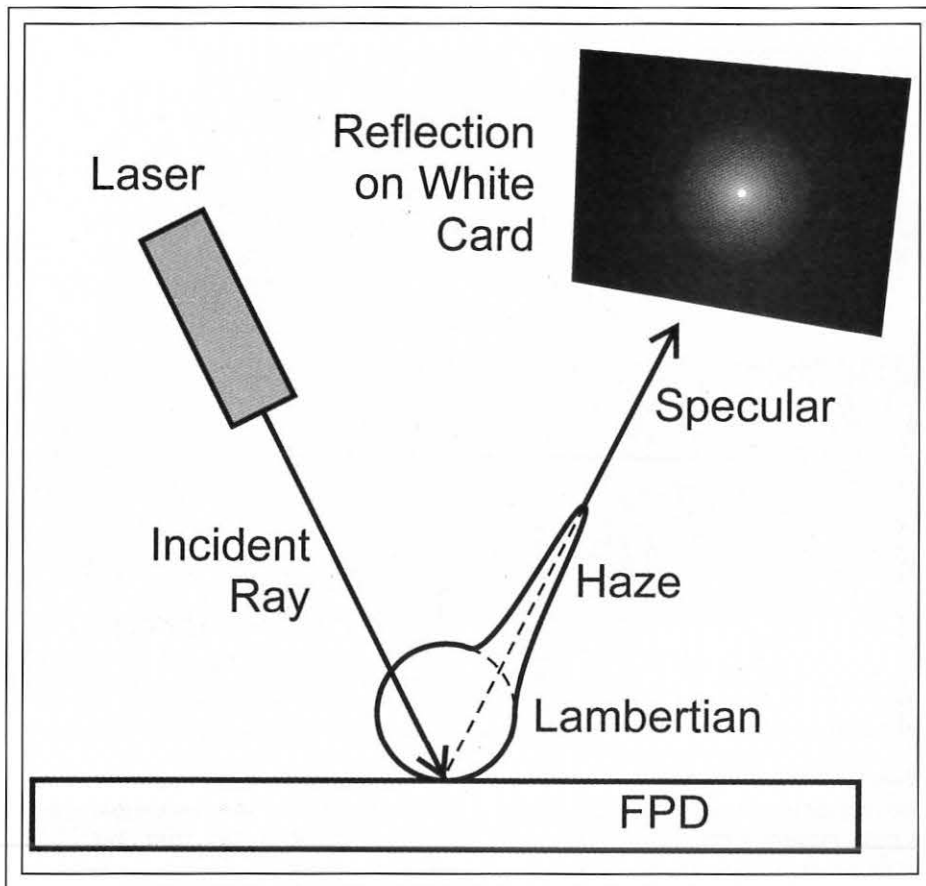


Fig. 5: The different reflection properties can also be manifested by the reflection of a laser beam onto a white card in a very dark room.

Those who measure BRDFs often fix the light source and move the detector. There is little difference in the BRDFs obtained by moving the source or moving the detector as applied to displays, provided that the specular angle – the angle from the normal – of the fixed part of the apparatus is small. When measuring the BRDF in a plane, the light source will obscure the detector (or the detector will obscure the light source) for some range of angles, and no data will be obtained. An idealized apparatus would be obtained if the detector and source were so infinitesimally small that they would not interfere with one another, and a BRDF could thus be obtained based on the normal direction and not some off-normal specular configuration.

For displays, the BRDF is almost always symmetric in any single plane aligned with the normal of the screen, but the haze need not be rotationally symmetric about the specular direction. If there is a pixel matrix beneath the

front surface, the haze may have spikes in several planes (most often either the horizontal or vertical planes, or both, and sometimes in planes at 45° from the horizontal plane).

One advantage of displays is that the haze profile doesn't change dramatically as it is viewed from different angles. This can be seen by moving the flashlight point source around (keeping the head fixed at the normal of the display) so that the haze reflection is viewed in all parts of the screen. Thus, a center-screen measurement of the BRDF is a sufficient specification of reflection in most cases.

The beauty of the BRDF is that, once obtained, it permits the calculation of how a display will appear in its environment, based upon the distribution of light sources in the room. In fact, that is the goal of this research: to provide a method of characterizing the BRDF parametrically in order to permit an adequate characterization of the three components of reflection so that the performance of

a screen can be calculated for any given environment. Research is currently under way to provide simple methods to parameterize the BRDF using simple instrumentation that does not require complicated goniophotometric data collection.⁵

Ultimately, we might expect to see four or five parameters required to specify reflection: the Lambertian component, the specular component, the peak of the haze component, some width measure of the haze component, and perhaps a shape parameter associated with the haze component. Probably the first three parameters will tell the main story, as in the fictitious advertisement at the beginning of this article, but three parameters are insufficient to permit a calculation of the reflected luminance in a given ambience.

If we were to go back to Fig. 2 and try to describe the reflection properties, this is what we would say. In Fig. 2(a), the CRT has a moderate Lambertian component, with a strong specular component and a front-surface treatment that produces some haze. In Fig. 2(b), the CRT has a much lower – but still not trivial – Lambertian component, very little haze, and a reduced but significant specular component. The reduction in the specular component from Fig. 2(a) to Fig. 2(b) is accomplished by a multi-layer anti-reflection coating applied to the front surface. The FPD in Fig. 2(c) does not display well in the photo, but it has only a haze component. The specular and Lambertian components are at least four orders of magnitude lower than the haze peak. The only non-trivial component in the FPD in Fig. 2(d) is also the haze component, but the peak of this haze component is reduced by the application of a multi-layer anti-reflection coating.

All of the preceding tells us that the metrology of display reflection is not a simple matter. We have discovered something disturbing but extremely useful: it is no longer adequate to limit our thinking to two types of reflection, diffuse and specular. Rather, there are three distinct components of reflection perceived by the eye when using electronic displays. Further research should clarify and simplify the complications associated with display reflection metrology.

References

¹ASTM Standards on Color and Appearance Measurement, American Society for Testing

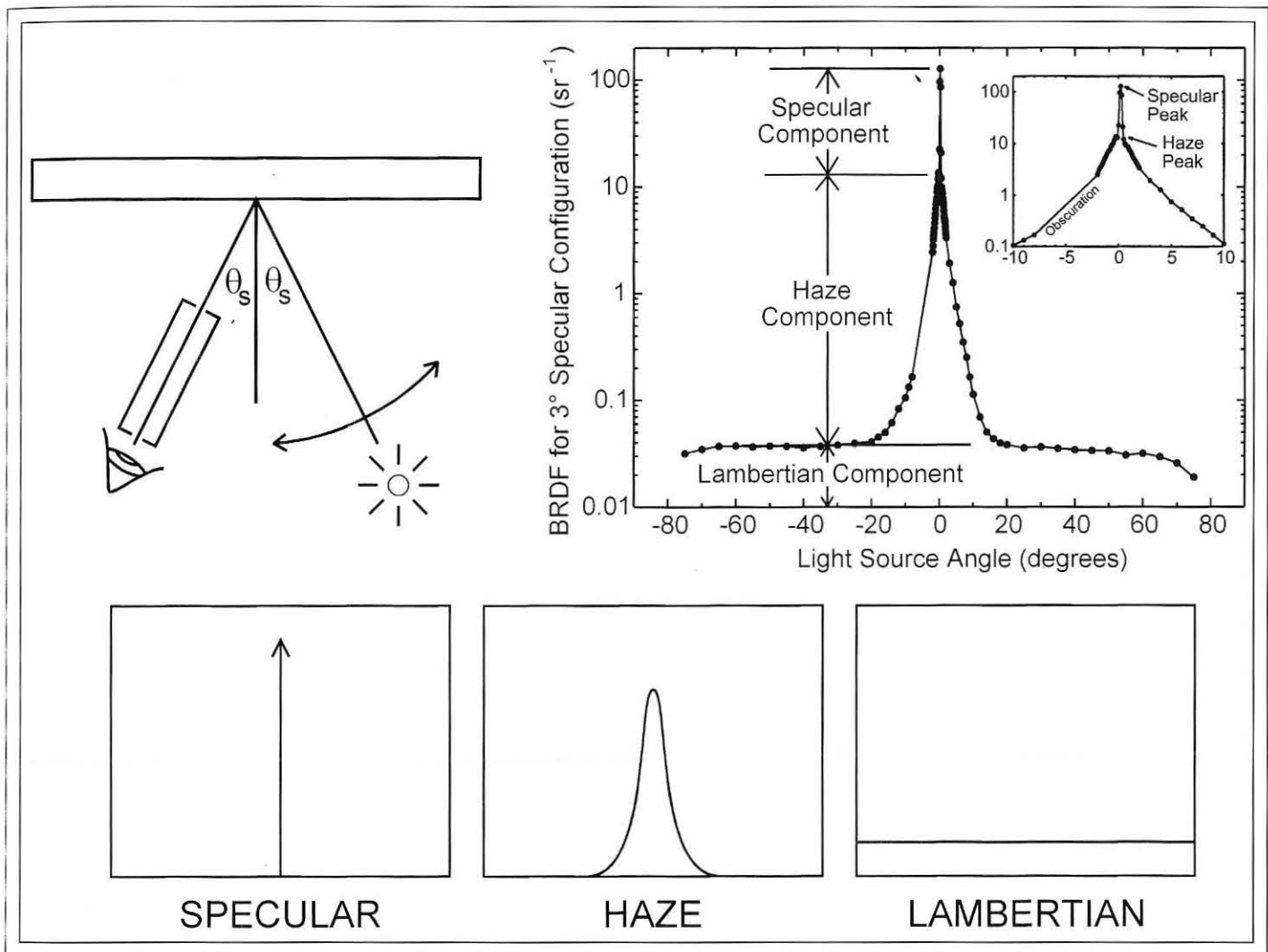


Fig. 6: This simple apparatus can be used to observe the reflection characteristics from a point source of light. Just as the three different components are distinctly visible to the eye, they are readily apparent in a bidirectional reflectance distribution function (BRDF).

and Materials, "Standard Terminology of Appearance," E284 95a, pp. 235-252.

²Michael Becker has recommended the use of the term "Lambertian" in this three-component model to avoid any confusion that may arise with using the term "diffuse." See Michael Becker, "Evaluation and Characterization of Display Reflectance," *Displays* 19/1, 35-54 (June 30, 1998).

³ASTM, *op. cit.*, "Standard Test Method for Visual Evaluation of Gloss Differences Between Surfaces of Similar Appearance," D4449-90 (reapproved 1995), pp. 178-182.

⁴ASTM, *op. cit.*, "Standard Practice for Goniophotometry of Objects and Materials,"

E167-91, pp. 206-209.

⁵E. F. Kelley, G. R. Jones, and T. A. Germer, "Display Reflectance Model Based on the BRDF Displays," *Displays* 19/1, 27-34 (June 30, 1998). Also see the VESA (Video Electronics Standards Association) *Flat Panel Display Measurements Standard (FPDM)*, sections 308 and A217 for more details on the complications of display reflection metrology (www.vesa.org). ■

SID '99

Symposium, Seminar,
and Exhibition

San Jose, California

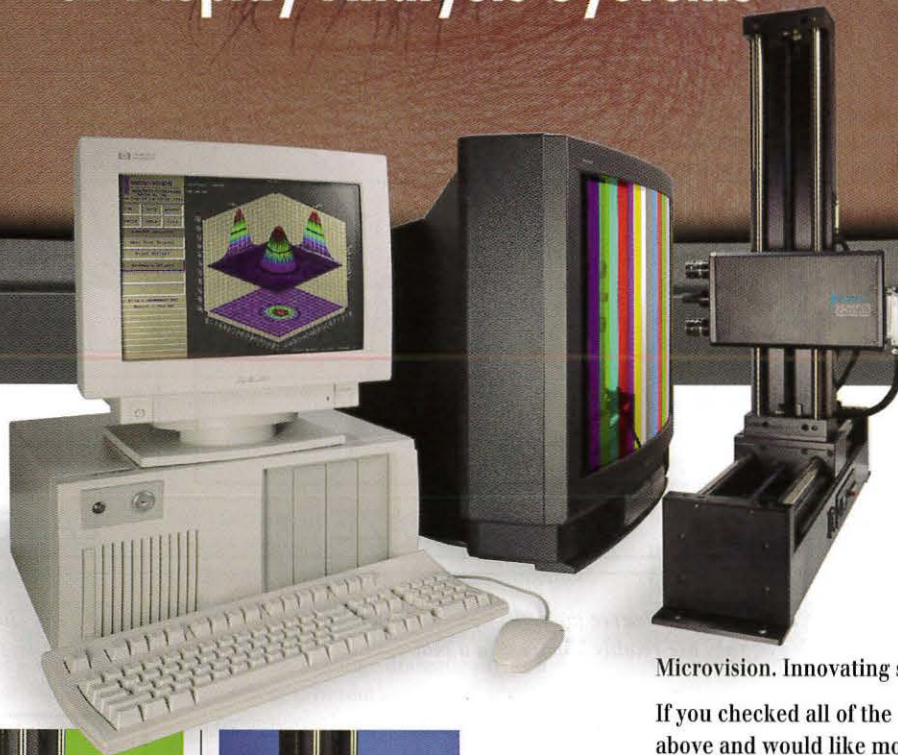
San Jose Convention Center

May 16-21, 1999

Check what you need in your display analysis system:

- ✓ flat panel tests
- ✓ CRT tests
- ✓ easy upgrades (hardware and software)
- ✓ standard for ISO, NIDL, and VESA testing
- ✓ optimized for fast, accurate, and automatic testing with many packaged test suites

If you checked all of the above,
you have chosen the Microvision SS200 Family
of Display Analysis Systems



With the SS200 family, you can precisely, automatically, and completely measure display performance—and that includes flat panels.



SS200

Complete turnkey system with computer, 6-axis positioner, monitor, software, and SS200 camera system. Automatically performs spatial and luminance measurements.



