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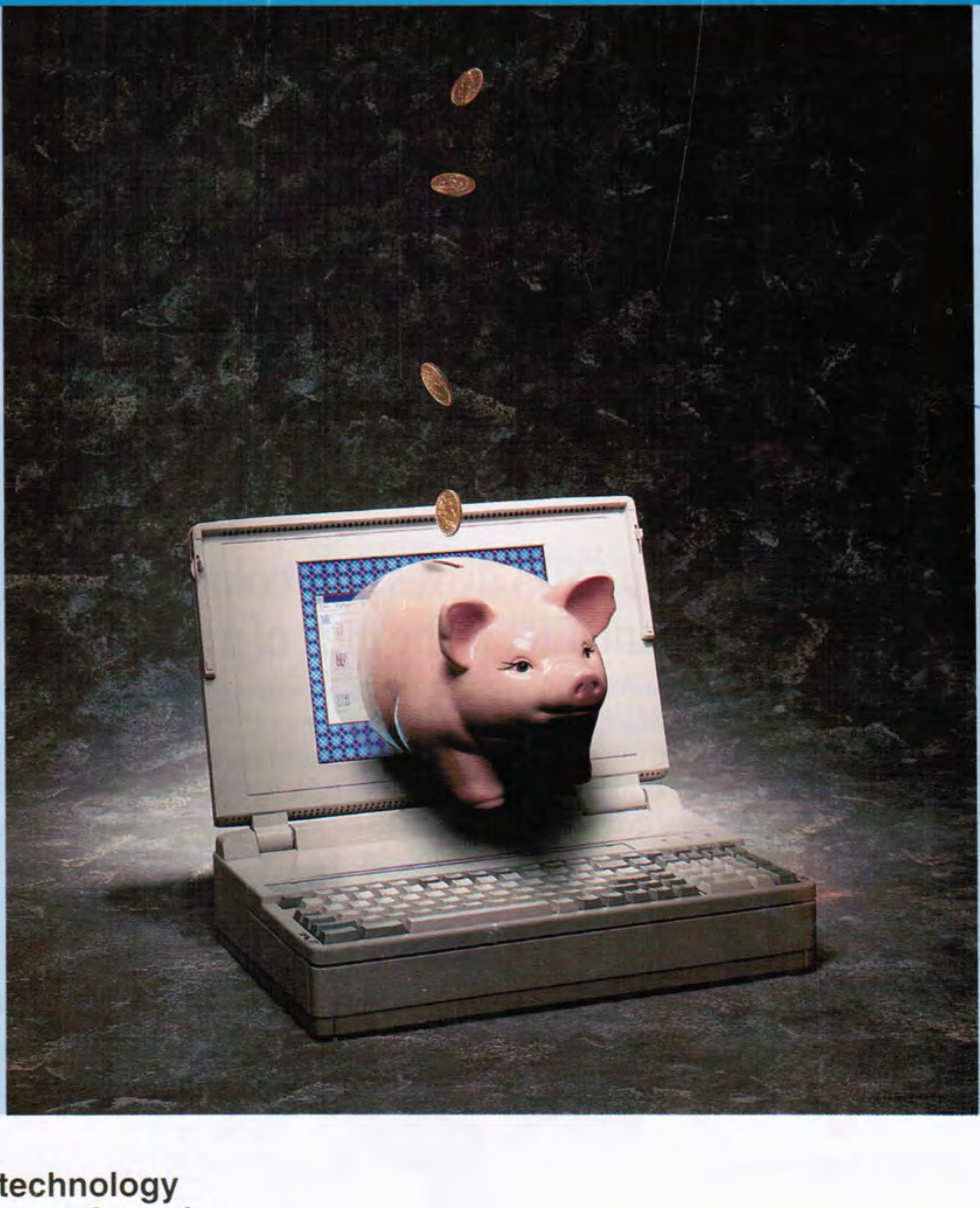
1993 TECHNOLOGY ROUNDUP



Display technology
Display manufacturing

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Cover: Makers of production equipment are helping manufacturers squeeze the cost out of flat-panel displays. For the first time, ID's year-end technology review incorporates coverage of manufacturing issues. See page 12.

Photon Dynamics, Inc.