SS210

You can easily field upgrade to the more powerful SS210 package, which provides all SS200 functions, plus an integrated spectrometer for spectral analysis and color measurements. Includes response time measurement capability.



SS220

For flat panel testing, a field upgrade to the SS220 is easy. The SS220 provides spectrometer-based off-axis measurement, color analysis, color shift and luminance testing. Coupled with the SS210, this is the most comprehensive test system ever offered—at a fraction of the cost of individual test instruments. All tests are performed at NIST-traceable accuracy.

Microvision. Innovating since 1985.

If you checked all of the above and would like more information, call Microvision at (800) 951-5188.

MICROVISION

Dedicated to the Needs of the Display Industry

550 High St., Suite 108 / Auburn, CA 95603
Tel: (530) 888-8344 / Fax: (530) 888-8349
Toll Free: 1 (800) 931-3188
Email: microvsn.com
Web site: <http://www.microvsn.com>

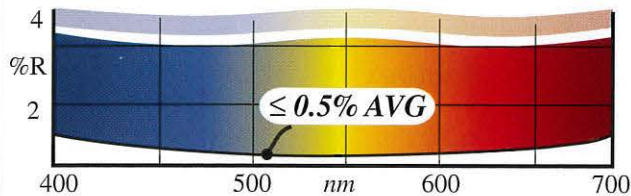
International Reps:

Japan - ARGO CORP., 06 539 5566
Taiwan - SUPERLINK TECH., 02 705 7090
Korea - B & P INT'L, 02 546 1457

Circle no. 19

Thin Film Devices "ANNOUNCES NEW PRODUCTS"

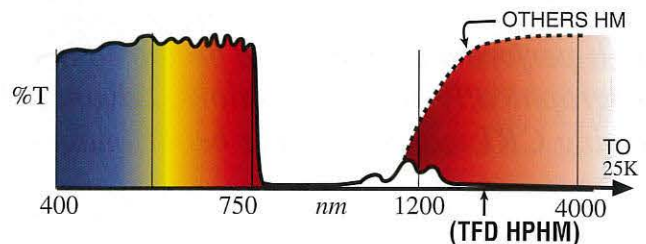
INDEX MATCHED ITO (IMITO) TO LG MATCHES LIGHT TO GLASS



MAKES HIGH PERFORMANCE LCD's BETTER!

APPLICATIONS: Reflective Mode, Projection LCD, STN and TFT LCD.

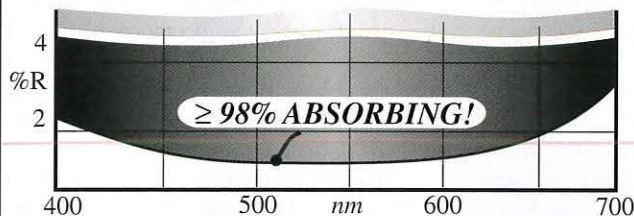
HIGH PERFORMANCE HOT MIRROR (HPHM) 25% BETTER HEAT REJECTION THAN HOT MIRRORS COMMONLY AVAILABLE



LCD's OPERATE TO 80° C AMBIENTS!

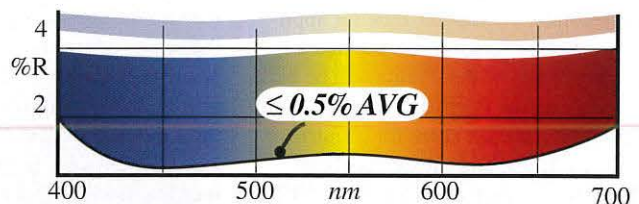
APPLICATIONS: Outdoor, Sunlit Environs, Gas Station Pumps, Drive-In Menus

BLACK CHROME GIVES DISPLAYS BETTER CONTRAST RATIOS



APPLICATIONS: CR Mask, Light Absorber for FED, LCD and Sensors

INDEX MATCHED ITO (IMITO) TO AIR or EPOXY



APPLICATIONS: EMI Shielding, Heaters and Display Ruggedization.

Just Compare Our Quality, Price and Delivery

Extremely low defect (@5KLux!), Large Area, High Volume

- ITO Coated Substrates
- Index Matched ITO (ITO with AR)
- Chrome-Copper-Chrome
- ITO and BBAR @ Room Temperature
- Black Chrome (Black Matrix)
- Anti-Reflective Coats (BBAR, etc.)
- Etching and Patterning (to $2\mu\text{m}$)

SPECIAL CUSTOMER SERVICES INCLUDE:

- Volume or Custom Orders
- Glass/Plastic Substrates
- Quality to Mil — 1-45208
- Precision Glass Cutting
- Large Sizes
- Stock Sheets and ... a lot more!

ALL COATINGS ARE ION-SPUTTERED

THIN FILM DEVICES, INCORPORATED

1180 North Tustin Avenue • Anaheim, CA 92807 • 714/630-7127 • Fax: 714/630-7119

Circle no. 20

TFD

Temperature-Compensating Shadow-Mask Mounting

As high-performance CRTs are produced in increasing numbers and in geographically diverse locations, advanced mounting technology is helping CRT makers achieve better images at lower cost.

by Keith Wheeler

THE CONTINUING GROWTH OF CRTs is being fueled by advanced digital television (ADTV) and high-resolution computer-monitor applications. Cost considerations dictate that a growing percentage of these units will be built in Asia and along the Pacific Rim. For example, current CRT market share for countries such as China, India, and Mexico is about 19%. This share is expected to grow to 29% by 2006.

The manufacturing technology for producing cathode-ray guns and tubes is widely known. But a problem arises when CRTs with lower color-purity performance are used in more demanding applications, such as color computer monitors.

Solving Color-Purity Problems

Color-purity problems arise as a result of the mismatch in the temperature coefficients of expansion of the metal used in the CRT aperture mask and frame, and the glass of the CRT itself, all of which expand as the CRT heats up in service. This is a major issue in color purity because the metal mask controls the landing positions of the electron beams from the electron guns.

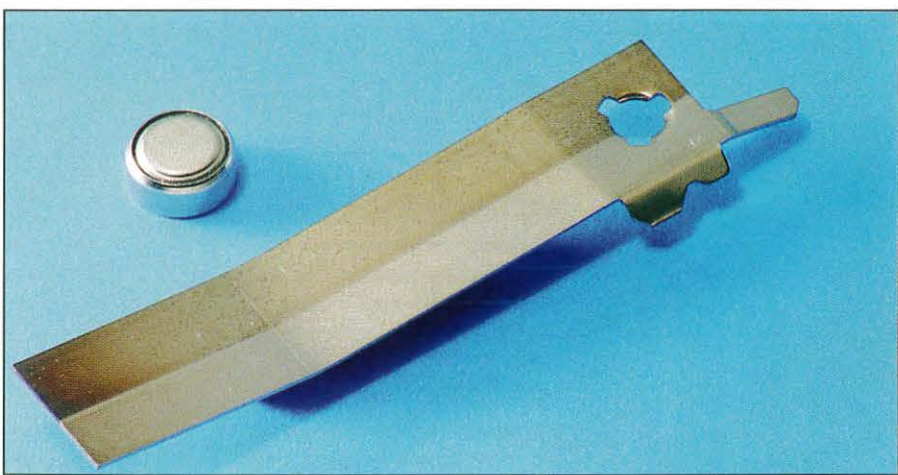
Keith Wheeler is CRT Components Manager at Texas Instruments' Engineered Materials business unit, MS 4-9, 34 Forest Street, Attleboro, MA 02703; telephone 508/236-3969, fax 508/236-3825, e-mail: kwheeler@ti.com.

The mask contains fine apertures through which the electrons must pass to illuminate the screen. The phosphor dots or stripes on the screen glow when excited by the electron beam, thus forming the screen image. CRTs heat up in use, and most metals expand faster than glass. If the metal mask and frame assembly expands in a way that causes geometric distortion, color purity is affected.

An early solution to the thermal-expansion problem was to use a special high-nickel-con-

tent low-expansion alloy called Invar for the mask. Invar was the common choice of mask material when thermal compensation was first used as a solution for the mask/panel distortion problem, and its good thermal-expansion match with glass often meant that no additional compensation was needed.

But with customers demanding sharper pictures, color-TV screen sizes growing larger, and CRTs finding broader use in computers, even the close match of Invar's temperature

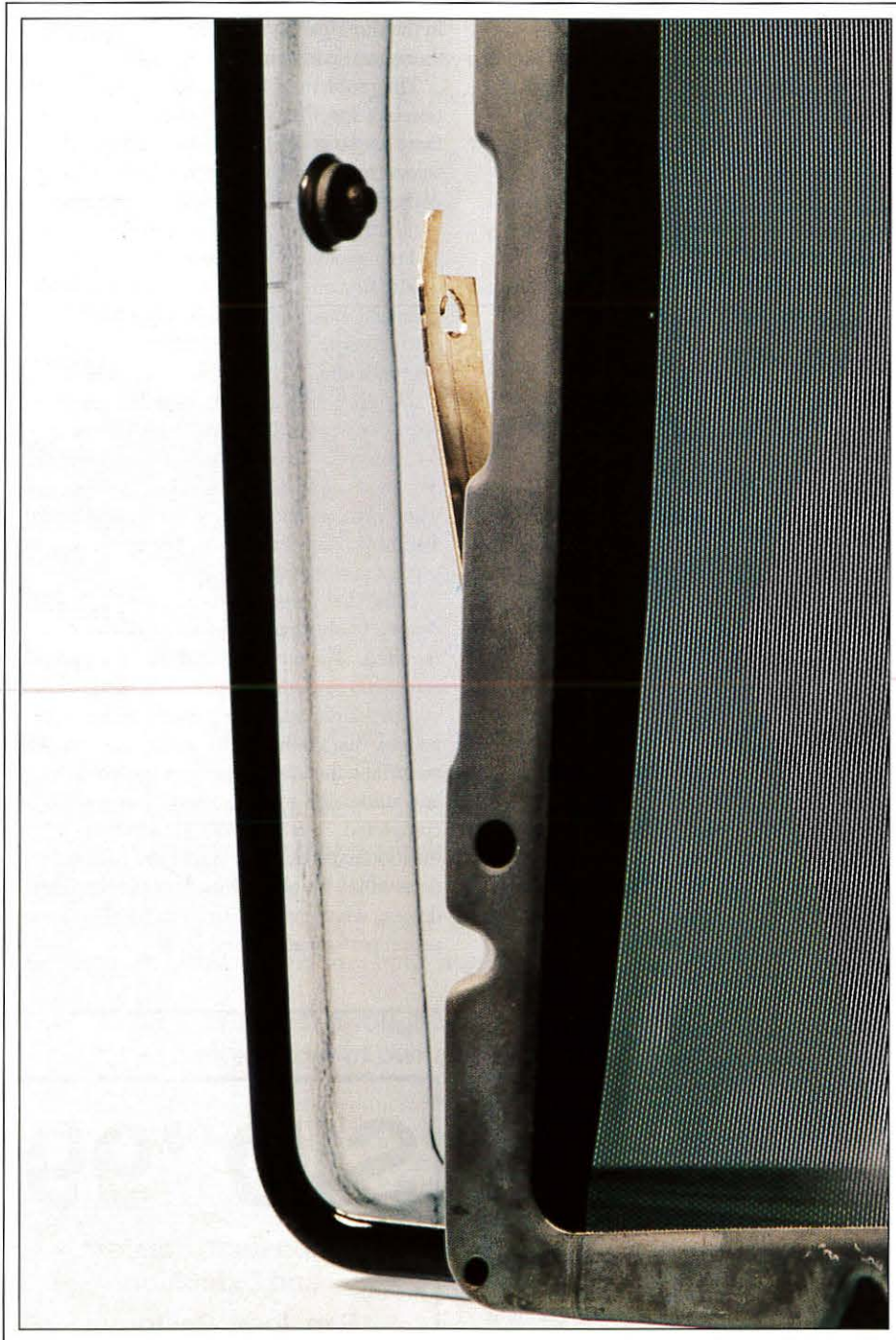


TI CRT Components

Fig. 1: In clad bimetal-strip thermostats, each of the two metals thermally expands at a different rate, causing the composite device to bend at a predetermined rate and force for any temperature. In CRT applications, the separate metal elements are electron-beam welded side by side.

coefficient of expansion to glass became inadequate to meet the demands for greater color purity. Initially, stainless-steel clips were used at the sides or corners of the masks to

solve the problem. To achieve even higher image quality, manufacturers began to use thermostatic metal components, which provide more precise dimensional control.



TI CRT Components

Fig. 2: This bimetallic temperature-compensating clip has been fastened to the mask frame and will be attached to the mounting lug on the CRT prior to final assembly and sealing of the CRT bulb.

CRT manufacturers, particularly new or inexperienced ones, sometimes copy a successful compensation design from another manufacturer who has already solved the thermal-expansion problem. Unfortunately, these designs may be out of date and may continue to use Invar for the mask material.

Experienced CRT manufacturers have sought less-expensive alternatives, such as substituting aluminum-killed (AK) steel as the mask material. But AK steel has a much higher thermal-expansion coefficient than glass, so using it usually calls for sophisticated design measures to compensate for the increased thermal-expansion mismatch.

Makers of high-quality CRTs have developed a wide knowledge of compensation technologies over the years, but newer manufacturers are often not aware of these techniques. In fact, only a few companies are familiar with sophisticated engineering approaches to the thermal-mismatch problem. They are usually large, high-quality manufacturers of television sets and computer monitors who have had the time and resources to devote to these engineering solutions. This engineering knowledge invariably includes an understanding of bimetallic thermostats.

“As CRTs have faced constant pressure to increase color purity and lower costs, knowledge of thermostat compensation technology has had to keep pace,” says Paul Galipeau, product engineer at Texas Instruments’ CRT Components business unit. “Many new tools, such as mathematical criteria to predict the performance of various thermostat-metal combinations, are now available to take advantage of years of development experience.”

Different Solutions for Different Problems

Thermal-compensation designs generally vary from manufacturer to manufacturer. Some use Invar masks with or without thermostatic devices in the mask/frame assembly. Other manufacturers use AK-steel masks, which require thermostatic compensators with varying levels of sophistication.

Older designs usually fall into one of two general categories:

- Invar is used as the mask material, with or without compensation clips.
- An AK-steel mask is used, but the compensation device is either too costly or does not meet the customer’s current image-definition quality requirements.

The Smart Choice in High Speed Video Generators

ASTRO VG-851/854



Dot Clock to 400 MHz
Horizontal Scan to
300KHz



Extremely easy operation
from front panel or PC



Highest Available
Performance



256 Levels at all
Frequencies



Fully compatible with all
HDTV-formats-
even 1080p

Accepts Bitmap-Files



NEW CONCEPTS in Highest Performance, Flexibility & Ease of Operation:

400 MHz for true 2K x 2K resolutions;
Storage of more than 1000 Timing/Pattern
Programs in Flash Memory and EEPROM;
Fully PC-compatible with "Bitmap"
capability; direct access to any parameter
from front panel or through PC-programs.
And any of the (E)EPROM you used in
earlier units can still be used.

That's what we call High Performance,
Flexibility and Ease of Operation!

Make the Smart Choice...

Contact TEAM Systems
1-800-338-1981
www.team-systems.com

TEAM
systems

"Test And Measurement Technology"

Circle no. 21

CRT technology

A CRT manufacturer satisfied with its Invar screen can often achieve some material cost savings and/or superior performance by updating its stainless-steel-spring design. This will sometimes require relocation of the spring in the mask/frame assembly. It is possible to further increase savings by a complete redesign, including replacement of the Invar mask by an AK-steel mask.

A manufacturer that already uses AK-steel masks may encounter problems because the design of the thermostatic compensation device does not provide adequate color purity for its customers' applications.

There are several levels of engineered solutions, from the simplest to the most complicated. It depends on the goal of the CRT manufacturer and the extent of the "purity drift" and/or reject rate he is able to tolerate. Purity drift refers to how far away the electron beam's landing point has wandered from its initial target. This is measured over time as the CRT heats up. Acceptable purity drift is measured in microns and varies according to application: less than 6 μm is a common goal for a computer monitor; 20 μm may be tolerable for a color TV.

CRT manufacturers whose purity-drift performance is outside of acceptable limits sometimes seek outside design help. TI's CRT Components business unit is one source of such services. (TI invented the first thermal-compensation device in cooperation with RCA.) TI's Galipeau says, "After we have completed the appropriate engineered solution, the CRT manufacturer typically gains a net cost savings of 20-30% over his previous compensation device." Savings as high as 40-45% have been achieved when the CRT manufacturer is able to move from an Invar to an AK-steel mask as well, he added.

An effective compensator design involves the selection of a thermostat-material combination, general design, and appropriate clip locations based on analytic techniques and design experience.

The Design Cycle

Most engineers are familiar with thermostats as clad bimetal-strip devices. Each of the two metals in the composite thermally expands at a different rate, causing the composite device to bend at a predetermined rate and force for any predetermined temperature. These devices have been widely used for many years in household thermostats, temperature con-

trollers for appliances, over-voltage protectors for motors, and many similar applications.

In CRT devices, the separate metal elements are electron-beam welded together side by side to become the critical thermal element in the three-part system of mask, frame, and thermostat compensator (Fig. 1).

The problem of finding an appropriate solution in a specific case is formidable because there are so many thermostat materials to select from, and actual performance also depends on factors such as the length and width of the part, the location in the assembly, and the geometry of the compensator.

The first engineering step is to analyze the present compensator in terms of spring force, material type, hardness, thickness, spring length, width, and location in the overall mask/frame assembly. Acceptable results are often possible by selecting a more suitable compensation material or by redesigning the device to achieve more accurate compensation - and perhaps relocating it in the mask/frame assembly. This may be all that is necessary to solve a customer's problem.

If the first-stage effort does not achieve the desired goals, thermostat-metal designs are required. The customer can then use prototype parts to evaluate the results in terms of compensation and spring force. From these results, fine tuning of the compensator design, material adjustments (perhaps alloy ratios), and automated-manufacturing features can be completed. The compensator attachment location is particularly important because it determines the active length of the thermostat device, which permits fine tuning of compensation performance (Fig. 2). ■

SID '99

Symposium, Seminar,
and Exhibition

San Jose, California

San Jose Convention Center

May 16-21, 1999

Introducing the world's most advanced FED technology in a high-volume cluster tool.

The new Temescal® FCE-7000 from BOC Coating Technology is very big news: In fact, if you're looking for high-volume FED flat panel deposition with lowest cost of ownership and incredible flexibility, it just doesn't get much better than this...

To start with, there's BOC's world-class e-beam technology – which gives you the best uniformity, highest rates, longest life and largest source inventory, to cite just a few of its merits.

Then, this is a cluster tool. So you can deposit a single film or a

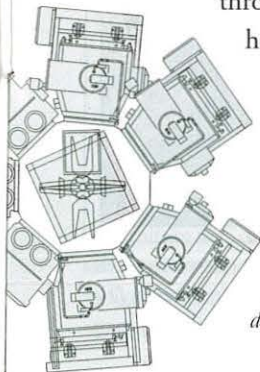
whole stack, in just about any way you'd like.

Plus, your panel size choices are virtually unlimited. The tool now handles up to 600mm x 720mm, which happens to be the largest in the world. But BOC can also configure it for even larger sizes upon request.

Highest throughput. Lowest cost of ownership.

The FCE-7000 is a proven production tool that generates throughput speeds of from 10 to 60 panels per hour – and even up to 70 and 75 on certain processes. And when you combine that kind of throughput with high production quality levels, you get a very attractive return on your investment.

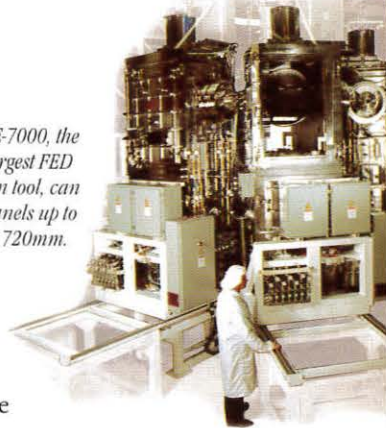
Designed for production, BOC's flexible cluster configuration lets you deposit a single film or an entire stack.



And this system also reduces downtime and requires less maintenance.

Plus, it provides more advanced automation and higher materials utilization. So you can see how it achieves the lowest cost of ownership of any flat panel deposition system in the industry.

BOC's FCE-7000, the world's largest FED production tool, can process panels up to 600mm x 720mm.



A full spectrum of solutions.

BOC has been producing coating systems for more than 35 years now.

So they can provide not only high-throughput production systems, but also prototype R&D and intermediate systems, as well.

They can also provide you with an unmatched repertoire of process and system knowledge and managed engineering expertise.

So, even if your process is not yet fully developed, you can depend on BOC to help you answer the questions, negotiate the risks and get where you want to go.

Bottom line, it means smarter solutions – from the big performance guys, BOC. Call them and see for yourself...

Temescal, a part of BOC Coating Technology, 2700 Maxwell Way, Fairfield, CA 94585. (707) 423-2100. Fax: (707) 425-6071.

 **BOC**
COATING
TECHNOLOGY

It Takes a Worried Man to Sing a Worried Song

Worried songs were sung as the Taiwanese dollar and stock market fell in value daily during Computex Taipei 1998 – but local monitor manufacturers put on a brave face and showed off their new products.

by Bryan Norris

THE GLOOMY ECONOMIC CLIMATE of Taiwan was reflected in the statistics for Computex Taipei '98, held this year June 2-6. When applications for a stand at the show closed back in October 1997, 996 companies had applied. In the end, there were only 892 exhibitors.

This number actually constituted an increase of 3.1% over the previous year, when 865 companies were present. But since the rise was markedly smaller than the double-digit increase expected – the number of exhibitors in 1997 was up 20% from the previous year – the organizers were still disappointed. And the disappointment nearly turned into despondency when visitor numbers for the first day were down by about 2000 from 1997.

But it wasn't only the organizers who went home feeling depressed after the first day. The demise of the magazine *Byte* meant the

absence of the prestigious "Best Products at Show" awards, normally announced at a presentation on the first day. This absence meant that certain members of the press were equally down, since they had become accustomed to having the "noteworthy" exhibits found for them and realized this year they would have

to do some real work to come up with their articles.

But for the organizers at least, spirits rose later in the week when visitor numbers for the first 3 days (13,281) exceeded those of the preceding year (12,373), and 16,225 "overseas" visitors (viewed as potential buyers)

Bryan Norris is the Senior Partner and founder of Bryan Norris Associates, Consultants in Electronics, 7 Biddenham Turn, Biddenham, Bedford MK40 4AT, U.K.; telephone +44-(0)-1234-26-7988, fax +44-(0)-1234-26-2345, e-mail: bnorris@kbnet.co.uk., which specializes in all aspects of VDU markets in Europe and provides the highly respected VDU Vision market-analysis service. Mr. Norris is a contributing editor to Information Display Magazine.



Fig. 1: A number of the monitor suppliers at Computex Taipei grouped together in Section D of the main exhibition hall.

CETRA Press Office



CETRA Press Office

Fig. 2: Proview's stylish MT-500, a forthcoming entry in the 15-in. category, was exhibited in a special grouping of Taiwan's "most prestigious IT companies" in Stella Hall.

attended the show overall compared with 15,761 in 1997. The number of overseas exhibitors was down only slightly (by 6) to 87, representing 15 countries: the largest contingents from the U.S.A. (45 companies), Singapore (12), Hong Kong (11), and Japan (5).

The Gloomy Economic Background

The Taiwanese dollar (NT\$) fell continually during the show week on its way down to an 11-year low against the U.S. dollar in mid-June - a 20% plunge since the Asian crisis began last summer. Taiwan's TWSE Index

also fell to a 5-month low on expectations of poor earnings from Taiwan Semiconductor Manufacturing Co. and other computer-related companies. And the all-important electronics sub-index - the IT sector is the largest industry in Taiwan - had its biggest fall in eight months!

Compared to the other countries affected by the "Asian crisis," the circumstances in Taiwan are still relatively favorable because the country is debt-free and has a strong manufacturing base. Nevertheless, the economic situation remains precarious, especially since Taiwan's manufacturers are heavily dependent on demand from U.S. PC houses, and cutbacks there are of major concern. The U.S. is Taiwan's largest IT export market, accounting for 41% of the total (followed by Europe with 29% and the Asia-Pacific region with 19%), and forecasts of cutbacks by major U.S. players, such as Intel, Compaq, Dell, and IBM, directly affect the Taiwanese electronics industry.

Monitors make up the largest share of Taiwan's total IT hardware production: In 1997 they accounted for 28.1% of production by value (with notebooks next at 22.5%). According to figures gathered by the Taiwanese CRT producers, 1997 monitor production in Taiwan reached 43.1 million units, an increase of over 19.6% compared to 1996. Around 55% of these units were made in overseas plants, compared with around 48% in 1996.

The monitor manufacturers in particular are looking nervously at the U.S. situation - and not simply because of U.S. cutbacks. They are also worried that OEM orders from U.S. and major European PC houses will be transferred to Korean suppliers as a result of the huge drop in the won against the U.S. dollar.

In 1997, Taiwan's monitor companies enjoyed a 33.6% share of the world computer-monitor market compared to the 20.9% taken by the Korean suppliers. But in 1998, the Korean share is expected to increase by at least another 5%! This expected transfer to Korea's manufacturers will make the task of increasing own-brand model sales in the U.S.A. and Europe even harder for Taiwanese suppliers. And this is already a challenge, even for the established Taiwanese monitor suppliers.

So how are the Taiwanese manufacturers faring so far this year? In terms of U.S. dollars, for Q1 '98, Taiwanese monitor sales

show report



CETRA Press Office

Fig. 3: SlimAge showed its 14-in. Model 610A and 15-in. Model 710A TFT-LCDs in contrasting modern and traditional cabinet designs.

were down in value by 13% (to US\$1.9 billion) compared to the same period in 1997, according to the government and industry-backed research group Market Intelligence Center. This is despite a 12.6% increase in sales volume, which is explained by the fact that prices have continued to plummet. According to an article in the *Asian Wall Street Journal* that appeared on May 4, 1998, prices in Q1 '98 fell by 22% on average. This, together with oversupply and the popularity of cheap products, has led to the fall in profits. Actually, in Taiwanese dollar terms, Q1 '98 sales were slightly up on the same period last year, albeit by just a few percent. But even this was disappointing compared to the usual double-digit year-on-year growth.

Down – But Not Out

Because of the economic worries, monitor exhibitors at the show were more reserved than in previous years and were devoting most of their headline promotions to other products – such as notebooks, scanners, digital cameras, and LCD projectors – which will hopefully command greater profit margins. Having said that, the manufacturers were not going to miss the opportunity of showing off their newest monitor offerings. Therefore,

Computex Taipei still proved the best venue to learn in detail what the Taiwanese VDU makers are offering.

Most of the monitor suppliers were located together in the first part of the D section of the main exhibition hall in the Taipei World Trade Centre (TWTC), where a newly reorganized stand area had been created (Fig. 1). But Taiwan's "most prestigious IT companies" were allocated large rooms in the Stella Hall – Home of the Stars – of the Taipei International Convention Centre (TICC), located across the road from the TWTC. These included the display manufacturers *Action (Axiom)*, *AOC*, *Chuntex (CTX)*, *Compal*, *GVC*, *Mitac*, *Proview*, *Tatung*, and *Teco* (Fig. 2).

On the Computex Taipei Web site, 64 exhibitors were listed as supplying color CRT monitors. The catalogs and product brochures collected from the booths of 43 of the Taiwanese CRT-monitor makers list some 435 different models. Of these, just 15% (67) were 14-in., 29% (125) were 15-in., and 30% (129) were 17-in. This was the first year in which 17-in. models constituted the largest sector of monitors on offer. A further 5% (21) were 21-in. models, and 8% (33) were current (or expected) 19-in.!