Next Month in Information Display

CRT Technology Issue
- Color-beam profiling
- Display controllers
- Air-traffic-control displays
- SMAU '93 report

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editorial

Welcome to the Jungle – and Happy New Year

The manufacturers who are trying to squeeze a profit out of color active-matrix displays will tell you. Makers of specialized CRT monitors who must adapt to programs emphasizing ruggedized off-the-shelf (ROTS) devices rather than full-custom products will tell you. Glassmakers wondering how they will push enough 16:9 bulbs through their plants to make a profit will tell you. Makers of flat-panel displays who have not found a graceful upgrade path to color will tell you. Tell you what? "It's a jungle out there, Maude."

Of course, this jungle is not a botanical one. It is the product of high technology and global trade. As such, it is treacherous – and it changes in the blink of an eye or the sweep of an electron beam. But jungles are ecosystems that support an incredible richness of life. They are places where the quick of wit and the fleet of foot not only survive, but thrive.

For most of us, the display jungle is not as threatening an ecosystem this winter as it was one or two winters ago. We understand the hazards better and we are quicker to see the opportunities. Daring new initiatives from Matsushita, Fujitsu, Motif, and Philips (to name a few); interesting ventures in customization and system integration from EDI and Dolch (to name just two); and expanded or new display-manufacturing efforts in India, Korea, and both parts of China are indicative of a revived worldwide entrepreneurial spirit.

So, I suggest we all take a moment off from slaying dragons and dodging vipers to raise a glass of champagne, a cup of sake, a pint of bitter, a glass of vodka – or a cup of tea – and congratulate ourselves. And we might also raise our glasses to those who have not fared as well in the jungle as we have.

To the fallen, as well as to the triumphant, we at *ID* dedicate this year-end technology review. For the first time in a December review issue, we are covering display-manufacturing issues. This is part of an editorial expansion that will provide increased coverage of manufacturing and systems issues in the months to come. Because of the new coverage, we have had to abbreviate our treatment of hard copy. But we still provide a highly informative snapshot of the U.S. printer market, thanks to data provided by BIS Strategic Decisions.

We at *ID* take this moment to wish you a happy and prosperous new year. Now, where's my machete?

– Ken Werner

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INFORMATION DISPLAY

the display continuum

At Warp Speed into the Information Age – "Beam Us Down Some New Displays, Scotty!"

by Aris Silzars

Attempting to describe something as grand as the Information Age can literally leave one at a loss for words. And that doesn't happen to me very often. So, what to do? Let's be scientific about it and invent some new ones! I am going to propose the definition of a new term – **Information Velocity.** Since the well-known Newtonian velocity is distance/time, our **Information Velocity** will be defined as the **amount of information per unit time**. (Perhaps some of you hard-core physicists would prefer more precise terminology, such as Information Flow-Rate?) If we have an Information Velocity, then we can also have **Information Acceleration**, which we will correspondingly define as ***Information Velocity per unit time***.

For well over a decade now, Information Acceleration has been approximately constant. If it stays constant for long enough, we will achieve some humongous "warp speed" for Information Velocity. Now, I don't know if there is a relativistic theory that will eventually apply here, but I sure hope so. However, we don't seem to be approaching any fundamental limits just yet. Is this then going to make our brains feel like trying to "take a drink from a fire hose"? I don't know about your brain, but mine can only process a limited number of bits at a time. So, I'm going to need some help in absorbing all this great new stuff.

As we talk to each other, the Information Velocity is about 100–150 words per minute. Reading textbooks goes only a little faster at somewhere between 200 and 500 words per minute, or approximately 1000 bits/sec. The number of significant people interactions we can handle at any given time in our lives is on the order of 50–100 (Information Velocity in people/time units). Thus, the only way I can see for us regular humans to achieve high Information Velocity is through pictures and/or graphics. With a picture, I can look at one million pixels and in less than one second extract what is significant to me. And I can keep doing that over and over, sometimes for hours on end. So, if you want me to absorb and process lots of information/time, show me pictures and do it on the very best display you can provide.