Will 19-in. Models End the Worries?

The future definitely holds out the promise that CRT units with larger screen sizes will increase in importance. In a pattern seen at CeBIT '98 in Hannover, Germany, in March, the trend was definitely toward models with larger CRT screens – notably the 19-in. In fact, last year's show had seen the advent of the 19-in. CRT monitor in prototype form, so by this year's show companies were able to promote second-generation 19-in. versions.

The more established 19-in. suppliers – such as *Acer*, *ADI*, *CTX*, *Forefront*, *MAG*, *Royal*, and *Sampo* – were displaying their models, all using the ubiquitous tube from *Hitachi*. Indeed, most of the forthcoming 19-in. models from Taiwanese suppliers will employ the Hitachi tube, though some new models, particularly those destined for the OEM market, can also be fitted with alternative 19-in. tubes. For example, *Compal's* M990, which had previously been sold with an Hitachi tube, was fitted with a microfilter tube from *Toshiba* on the company's stand. (Compal is promising three new 19-in. models by Q1 '99.)

Leading-edge OEM-only supplier *AmTRAN* offers a variety of tubes in its models. In its Grand Hyatt Hotel suite, AmTRAN showed off two 19-in. models: the AT1097F with an Hitachi tube and the AT1097D with *Mitsubishi's* "Natural Flat" Diamondtron™ aperture-grille tube (available in Q4 '98). And in one of the product lists obtained in the suite, a future NEC 19-in. CromaClear™ tube was introduced. *MAG* confirmed that it will have a 19-in. with the Mitsubishi tube available by the end of 1998.

As at CeBIT, non-Taiwanese exhibitors *Samsung* and *Panasonic/Matsushita* showed their own models that use their own-make 19-in. tubes. Some Taiwanese makers are expected to take advantage of these tubes. For example, *ViewSonic* is to have the 100% "short-neck" – more accurately, "reduced-length" – Panasonic/Matsushita 19-in. tube in its PS790 model. The short length allows this monitor (and others) to offer an extremely small footprint. And *Teco* is planning to produce a second 19-in. model as a basic low-end unit that will probably use the Samsung tube. At the time of the show, this would reduce the selling price from the current US\$460 to US\$410. *Proview's* current 19-in. uses the Hitachi tube but may also house the Samsung in the future.

Abandoning CRTs?

Apart from parading the 19-in. CRT models, the manufacturers were also getting down to the show's other main monitor business: the promotion of LCD monitors, especially 14- and 15-in. models. As witnessed at CeBIT, Taiwanese monitor makers are looking to LCDs to provide them with a worthwhile return on their investment.

A few of the exhibitors at the show talked about the possibility of withdrawing from the manufacture of CRT monitors altogether in order to concentrate on making LCD models. One company which has already done this is **Mitac**, which confirmed that its production of CRT monitors had now ceased and its displays department will now concentrate on building and selling a range of LCD models.

Although some suppliers still offer STN units, most are backing TFT-AMLCDs. On the Computex Taipei Web site, 60 exhibitors were listed as supplying some kind of LCD, and approximately 30 of these were promoting current or promised TFT-AMLCD monitors. A look at those listed reveals that the 15- and 14-in. units are by far the most popular LCD screen sizes. Over a third of the LCDs (47, or 35%) fell into the 15/15.1-in. category and 19, or 14%, fell into the 14/14.1-in. category (Fig. 3).

In addition, Computex Taipei held out the promise of 18-in. LCD models before the year is finished, though the facts concerning the forthcoming 18-in. models were somewhat tentative. Prototype units could be seen on the stands of **AmTRAN**, **CTX**, **Singaporean DMC/GES**, **Lite-On**, **MAG**, **Mitac**, **Teco**, **Topvision**, and **ViewSonic**. On the **Samsung** stand, an 18-in. was on show as well as a 17-in. LCD monitor, both fitted with Samsung panels. Stand personnel were unable to clarify whether both sizes would become commercial items, but the 17-in. may well be quietly dropped.

The growing popularity of LCD monitors is clearly tempting new players into the business. **Topvision** is a newcomer to the displays industry, having been founded in April 1997. In a presentation introducing the company, Topvision declares itself to be "the company that is dedicated to the LCD monitor and flat-panel display technologies." Another new player on the scene was **Twinhead**, the well-known notebook maker, which was also showing a forthcoming 15-in. TFT-LCD

model. As a senior figure on the Twinhead stand commented, "We have been used to assembling LCD panels into notebooks, so putting them into monitors is a logical and easy thing to do to extend our product range."

But if PC manufacturers are looking at monitors, the monitor suppliers are also looking at PCs, and there were a number of LCD-PCs being displayed at the show. **Mitac** has been making all-in-one LCD-PCs for a considerable time. In Taipei, Mitac positioned its latest LCD-PC, the ECO, in a prominent position on the center stand of the room. The new model has the option of a rotating 15- or 13.8-in. TFT-LCD screen and a variety of Pentium® processors. (The Fujitsu LCD-PC sold in Europe is recognizable as a Mitac-made product.) And a **VGO** LCD-PC model was widely advertised in various magazines as "the most powerful all-in-one LCD PC in the world." (VGO is the brand name of notebook manufacturer **Y.C.L. International Technology** and the model itself was on display in a Grand Hyatt Hotel suite.

What's Coming?

The VDU suppliers of Taiwan are not blind to the signs that indicate they will face extremely difficult trading conditions in the year ahead: intense competition in the OEM sector, where low-priced won-based products are now available from Korean suppliers; greatly reduced markets in the troubled Asia-Pacific region; restrained "branded" markets in Europe and the U.S.A.; and the resulting sharp fall in prices!

But Computex Taipei demonstrated that despite difficult times the Taiwanese monitor manufacturers are still keenly researching, designing, producing, and presenting a multitude of monitors - both CRT- and LCD-based - in a sustained effort to maintain their position as suppliers of over half the world's monitors. We will no doubt find out how well they have managed to maintain this position at next year's show, to be held June 1-6, 1999. Still, at the very least, the organizers, CETRA, are optimistic that the local IT industry will weather any current storms. They talked of adding another exhibitor hall for next year! ■

Display Technology

The Sixth Color Imaging Conference. Sponsored by IS&T and SID. Contact: IS&T, 7003 Kilworth Lane, Springfield, VA 22151; 703/642-9090, fax 703/642-9094, e-mail: info@imaging.org.
Nov. 17-20, 1998 Scottsdale, AZ

Flat Panel Display Devices Symposium at LEOS '98. Contact Paul E. Burrows, Princeton University, 609/258-4454, fax -1954, e-mail: burrows@ee.princeton.edu.
Dec. 1-4, 1998 Orlando, FL

7th International Symposium on Advanced Display Technologies. Organized by the Belorussian and Ukrainian Chapters of the Society for Information Display in cooperation with the Belorussian Ministry of Education, Belorussian State Committee on Science and Technologies, the State University of Informatics and Radioelectronics, and the Scientific Production Corp. "INTEGRAL." Contact: Prof. A. Smirnov, tele/fax +375-17-239-88-58, e-mail: smirnov@display.rei.minsk.by.
Dec. 1-5, 1998 Minsk, Belarus

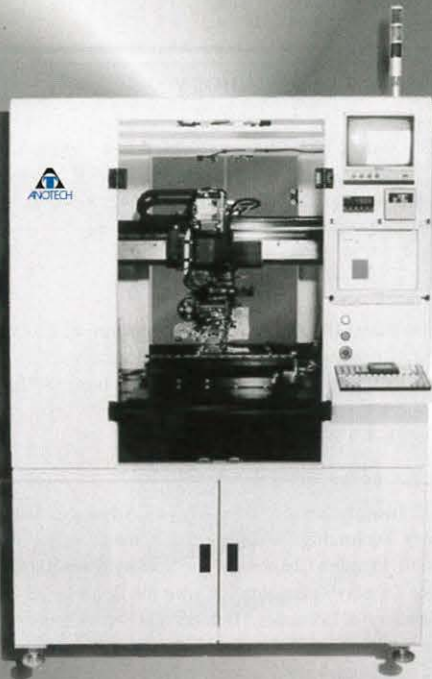
The 15th Annual Flat Information Displays Conference. Contact: Stanford Resources, Inc., Attn: Laura Barretto, P.O. Box 20324, San Jose, CA 95160; 408/448-4440, fax -4445, e-mail: www.stanfordresources.com.
Dec. 2-3, 1998 Monterey, CA

The Fifth International Display Workshops (IDW '98). Sponsored by SID/Asia Region, Japan Chapter, and the Institute of Image Information and Television Engineers (ITE). Contact: IDW '98 Secretariat, c/o The Convention Anncy; phone/fax +81-3-3423-4180.
Dec. 7-9, 1998 Kobe, Japan

Display Works 99: Display Manufacturing Technology Conference. Co-sponsored by SID, SEMI, and USDC. Contact: Mark Goldfarb, Palisades Institute for Research Services, Inc.; 212/460-8090 x202, fax -5460, e-mail: mgoldfar@newyork.palisades.org.
Feb. 2-4, 1999 San Jose, CA

The 1999 SID International Symposium, Seminar & Exhibition (SID '99). Sponsored by SID. Contact: Mark Goldfarb, Palisades Institute for Research Services, Inc.; 212/460-8090 x202, fax -5460, e-mail: mgoldfar@newyork.palisades.org.
May 16-21, 1999 San Jose, CA

SIMPLIFY YOUR TAB-ON-GLASS ASSEMBLY WITH THE AFG-4000



THREE PROCESSES ON ONE MACHINE

- Fully automated operation for ACF dispense, component pick & place, and final cure
- Panel sizes up to 400mm x 300mm
- 7 micron placement accuracy

BUY CAPACITY AS NEEDED

A single AFG-4000 cell supports moderate production volumes at an attractive price. Invest in additional capacity by integrating modules as your sales grow!

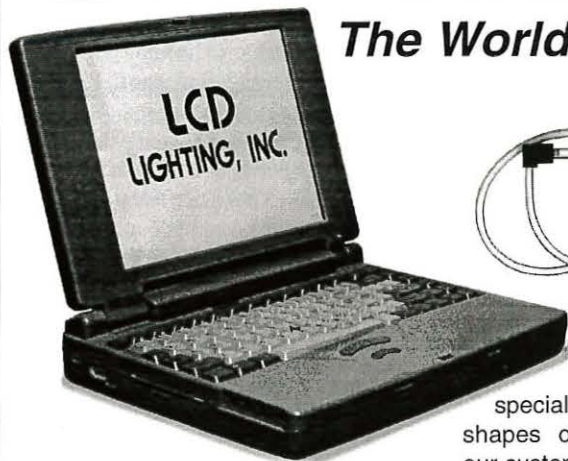
BUILT AND SERVICED IN THE USA



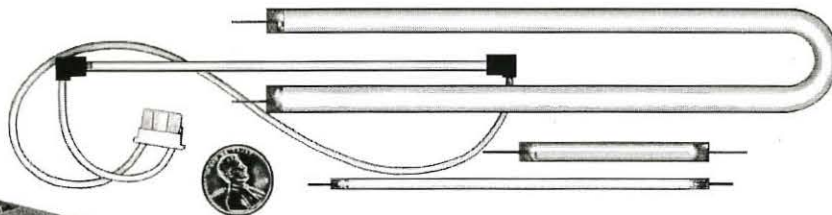
Anotech Inc. • 135 Ricefield Lane • Hauppauge, NY 11788 • Phone: 516-231-1995 • Fax: 516-232-1407 • E-mail: anotech@anorad.com • Website: www.anorad.com/anotech

Circle no. 23

Miniature & Sub-Miniature Fluorescent Lamps for Laptop LCD Displays



The World Leader in LCD Backlighting...



Our ability to manufacture special multiple-bend complex lamp shapes offer unique advantages to our customers.

We can also provide the wiring harnesses, connectors, or heater assemblies that accompany many of our lamps. Contact us today with your lamp needs.

LCD Lighting is your best source to design and manufacture miniature & sub-miniature fluorescent lamps used as replacements or original equipment in laptop computers. Cold cathode lamps are available in standard lengths and diameters of 2.6mm to 10mm; hot cathode lamps in 8mm to 20mm.

Most importantly, we will meet your requirements and deliver the solution. LCD phosphor engineering can fulfill your chromatic requirements in standard, tri-band, or custom blend. Lamp design can incorporate any environmental, electrical, and dimming requirements.

LCD LIGHTING, INC.

37 Robinson Blvd., Orange, CT 06477
Phone: 203 795-1520 • Fax: 203 795-2874

Circle no. 24

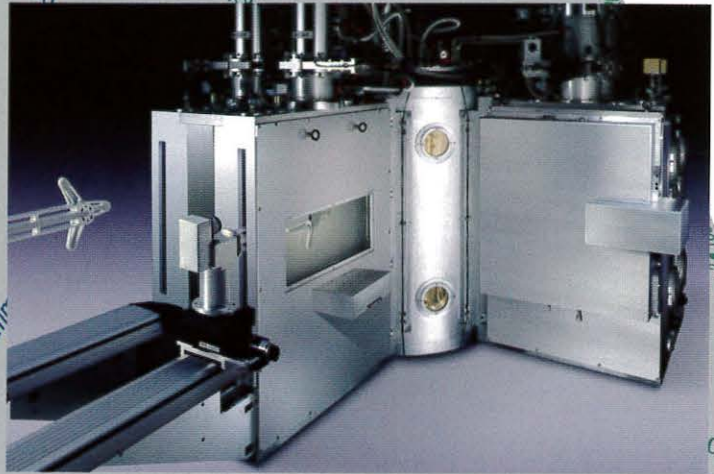
We have some really big FPD news.

We're shipping the industry's LARGEST CLUSTER-TOOL FOR SPUTTERING.

Intevac D-STAR™ sputtering systems for FPDs are the most complete family of PVD cluster-tools available. Capable of Gen 2, Gen 3, Gen 3.5, Gen 4, and beyond. Up to 1600 x 1200 mm². That's big. And there's more.

D-STAR delivers ITO and metal thin film uniformities to 3%. That's uniformity. And a-Si, SiN_x and SiO_x films too. That's process flexibility.

Add high throughput and lower cost of ownership and you have the really big FPD news.



And we have really HOT NEWS FOR POLY-Si PRODUCTION.

Intevac is delivering high volume manufacturing ready Rapid Thermal Annealing (RTA) systems for poly-silicon production. With models up to 720 x 600 mm², RTA enhances many poly-Si LCD manufacturing steps including:

- activation
- dehydrogenation
- densification
- crystallization
- and defect repair in ELA poly-Si films

With throughput to 60 substrates per hour, RTA sets a new benchmark for poly-Si LCD production cost of ownership. That's money in your pocket.

As a large area thermal processor with many degrees of process control, new applications for poly-Si, EL phosphors, and PDP processes are being tested constantly. That's versatility.



Intevac, Inc.
3550 Bassett Street, Santa Clara, CA 95054 USA
Tel: (408) 986-9888
Fax: (408) 988-8145
Email: fpd@intevac.com

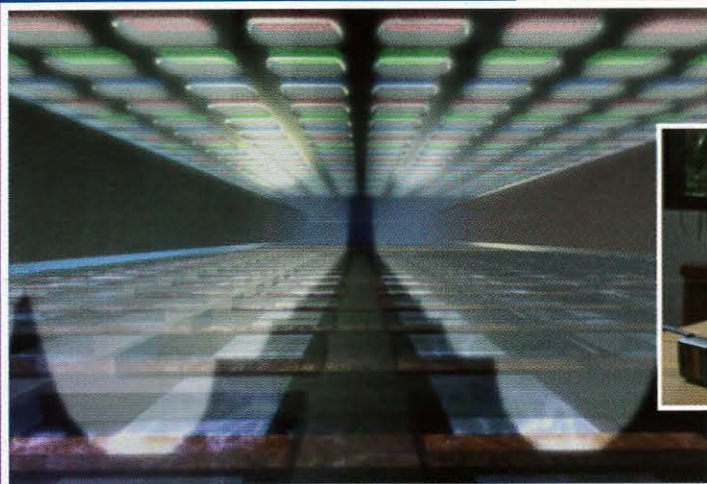
In Japan: IMAT Inc.
Tel: (03) 5472-4421
Fax: (03) 5472-4422
Email: fpd@imat.co.jp

© 1998 Intevac, Inc. D-STAR is a trademark of Intevac, Inc. All rights reserved.

intevac

Circle no. 25

Pioneering the Future of Display Technology!



We are Candescant Technologies, a seven year old company with over 350 skilled and professional employee-shareholders who are laying the foundation for our revolutionary new flat panel display called the "ThinCRT". Thin CRTs embody what display engineers have envisioned for over 40 years: an 8mm thin, lightweight, ultra-low power CRT with an image quality that sets new industry standards. In addition to our breakthrough technology, we have gathered an exceptionally experienced management team, a set of powerful corporate allies and broad financing (more than \$433 million in committed capital so far, with \$125 million of this acquired in May '98) from blue chip investors and corporate partners.

We are now preparing to become a major manufacturer of Thin CRTs for notebook computers, desktop monitors and handheld products. We offer a chance to help shape the future of our company and make an indelible mark on our industry.

We're looking for world-class professionals in the following areas:

ENGINEERING

Process
Lithography
Polymer
Test and Development
Hardware Design
Mechanical Process
Test Software
Test Electrical
Software Development

TECHNICIANS

(Days, Swing & Graveyard)
Production and Engineering
Chemical

MANAGEMENT

Manufacturing Mgr. -
Production
MES Applications Mgr.

INFORMATION TECHNOLOGY

Oracle DBA
CIM Engineers

Please visit our web site for specific position details of our open positions at: www.candescant.com

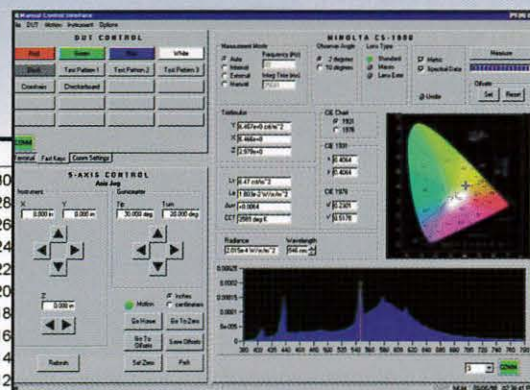
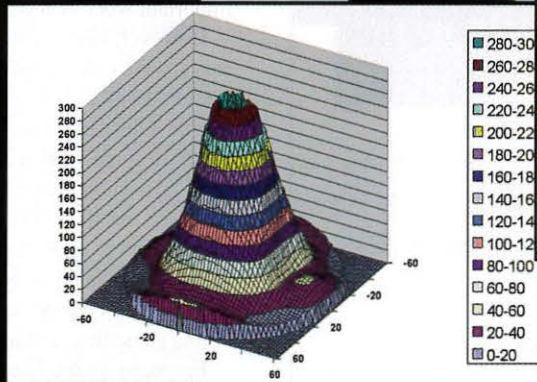
Candescant offers a competitive salary and benefits package, including company 401K & stock plan. Please email your resume to: recruit@candescant.com or fax to (408) 229-0664. Our mailing address is: Attn: Staffing, 6320 San Ignacio Avenue, San Jose, CA 95119. EOE.



CANDESCANT

When you want accuracy and flexibility... Westar's FPD Performance Measurement Systems

- ✓ Tests displays up to 54" automatically
- ✓ Works with Minolta, Topcon, and PR instruments
- ✓ Stimulates any monitor, module, and cell assembly
- ✓ Executes VESA basic and extended tests including:
 - Flicker and response time
 - Shadowing (Crosstalk)
 - Ambient Contrast Ratio
 - Power Consumption and L-P Ratio
 - Viewing Cone Thresholds
 - And many others!
- ✓ Supports all popular spectroradiometers, including the new Minolta CS-1000



- ✓ Includes Westar's powerful **ViewPoint™** Software to operate the FPM systems manually or automatically

Westar Corporation is a leading international supplier of flat panel display test systems to the aerospace, computer, and FPD product industries. Contact us in the US at: (314) 298-8748, ext. 286, or visit our website at www.westar.com/id.

Circle no. 27



display continuum

continued from page 4

illuminated by that wonderful presentation device known as the overhead projector, there were other *very important* things going on. Since the incoming information rate during a

typical presentation seldom exceeds 10 bytes per second, one is left with at least 99.99% of one's mind free to wander through all those creative and private thought-places in meet-

ing-land - wanderings that one would occasionally not wish to share even with one's closest colleagues.

We've all heard the saying that "A mind is a terrible thing to waste." Since intuitively we already know that, we have all learned to use this opportunity for many good and sometimes even noble causes. One of my favorites has always been to use this time to do the detailed problem solving on one of my week-end projects. Perhaps, it could be working out the next steps in restoring a piece of antique furniture, or how to best position my dark-room equipment for optimum printing efficiency, or which digital camera and color printer I should buy, and so on and so forth - you get the idea.

Let's add all this up. *As an attentive meeting attendee, I am accomplishing all of the following: I am absorbing all the information that is being presented to me, I am physically comfortable and resting while seated in a transcendently meditative posture, I am using most of my mind's capabilities to work on problems of my choosing, and I am getting paid my full salary by the company for doing this.* This is great stuff!

Is it any wonder that managers spend most of their days in meetings? In fact, have you noticed that the percentage of the day spent in meetings seems to have a direct correlation with the level of the manager. (In this case, there is no asymptotic behavior; it increases linearly by roughly 24% per management level and then simply goes flat at 96%. Apparently, the remaining 4% is the irreducible residual time needed to do some other important work-related activities.)

However, I must confess that for me there was always a down side to all this. Once the presentations were finished, there would usually be a discussion period with the intent of reaching some kind of a decision. Now, since most boss-subordinate interactions occur during these meetings, this time is one's optimum opportunity to make the "right" kind of impression on the boss. My problem was that I was never very good at that. Others beat me at this game time and again.

For many years, I kept thinking that if I produced world-class technical results my contributions would be recognized and the "results would speak for themselves." It took longer than I would like to admit to realize how naive a concept that really is.

300MHz Video Test Generator

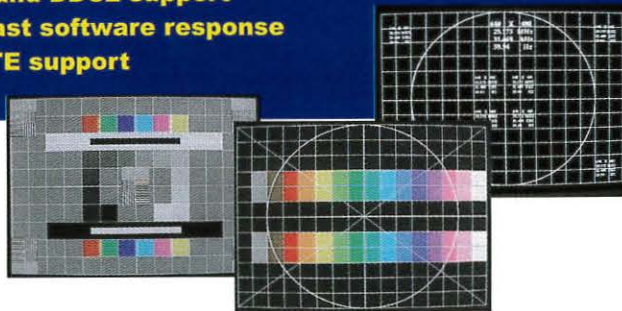


Unigraf VTG-1300

High-performance Video Test Generator on a board

As the other Unigraf video test generators, VTG-1300 comes loaded with features and backed by extensive software support

- Pixel frequency up to 300 MHz
- Fully programmable
- Fast bitmap patterns
- 255 colours, 16.7 million shades
- 2k x 2k x 8 VRAM
- DDC1 and DDC2 support
- Very fast software response
- Full ATE support



VTG-1300 is the latest addition to the family of High-performance Video Test Generators from Unigraf. The 300 MHz pixel frequency enables 1800 x 1440 display resolution at 85 Hz and above. Fast software response makes the VTG-1300 an ideal choice for ATE systems. It is full of features like DDC1/DDC2, fast bitmap patterns, 255 simultaneous colours and a powerful software support for both DOS and Windows including drivers for Windows 95 & NT 4.0.

 **UNIGRAF**
ISO 9001 CERTIFICATED FIRM

UNIGRAF Oy, Ruukintie 18
FIN-02320 Espoo
Finland
Tel. +358 9 802 7641
Fax +358 9 802 6699
<http://www.unigraf.fi>

Since most technical innovations, new product developments, or project management accomplishments have few comparisons by which to measure their true significance in the short term, *it's the perceived success that matters and not the actual result.* Let me explain. Let's say you've just invented a new flat-panel display that requires no matrix addressing. How does your management decide if this is a significant result or not? They would have to be very knowledgeable about display technology and would have to know how many others have tried and not succeeded. But they most likely aren't that knowledgeable and don't know about the many prior attempts. So until your product is a marketplace success ten years from now, only your peers will know what an incredibly significant result you have achieved. But, unfortunately, your peers may also be your competitors for corporate budgets, the next promotion, lab space, and/or the boss's attention. So do they really want you to get all the recognition you may deserve? Hmmmm...

Well, as I told you, I was never very good at this stuff. But others were, and after a while I started observing that there were certain personality types which seem to populate staff meetings everywhere. So I took the scientific approach and started to create categories for some of these characters. The behaviors were sufficiently distinct that I decided to keep separate dossiers on bosses and colleagues. Perhaps, I thought, that way I could at least learn from their successes, and even if I chose not to emulate them, I could at least understand how they were able to pull off their feats of persuasive legerdemain.

Think of the list that follows as the introductory program to a play you are about to enjoy. Unfortunately, in this month's column, I won't be able to entertain you with the play itself. (That will have to wait for a future column.) In any case, each of these characters would be worthy of an entire play (or column) - in at least three acts.

Therefore, let me welcome you to the Issaquah Village Theater, where tonight's play, *The Meeting*, is presented with the generous support of high-technology corporations everywhere. The cast of characters you will meet is the following, in alphabetical order:

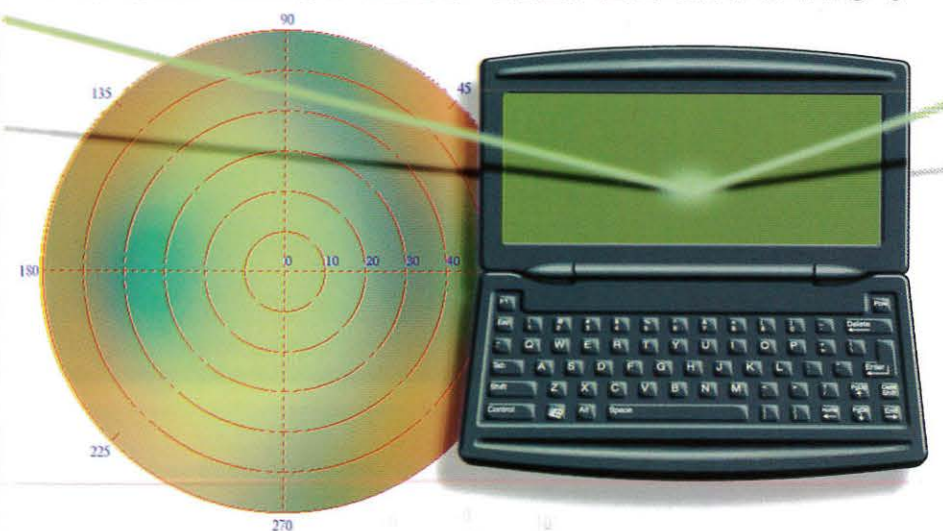
The Bosses:

Consensus Builder - This boss-character you will quickly recognize as seeking agree-

ment from all his employees before he makes a decision, even when that decision involves making a change that will negatively impact one of those whose consent the boss is seeking.

Controller Queen - Her dictatorial majesty will impress you with her ability to ask the most detailed question, especially when it comes to keeping track of orders and sales and other financial matters. The controller

HOW WOULD YOU MEASURE YOUR DISPLAY REFLECTIONS?



EZContrast well known display measurement solution now provides:

- > Diffuse illumination measurements
- > Specular illumination measurements
- > BRDF analysis
- > Automatic angular dynamic adjustment

Over $\pm 80^\circ$ incidence, $0-360^\circ$ azimuth angle while maintaining a measurement speed of less than **1 mn** for luminance measurements.