With this limited ability to process information, what will happen to us if Information Acceleration remains constant? And why am I even saying that it is? My baseline for this assertion comes from the well-known doubling of computer memory-chip size every 2–3 years, which has now been sustained for at least the last two decades, with no end yet in sight. I do remember hearing a talk at a technical conference not so many years ago that "proved" it would be impossible for the world to use more than a few million bytes of memory per person. Apparently, what was not too well understood by this speaker was how memory intensive image manipulation would be and how every family would soon be doing its own computer-aided image processing. Perhaps that would have seemed like something right out of StarTrek.

Of course, just moving the same information around faster and faster isn't the only thing we are experiencing. New information is being created and added all the time. But that by itself doesn't take us into the Information Age – we have

continued on page 34

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Emissive Flat-Panel Displays

Fujitsu brought the first color plasma TV set to market, high-brightness LEDs earned millions, and a full-color EL display earned respect.

by Ken Werner

MILLIONS of light-emitting diodes (LEDs) and vacuum fluorescent displays (VFDs) went into cars, instruments, appliances, communications equipment, and audio components in 1993, and Planar Systems demonstrated the world's first full-color electroluminescent (EL) display. But the only emissive-display issue able to sustain excitement outside the display community was color plasma television.

Late in the year, Fujitsu General brought the first commercial plasma TV set to market in Japan (Fig. 1). This 21-in.-diagonal NTSC (4:3 aspect ratio) set uses a three-electrode surface-discharge ac-plasma display. The display has 640 × 480 pixels, an impressive white peak area luminance of 200 cd/m^2, 256 gray levels, a contrast ratio of 50:1, and a luminous efficacy of 0.7 lum/W. Fujitsu says the display should be available in the U.S. next year.

Katsutomi Yoshida, manager of Fujitsu's visual systems engineering department, gives the credit for Fujitsu's being first to market to the company's decision to pursue ac-plasma technology. Also making rapid progress down the ac-plasma road is Photonics Imaging of Northwood, Ohio. At the Association of the United States Army's annual meeting in October, Photonics demonstrated its developmental 30-in. color plasma display with 1024 × 768 pixels, giving it bragging rights to the highest pixel density yet for a color plasma display.

Nippon Hoso Kyokai (NHK) – the Japan Broadcasting Corporation – announced the fabrication of an improved 40-in. dc-plasma display for HDTV and has subsequently discussed further improvements in private communications (Fig. 2). Image quality seems good, which has been true of previous NHK displays, but the peak area luminance of 65 cd/m^2 indicates the continuing problem facing developers of dc-plasma display panels (DC-PDPs). The panel's luminous efficacy of 0.15 lum/W is down by nearly a factor of 5 compared with the Fujitsu panel. NHK continues to develop dc panels because the structure is simpler than that of AC-PDPs and fabrication does not require vacuum thin-film depositions. The resulting economies are undeniably alluring.

Senior officers of Plasmaco, the highly visible producer of monochrome plasma displays

Fujitsu

Fig. 1: *The first commercial color plasma TV is Fujitsu's 21-in.-diagonal set, which uses a three-electrode surface-discharge ac-plasma display that produces an impressive peak area luminance of 200 cd/m^2.*

Ken Werner *is the Editor of* Information Display Magazine.

in Highland, New York, were caught in a boardroom coup. Some board members had become impatient at red ink that refused to dissipate in the face of superb power-conservation technology. The company, sharply downsized, has retreated from production to R&D mode.

Electroluminescent displays

Planar Systems produced a genuine technological breakthrough by developing blue thin-film EL phosphors based on alkaline earth thiogallate host materials – $CaGa_2S_4$, for example – that can produce a luminance of up to 1.5 cd/m^2 under actual panel operating conditions. At SID '93, Planar exhibited a display utilizing this phosphor that produced a good color gamut. The display was balanced to produce a true white – actually gray at this luminance – with a resulting white area luminance of about 15 cd/m^2. The question is whether this technological breakthrough can be converted into a commercial one. The luminance is less than half of that needed for commercial applications.

Sharp Microelectronics studiously avoided any mention of color in their EL display line, but introduced high-brightness (65 fL) monochrome VGA-resolution displays – including a 17-in.-diagonal unit – that are plug-compatible with LCDs. There is also a 13-in. 1280 × 1024 display producing 60 fL.