Compatibility with main display characteristics measurement standards (ISO, VESA...).

ELECTRONICS FOR DISPLAYS AND IMAGING DEVICES

1185 rue d'Epron 14200 HEROUVILLE SAINT CLAIR - France
Phone : + 33 2 31 94 76 00 - Fax : + 33 2 31 94 09 50
 EMail : eldim@eldim.fr - Internet address : <http://www.eldim.fr>

Circle no. 29



ELDIM

© ELDIM SA - 1998 / Aug0100 - V2.0

ERG Display power is what we do.

Only one company specializes in magnetics-based inverters & converters to power backlit displays – ERG.

Want better performance, lower pricing, faster turnaround and U.S.-based

engineering support? Need help with a custom application or special problem? Call the expert – ERG.

Display power. It's what we do. It's all we do.

Call: 1-800-215-5866 ext. 3011



Endicott Research Group, Inc.
the power behind the display



2601 Wayne Street • PO Box 269 • Endicott, NY 13760
Fax: 607-754-9255 • E-Mail: sales@ergpower.com • http://www.ergpower.com

Circle no. 30

CRT picture quality in a thin, flat panel display...

Introducing the PixTech Field Emission Display (FED) Enjoy the same full viewing-angles as a CRT, and the same smooth, continuously variable brightness up to 600 cd/m² ... all in a compact, lightweight (250 gm) package. Low power (1 W at 150 nits)

makes the 5.2 inch PixTech FED the perfect replacement for bulky CRTs ... and the perfect replacement for LCDs, as well. "Instant-on" at -45°C to +85°C, the FED can take on the toughest outdoor environment. With 320x240 resolution, the PixTech FED is the display upgrade you've been looking for.

... when you upgrade to PixTech FED

How does it work? The PixTech FED is a flat, thin (2.5 mm) CRT, but with millions of micron-size cold cathode emitters, all packaged in a 11 mm deep package. Monochrome (green) FEDs are in production now, with full color evaluation kits available for testing to qualified OEMs and display integrators. Call today to discover the many advantages of PixTech FEDs.



PixTech
Flat panel displays for the real world.™

3350 Scott Boulevard, Bldg. 37 ■ Santa Clara, CA 95054
(408) 986 8868 ■ Fax: (408) 986 9896

<http://www.pixtech.com>

Call us! 1-888-PIXTECH

Circle no. 31

display continuum

queen does not wish her subjects to present reasonable explanations – only favorable results.

Duke of the Inner Circle – The duke you will quickly spot by his entourage of loyal followers. His inner circle follows him from company to company and from job to job. If you are not one of the inner circle, your influence will be immeasurably small.

Entrepreneurial Inventor – When you see him make his entrance, you will quickly note that he tries to solve all the world's problems with his technology and will tolerate no thought that his germinating ideas are not ready for immediate scale-up to high-volume manufacturing.

Maker of the Numbers – This character will entertain you with her single-minded objective of beating each week's, each month's, and each quarter's financial plan. Unfortunately, you may find her a bit one-dimensional.

Promoter of Thyself – Let's give credit where it's due – to the boss. If you don't, he will take it anyway. His presentations are a sight to behold. Search we high or low, a more self-proclaimed capable individual is not to be found anywhere.

The Whiz – Such a smart one is he that all sorts of problems will yield to a purely analytical approach. The intellect side of his brain is so dominant that the emotional side has had no chance to develop, and all people problems are either ignored or "solved" by writing an algorithm.

The Colleagues:

Entertainer – What a charmer you will find this character to be, one so endearing to his colleagues and his boss. Many promotions and other blessings have come as a result of such a wonderful ability to keep everyone so up to date on the latest of humorous stories.

Follower of the Party Line – Ah, it's all in the timing. One must listen to all opinions and then wait to see what the boss is thinking. Then just before the decision is to be announced, one must jump up as if inspired from the heavens above and quote said decision. You will be amazed at how this ability will be demonstrated time and again during Act II.

Manipulator – Such a well-behaved individual is he – never a discordant word during the meetings. But, there is an ominous air

about this character. His turf is the back alley and the one-on-one encounter. You will note the excessive attention lavished upon the boss by this individual. And you will also note that the boss always seems to have a less than accurate slant on the facts after a meeting with the manipulator.

Problem Solver - Poor problem solver, she takes the meeting agenda at face value. She assumes that the problems are really as presented and offers up logical solutions. Why won't anyone listen? Why won't the others believe her when she describes how other companies at which she has worked resolved similar situations?

Rainmaker - Whatever it is, it just won't work. Be it a new company policy or a new product idea, it just won't work. Everything is getting worse. Rainmaker will make you oh so sad with her soliloquy of problems - problems at work and problems at home.

Traditionalist - Well, after more than 25 years at the same company wouldn't you also try to resist change? In fact, would you even know what change is? This character lives out his final corporate days pursuing the thankless task of trying to preserve what little is left of past grandeurs - at least as remembered by this old-timer.

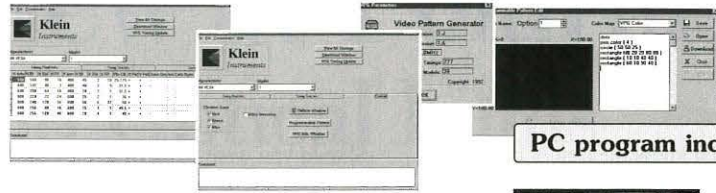
Waffler - This character, you will discover, is right out of *Fiddler on the Roof*. Tevye could also see both sides of every issue and finally made only one decision - and then lived to regret it. Waffler has a real problem with decisions because he can see the nearly infinite positive and negative possibilities in every situation. Such brilliance would be great if only it could be harnessed for some useful purpose.

Well, my goodness, we seem to have come up with about the same number of boss and colleague categories for our play. Certainly this does not mean that we have exhausted the possibilities. In fact, we most likely have just scratched the surface. So let's get on with our play and enjoy watching what happens as these characters interact.

Oh, I'm sorry! I forgot that you don't live here in Issaquah. That will certainly make it harder for you to make it in time for tonight's performance. But please don't despair. I have a perfectly adequate alternative to offer you. Tomorrow, when you go to work, you will almost surely have some kind of a meet-

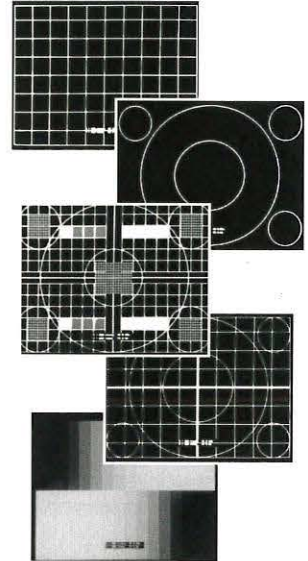
KLEIN Instruments Corporation

KLEIN VPG 250 Stand-Alone Pattern Generator



PC program included

- Programmable Timings (500)
- Programmable Sequences (30)
- User Programmable Patterns
- 2048 x 2048 pixel resolution
- 999.9 Hz max Vertical frequency
- 999.99 KHz max Horizontal freq.



Test Equipment for Computer Monitor Displays
ph: 503-245-1012 • fax: 503-245-8166 • www.kleininc.com

Call for Prices!
Portland, OR USA

Circle no. 32



Call For A
Sample And Our
New Literature

Light Shaping Diffusers®

- High transmission efficiency (up to 92%)
- Controlled light distribution (0.2° to 95°)
- Homogenized light
- Mass produced technology

Poc Physical Optics Corporation®

Ph: (310) 320-3088 Fax: (310) 320-8067 Web: www.poc.com

Manufactured under U.S. patent nos. 5,365,354; 5,534,386; 5,609,939; 5,631,754; 5,629,996 and other patents pending.

Circle no. 33

display continuum

ing. Now that you know the cast of characters, you can experience theater-in-the-round as you've never experienced it before. Welcome to the play.

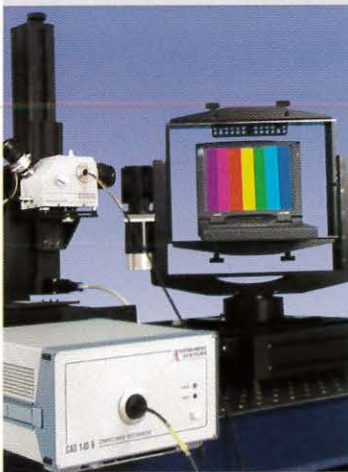
Should you want to provide me with a critical review of your personal theater experiences, or perhaps others, please contact me by any of the following methods: e-mail at

silzars@ibm.net, telephone at 425/557-8850, fax at 425/557-8983, or by mail at 22513 SE 47th Place, Issaquah, WA 98029. ■



www.instrumentsystems.com

Get the DISPLAY TEST SYSTEM with the best spectroradiometer...



For Accuracy

The most sensitive and fastest spectroradiometer in its class has a cooled & back-thinned CCD detector with 4 times the resolution of competitive systems.

For Versatility

The most accessories and probes including automated 5-axis positioners & power supplies with full software integration.

For Productivity

Windows 95™ and NT™ software. Real-time link to spreadsheets for customized analysis. Automated VESA testing of FPDs.



North America Instrument Systems

576 Golden Avenue, Ottawa, Ontario, Canada K2A 2E9

• Tel: 613-729-0614 • Fax: 613-729-9067 • E-mail: info@instrumentsystems.com

International (World Headquarters) Instrument Systems GmbH

Neumarkter Str. 83, 81673 Munich, Germany

• Tel: 49/89454943-0 • Fax: 49/89454943-11 • E-mail: info@instrumentsystems.de

Circle no. 34

2

99

FEBRUARY

Display Works 99:

*SAN JOSE, CALIFORNIA
FEBRUARY 2 - 5, 1998*

- An international conference addressing all aspects of Display Manufacturing including:
- Flat Panel and CRT Manufacturing
- Display Materials
- Manufacturing Equipment
- Cost Reduction and Yield Improvement
- Industry Forecasts
- Investor Presentations
- International Standards

17

98

NOVEMBER

*Sixth Color Imaging
Conference: Color Science,
Systems & Applications*

*SCOTTSDALE, ARIZONA
NOVEMBER 17 - 20, 1998*

- An international multidisciplinary forum for dialogue on:
 - Creation and capture of Color Images
 - Color Image reproduction and interchange
 - Co-sponsored with IS&T.

Please send new product releases or news items to Information Display, c/o Palisades Institute for Research Services, Inc., 411 Lafayette Street, 2nd Floor, New York, NY 10003.

What's New at Polaroid

Polaroid Optical Films

The ultimate solutions that eliminate glare and enhance contrast to bring out the brilliance of your displays.



- **“Durable KE” Polarizers** - The ideal product for displays requiring durability and reliability. “Durable KE” Polarizer maintains superior optical properties especially in harsh conditions where extreme temperatures and humidities exist.

- **“LIFT” Holographic Reflectors** - Light Intensifying Film Technology “The brightest idea in the world for LCD's”.

- **Anti-Reflection Film** - Polaroid introduces a high-performing, low-cost, anti-reflection film.

- **Circular & Linear Polarizers and Retarders** - Complete spectrum of polarizers available in a wide variety of colors, transmittances and formats. Polaroid offers the knowledge, expertise, and facilities to provide the polarizer that's exactly right for your application.

Polaroid offers the most comprehensive line of optical film products for all types of displays.

For more information:

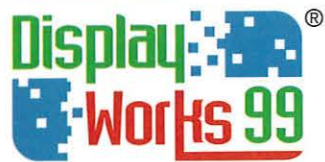
Polaroid Corporation

Optical Films Division
1 Upland Road - N2
Norwood, MA 02062

Tel: 800 225 2770

Fax: 781 386 4600

www.polaroid.com



Plan Now to Attend! Display Works® 99

*The Only Display Event
Focused on the Business
and Technology of Display
Manufacturing*

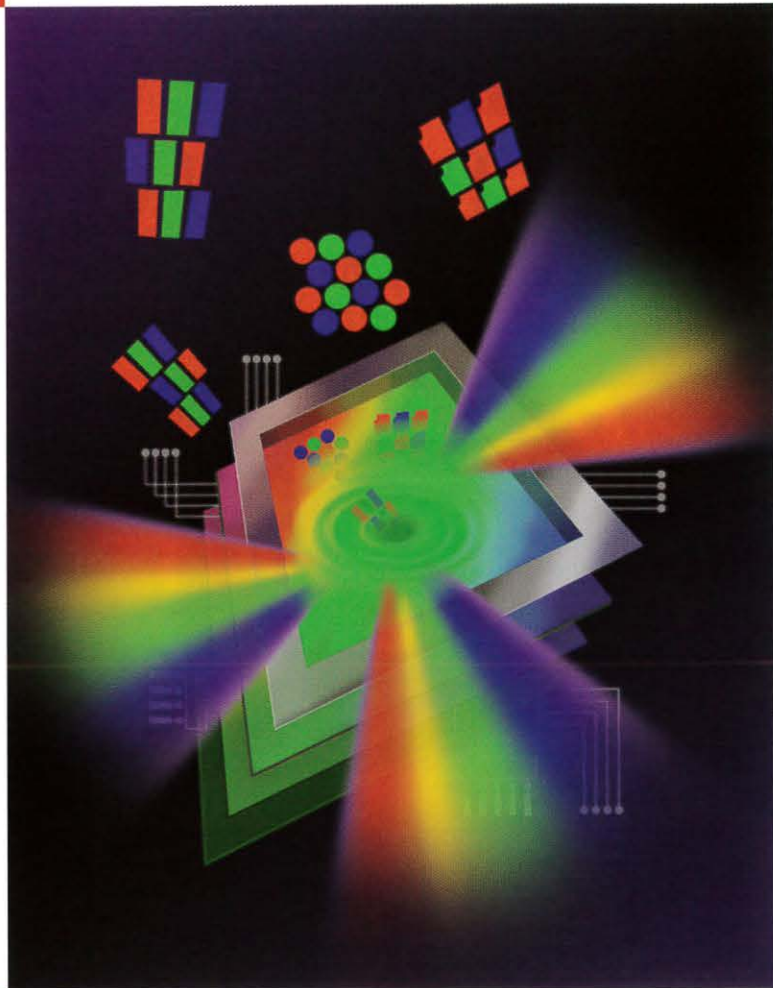
Exposition:
February 3-4, 1999

Conferences and Events:
February 1-5, 1999

Hear these exciting keynote speakers
at the USDC Business Conference:
*Display Applications for the New
Millennium:*

- John Vrolek, Senior V.P., Silicon Graphics
- John Medica, V.P., Dell Computer
- Julie Chen, V.P., Primeview International
- Ross Young, President, DisplaySearch
- Professor Stephen Cohen, Co-director, Berkeley Roundtable
- Jim Larimer, Principal Engineer, NASA

Visit www.displayworks.org
for full agendas!



**Display, Equipment, Materials and Services
Suppliers—Exhibit Your Latest Technologies!**

Display Works 99 is a one-of-a-kind opportunity developed to give you the most bang for your exhibit buck, featuring:

- A Two-Day Exposition: Buyers and Sellers Exhibit Side-by-Side
- SID Technical Conference including an Exhibitor Track
- USDC Business Conference
- Industry-wide Standards Meetings
- Market Briefing
- Cost of Ownership Course
- Environmental, Health & Safety Industry Meeting
- Plus, Press Conferences, Social Events and Special Industry Exhibits

Meet your target customers—the key decision-makers—at Display Works 99:

- 27% of Display Works visitors make the final purchase decision
- 41% recommend or strongly influence the final decision
- 19% specify needed products and services

To exhibit or for more information, call Brian Santor, at SEMI, 650.940.7992, e-mail your request to bsantor@semi.org, or visit www.displayworks.org.



Ten reasons to go with Toddco:

1 All-Ceramic Hot Bar*

TODDGO PATENTED TECHNOLOGY

- Superior thermal uniformity
- Superior planarity (flatness)
- No voltage or current on parts or traces

2 Computer Controlled Temperature & Force

- Precise repeatability
- Reduce process variation
- Software configurable for ACF heat seal or solder applications

5 Graphical User Interface*

- Simplifies process development
- Easy to learn
- Easy to use

3 Automated Vision System*

- Speeds alignment task
- Improves accuracy and repeatability
- Fine pitch <90 micron capable
 - Upper and lower cameras

NEW!

4 Auxiliary Thermocouples

- Process development tools
- Characterize the actual bond surface
- Record measured data

Toddco's Flat Panel Display Workstations

offer you exclusive design features that provide the most effective and profitable flat panel repair, rework operations, high-mix production and prototyping.

Our hot bar is all-ceramic which ensures consistent temperature and pressure across the bond surface. A universal glass stage means you get faster and more accurate product change-over from model to model.

More models to choose from, more industry-specific features and more application experience than any other vendor makes Toddco General the manufacturer of choice for the flat panel industry.

Contact Toddco General today, and find out how we contribute to the success of our customers worldwide.

(619) 877-2100

6 Universal Glass Stage*

- Accommodates variety of glass stages
- Recordable, repeatable settings for quick product change over

7 Customized Fixtures

- Optimize efficiency and quality
- Precise matching of parts and bonder
- Universal tab feature

NEW!

8 Real-Time Data Acquisition

- View and plot real-time values.
- Data for reports and quality assurance
- Part/lot histories

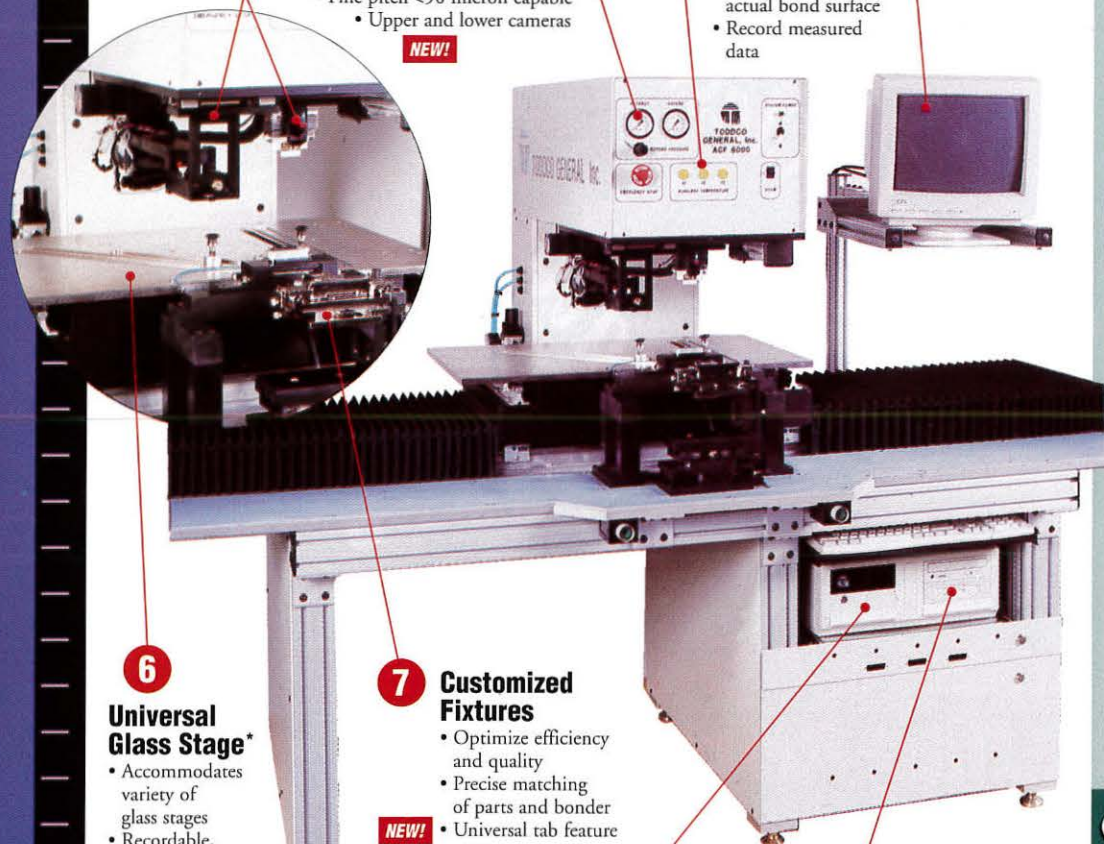
9 Security

- Key-lock or software password protection
- Eliminate unauthorized access or changes
- Control profile and sequence revisions

10 Selection & Service

- More price performance options
- More automation options
- Technical and application engineering support

*On selected models



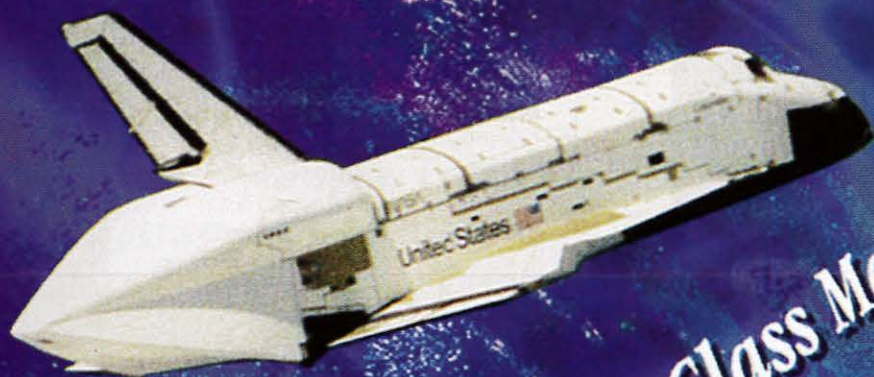
Toddco General, Inc.

13535 Danielson St.
Poway, CA 92064
Fax: (619) 877-2110

E-mail:
sales@toddco.com

Web:
http://www.toddco.com

Reaching Galaxies of Technology Never Explored Before!



- World Class Manufacturing
- Advanced Technology
- Customer Focused

**Imaging and CRT Solutions
for Demanding Applications**

LEXEL

IMAGING SYSTEMS, INC



A SUBSIDIARY OF LEXEL CORPORATION

1501 Newtown Pike • Lexington, KY 40511 • (606) 243-5500 • Fax: (606) 243-5555

Sales & Marketing: (970) 731-5260 • Fax: (970) 731-5261

Circle no. 37

Increase EMI/RFI Protection with DURALAN II™

High Performance Windows, Lenses and Filters

- Laminated Within the Filter
- Various Conductors Available
- Abrasion Resistant Surface
- Anti-Glare Finishes
- Various Transparent Colors
- Contrast Enhancement



SILVER CLOUD
MANUFACTURING CO.
GRAPHICS AND ELECTRONICS

For additional information call 609/825-8900, FAX: 609/825-8969, or visit our Web site at: www.silver-cloud.com

Circle no. 38

SID '99

San Jose, California

San Jose Convention Center

May 16-21, 1999

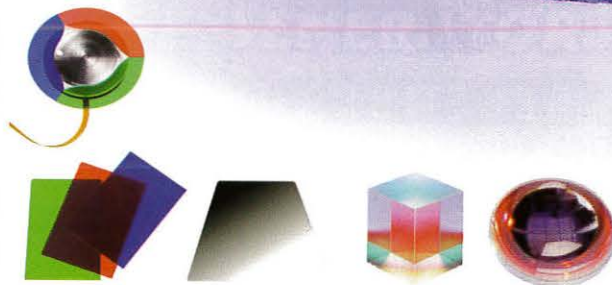
Mark Your Calendar Now!

balzers

Thin Films



Light Management Solutions™



As multi-faceted as a diamond... are the many solutions we offer as a leading producer of thin films and optical components. Always providing a dedicated effort to benefit our worldwide partners – Balzers Thin Films has the professional skill and expertise to meet the needs of your most challenging applications.

Combining our proven thin film technology with our manufacturing knowledge – integrated solutions for optical components and assemblies are now available from one source. Optimized to the needs of the projection display manufacturer we offer the ColorCube™ and ColorWheel™ for color splitting and recombination, Silflex™ ultra-high reflective mirrors, Callflex™ hot mirrors and much more...

Balzers Thin Films
FL-9496 Balzers
Principality of Liechtenstein
Tel. +41(0)75-388 44 44
Fax +41(0)75-388 54 05
E-Mail: sales@btf.balzers.net

USA, Golden, CO
Tel. +1(303)273-9700
Fax +1(303)273-2995

Germany, Geisenheim
Tel. +49(0)67 22-99 30
Fax +49(0)67 22-99 31 61

<http://www.btf.balzers.com>

5202/2/98 www.btf.ch

Circle no. 39

SID Conference Calendar

Next Show!

The Sixth Color Imaging Conference

The Color Imaging Conference has become the premier technical conference for scientists, technologists and engineers working in the areas of color science and systems and their application to color imaging. 1998 marks the sixth year of this topical, annual conference with a significant growth in overall participation. The conference is international in nature. As the Conference has grown and matured, the focal areas have expanded dramatically. Professional disciplines represented range from psychophysics, optics, image processing, color science, photography, graphic technology, systems engineering and applications as well as hardware and software development. The focus is color – color as a critical element of the research and application efforts of this segment of the professional community.

17

98

NOVEMBER

Sixth Color Imaging Conference: Color Science, Systems & Applications

SCOTTSDALE, ARIZONA
NOVEMBER 17 – 20, 1998

- An international multidisciplinary forum for dialogue on:
 - Creation and capture of Color Images
 - Color Image reproduction and interchange
- Co-sponsored with IS&T.

7

98

DECEMBER

Fifth Annual International Display Workshops (IDW '98)

KOBE, JAPAN
DECEMBER 7 – 9, 1998

- Information Display Workshops
- Invited experts will present talks at workshops on:
 - Emissive Displays
 - Non-Emissive Displays
 - Plasma and EL Displays
- Sponsored by SID/Asia Region, Japan Chapter. IEKE. ITE

For additional information:

Dee Dumont
Society for Information Display
31 East Julian Street
San Jose, CA 95112
408/977-1013, fax - 1531
www.sid.org

2

99

FEBRUARY

Display Works 99

SAN JOSE, CALIFORNIA
FEBRUARY 2 – 5, 1999

- An international conference addressing all aspects of Display Manufacturing including:
 - Flat Panel and CRT Manufacturing
 - Display Materials
 - Manufacturing Equipment
 - Cost Reduction and Yield Improvement
 - Industry Forecasts
 - Investor Presentations
 - International Standards

16

99

MAY

SID '99

SAN JOSE, CALIFORNIA
MAY 16 – 21, 1999

- SID's MAJOR ANNUAL EVENT
- An International Symposium, Seminar, and Exhibition – Featuring:
 - Technical Sessions – Poster Session
 - Author Interviews – Evening Panels
 - Short Courses – Applications Seminars
 - Technical Seminars – Applications Sessions
 - Product Exhibits - Executive Poster Sessions
 - Display Technology Showcase



Since 1962, a professional worldwide interdisciplinary society committed to the advancement of information display.

Interface Solutions for flat panels

Speed up development and product realisation time with our high quality flat panel interface controllers for your LCD, Plasma or EL projects. Suitable for small or high volume projects and monitor production.

Analog - Computer

AC series: A range of interface controllers for LCD, Plasma or EL, to connect to analog graphics source. **VGA** (640x480), **SVGA** (800x600), **XGA** (1024x768), **SXGA** (1280x1024).

SV-Series: A combination interface for both computer graphics and video (PAL, NTSC) for LCD & Plasma.

➤ **NEC analog panels** are also supported.

Digital View

USA: Tel: 408-782-7773, Fax: 408-782-7883
England: Tel: (0)1438-816 600, Fax: (0)1438-816 909
Hong Kong: Tel: 2861 3615, Fax: 2520 2987

Bus card - PC

DC series: Includes PCI bus LCD graphics card for providing LCD digital signal output from a PC.



Video - PAL/NTSC

PN series: Advanced multi system video interface for TFT LCD and Plasma panels.

Accessories: A wide variety of support accessories.

Enclosure options:

- Open frame kits: panels & interface controllers in easy to use frames.
- Industrial display systems
- Desktop monitors
- LCD multimedia systems

Internet: www.digitalview.com
Email: sales@digitalview.com

Circle no. 40

SID '99

San Jose, California

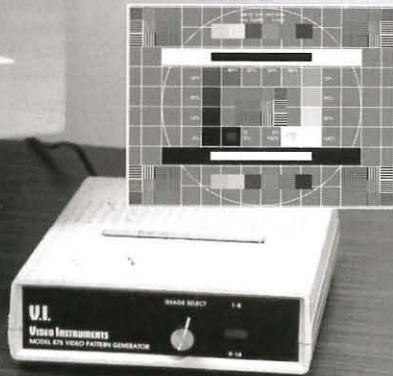
San Jose Convention Center

May 16-21, 1999

Mark Your Calendar Now!

VIDEO REFERENCE IMAGE GENERATOR

*The V.I.
Model 875A
gives you
the picture!*



- Programmed as **you** need from your p.c. using the V.I. Image Master library.
- Stores up to 16 reference images - one pattern at 16 different rates, or 16 patterns at one rate, or any combination in between.
- Monochrome and RGB color video.
- External synchronizing pulses.
- Small, light, portable.

**Affordable
\$1,695.00**

V.I.
VIDEO INSTRUMENTS

2155 Bellbrook Avenue • Xenia, OH 45385-4043
Ph.: 800-962-8905 • 937-376-4361 • Fax: 937-376-2802
E-mail: sales@videoinstruments.com
Visit our Web Site: www.videoinstruments.com
Visa • Mastercard • American Express

Circle no. 41

sustaining members

Acer Display Technology
 Ad-Vance Magnetics, Inc.
 Advanced Display Technologies
 Arconium
 Artesyn Solutions, Inc.
 ATI Technologies
 autronic - Melchers GmbH
 Brewer Science, Inc.
 Brimar Ltd.
 Canon, Inc.
 CELCO
 Cherry Electrical Products
 Chunghwa Picture Tubes, Ltd.
 Clinton Electronics Corp.
 Colorado MicroDisplay, Inc.
 Corning Japan K.K.
 Crystaloid LCDs
 Display Laboratories
 DisplaySearch
 Displaytech, Inc.
 DNP Denmark
 Dolch Computer Systems
 Earth Computer Technologies
 Electronic Designs, Inc.
 Electro-Plasma, Inc.
 Emco Electronics Ltd.
 Endicott Research Group, Inc.
 ERSO/ITRI
 FED Corp.
 F-P Electronics
 Futaba Corp. R&D Center
 General Vacuum, Inc.
 Hewlett-Packard Co.
 Hitachi, Ltd.
 Hoya Corporation USA
 Imaging & Sensing Technology
 Incom, Inc.
 Industrial Electronic Engineers, Inc.
 Infinite Graphics, Inc.
 Infodex, Inc.
 Instrument Systems
 Interface Products, Inc.
 Interserv Corp.
 Interstate Electronics Corp.
 ISE Electronics Corp.
 Kent Display Systems
 Lexel Imaging Systems, Inc.
 LinFinity Microelectronics, Inc.
 Micron Display Technology, Inc.
 Microvision Corp.
 Mitsubishi Electric Corp.
 Mitsubishi Electronics America

Motorola FPD Division
 NEC Corp.
 Nippon Seiki Co., Ltd.
 OIS Optical Imaging Systems, Inc.
 OKI Electric Industry Co., Ltd.
 Optical Coating Lab., Inc.
 Optrex America, Inc.
 Phosphor Technology Ltd.
 Photon Dynamics
 Photo Research
 Pilkington Micronics Ltd.
 Pix Electronics, Inc.
 Planar America
 Planar Standish, Inc.
 Plasmaco, Inc.
 Polar Vision, Inc.
 Polytronix, Inc.
 Q.C. Optics, Inc.
 Quantum Data Inc.
 RF Power Products
 ROLIC Research Ltd.
 Sarnoff Corp.
 Semiconductor Systems, Inc.
 Sharp Corp. - Japan
 SI Diamond Technology, Inc.
 Sony Corp. Research Center
 Stanford Resources, Inc.
 Supertex, Inc.
 Symbol Technologies, Inc.
 Syntronic Instruments, Inc.
 Tamarack Scientific
 TDK Corp.
 TEAM Systems
 Techneglas, Inc.
 Teledyne Lighting & Display
 Terapixel, Inc.
 Thomas Electronics, Inc.
 Three-Five Systems, Inc.
 Toshiba America Electronic Corp.
 Ultra Electronics Command &
 Control Systems
 ULVAC Technologies, Inc.
 Unipac Optoelectronics Corp.
 Universal Display Corp.
 Ushio America, Inc.
 Viratec Thin Films Inc.
 Vishay-Dale Electronics, Inc.
 Westar Corp.
 WINTEK Corp.
 WinTron Technologies
 XCITEK, Inc.
 XMR, Inc.

index to advertisers

Anotech	40	Microvision	10,30
Applied Science Labs.....	56	Nano-Master.....	22
Balzars Thin Films.....	53	OCLI	23
BOC Coating Technology.....	35	Optrex America.....	C2
Candescent Technologies.....	42	Photo Research.....	5
Computing Devices Canada Ltd.	6	Physical Optics Corp.....	47
CyberTouch.....	16	PixTech	46
DATA MODUL.....	9	Polaroid	49
Digital View.....	55	Quantum Data	11
Display Works 99.....	50	Silver Cloud Manufacturing.....	53
ELDIM.....	45	Society for Information Display	54
Endicott Research Group	46	TDK	C3
Ergotron	10	TEAM Systems.....	3,34
H. L. Funk Consulting.....	22	Thin Film Devices.....	31
Instrument Systems	48	Three-Five Systems.....	C4
Intevac.....	41	Todoco General.....	51
Kent Displays.....	8	Topcon America Corp.....	7
Klein Instruments Corp.....	22,47	Unigraf	44
LCD Lighting	40	Video Instruments.....	55
Lexel Imaging Systems.....	52	Westar Corp.	6,43
LinFinity Microelectronics	17		

Business and Editorial Offices

Palisades Institute for Research
 Services, Inc.
 411 Lafayette Street, 2nd Floor
 New York, NY 10003
 Jay Morreale, Managing Editor
 212/460-8090 x212 Fax: 212/460-5460

Sales Office

Palisades Institute for Research
 Services, Inc.
 411 Lafayette Street, 2nd Floor
 New York, NY 10003
 Christy Smith, Director of Sales
 212/460-8090 x211 Fax: 212/460-5460

Take Advantage of our Experience

For over 25 years, ASL has led the way in the development of eye tracking technology and systems.



Model 504 with remote optics

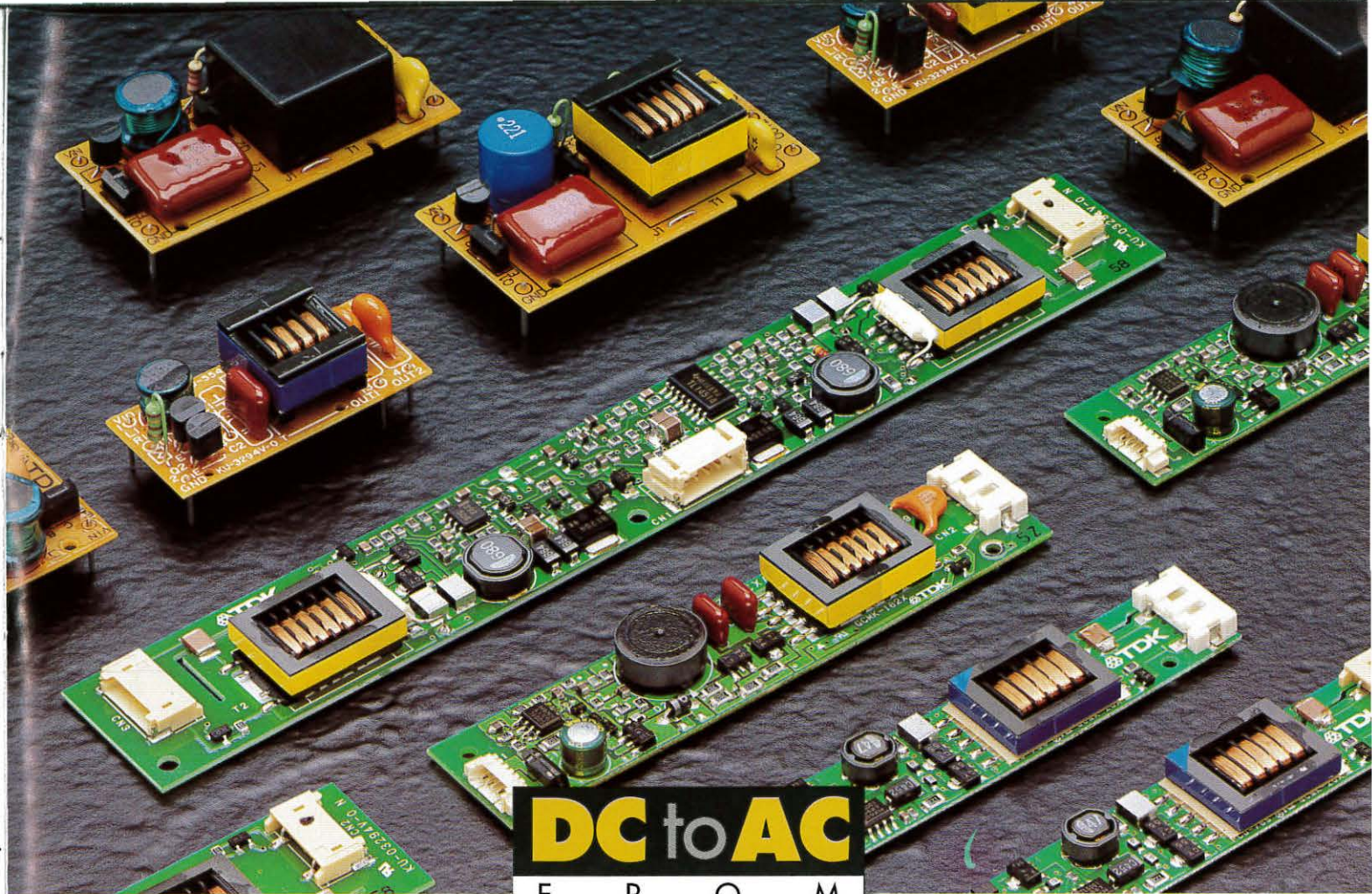


Eye scan pattern

Contact us.
 Learn how eye tracking can fit into your application.

Applied Science Laboratories
 175 Middlesex Turnpike
 Bedford, MA 01730

Tel: (781) 275-4000
 Fax: (781) 275-3388
 Email: asl@a-s-l.com



DC to AC
F R O M
A to Z

With over 25 standard models, and the option to customize, TDK offers a complete range of DC/AC inverters, readily available from stocking distributors throughout North America. To maintain these inventories, five TDK factories are dedicated to producing a total of more than one million DC/AC inverters per month.

Developed with the same quality and ingenuity that's come to be associated with our line of tapes and rewritable CDs, our DC/AC inverters, too, are making a powerful name for themselves. Fact is, they come highly recommended by top display manufacturers.

Choose from encapsulated or non-encap-

TDK Offers a Complete Inventory of Every Standard DC to AC Inverter.

sulated, PC mounts or connectors, dimming or non-dimming, models in 2 through 20 watt ranges with 1 to 4 lamps standard (8 or more available). You'll find TDK DC/AC inverters have some of the highest efficiency ratings in the industry. And, we're currently developing an inverter designed to operate more efficiently than any other in its class.

Call for a sample or to consult with an engineer about your application.

Ask about our cross-reference guide. It indicates which TDK inverter is specifically compatible with your application. Also available, our Technical Applications Note to assist you with your designs.



TDK CORPORATION OF AMERICA
 1600 Feehanville Dr., Mt. Prospect, IL 60056 (847) 390-4478
 Fax (847) 390-4498 website: <http://power.tdk.com> e-mail: power@tdkca.com



QS 9000
 CERTIFIED

ISO 9001
 CERTIFIED

Get Active

Three-Five Systems, Inc. is proud to introduce an off-the-shelf display solution - the LCaD™ 1/4 VGA display. LCaD™, Liquid Crystal Active Drive, is a passive matrix display which uses customized drive circuitry to scan multiple lines of the display simultaneously. The result is a display with a higher contrast ratio, wider viewing angle, and a lower power requirement than a display using conventional LCD drive techniques.

LCaD™ 1/4 VGA displays bring enhanced viewing capability usually reserved for active matrix displays at a fraction of the cost. The LCaD™ 1/4 VGA generates up to 16 shades of gray and is also easy to interface. With serial and parallel capability

for command/data and all LCD rastering self-contained within the LCaD™ display, developing exciting content of both text and graphics is just a few short programming steps away.

Is the information content of your design increasing? Is your instrumentation or appliance design in need of a facelift? Does your point of sale terminal need an enhanced capability to make a more user-friendly product? Then, get active with LCaD™ displays from Three-Five Systems. For more information or to learn more about how Three-Five's display solutions can revolutionize your products and your business, please contact us.



Display is actual size. LCD image has not been retouched.



THREE-FIVE SYSTEMS, INC.™

We Display Excellence

Three-Five Systems, Inc.
Tempe • 602-389-8600 Fax: 602-389-8801

Three-Five Systems Ltd.
Europe • 44-1793-549100 Fax: 44-1793-549135

Three-Five Systems, Inc.
www.threefive.com email: Display@threefive.com

Circle no. 44