Despite the advances and the excellent characteristics of EL displays, the opinion was increasingly expressed in 1993 that EL technology had topped out and would increasingly be a niche technology – unless color can get much brighter very quickly and beat AMLCDs on price. A lot of people just don't believe that will happen.

Light-emitting diodes

The high luminous efficacy – up to 8 lum/W – of the new generation of AlGaAs LEDs led to their acceptance as incandescent lamp substitutes in the "third brake light" on many automobiles, and is opening an interesting market for LEDs as incandescent bulb replacements in traffic signals and airborne applications. Avionic and airborne indicator applications were pursued with particular enthusiasm by Teledyne Microelectronics.

In laboratories at Hewlett Packard Optoelectronics and elsewhere, the next generation of LEDs, which is based on AlInGaP, exhibited efficacies up to 20 lum/W in orange and yellow and up to 6 lum/W in green. Stanley was selling a red incandescent-bulb replacement for traffic signals and predicting commercial availability of green in 12–18 months.

The materials research that is leading to bright red, amber, and green LEDs holds long-term promise for blue. This is making the prospect of an all-LED full-color display an RGB gleam in designers' eyes, but don't expect to buy such a display much before the turn of the century.

Field-emission displays

Quietly (for the most part), interest in field-emission displays (FEDs) increased in 1993. Work on the now-classical microtip architecture continued at scattered university, government, and industrial laboratories, and new excitement was generated by electron emission from diamond films. The reason for the excitement is that emission from diamond films does not require hard-to-fabricate microtips with their problems of limited lifetime. But – despite implications to the contrary by one company – diamond films for displays are in a very early stage of development. The technology *could* turn out to be of major importance. But you can easily tell the responsible workers in this field: they're the ones who are playing their cards methodically – and very close to their chests. ■

NHK

Fig. 2: Nippon Hoso Kyokai (NHK) – the Japan Broadcasting Corporation – announced a 40-in. dc-plasma HDTV display fabricated using a new high-accuracy large-area screen printer developed with Dai Nippon Printing Co.

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Manufacturing Flat-Panel Displays

Until OEMs have industry-standard displays that are economical and readily available, they will not pay a premium for application-specific manufacturing.

by François Henley, Alan Nolet, and Renée Mello-Robinett

FLAT-PANEL-DISPLAY (FPD) manufacturers know that both the OEM market and end-users are ready for more FPDs if they can deliver higher quality, more consistent performance, and a lower price point. Today's typical thin-film-transistor (TFT) FPD unit prices – which range from $800 to $1200 – limit demand for laptop computers and other cost-sensitive applications. FPD manufacturers have hoped that prices can fall to $350–$400 by 1995 (although this now seems optimistic).

Although FPD manufacturing parallels semiconductor manufacturing in many ways, there is a significant difference: FPDs have *not* followed the IC pattern of dramatically reduced prices and improved performance with each new generation. Yet the demand is there, as indicated by market projections from numerous reliable market-research organizations (Fig. 1). The organizations may disagree on the exact size of the market and its growth rates, but all see significant potential.

Most of today's yield and quality problems can be solved through sound manufacturing engineering, most notably through process characterizations with subsequent feedback to improve yields and quality (Fig. 2).

Production issues

There are general economic conditions, market trends, and user issues that should not be ignored. Some key issues for display producers are:

- FPD manufacturing processes must be better characterized, with the characterization based on scientific and engineering realities, and the results must be used to improve yields of good displays.
- Product designers always have alternatives for producing any OEM product, display-based products included. Make it easy for them to use your display by complying with some basic standards.
- The customer is always right. If end-users do not like the display, there is a real problem – regardless of whether advertising created unrealistic user expectations or whether the display is in fact an unsuitable product.
- The global economy is down and OEM producers – especially PC manufacturers, who are the largest users of FPDs – are in the midst of cost-cutting wars. Display prices must drop now to accommodate short-term market realities and stay low for long-term growth.

Standards are key

From the OEM end-product manufacturers' and the final customers' perspectives, developing and using industry standards are more important than striving for product differentiation. The OEM electronics industry needs standards for FPD components. FPDs, being nothing more than components and subassem-

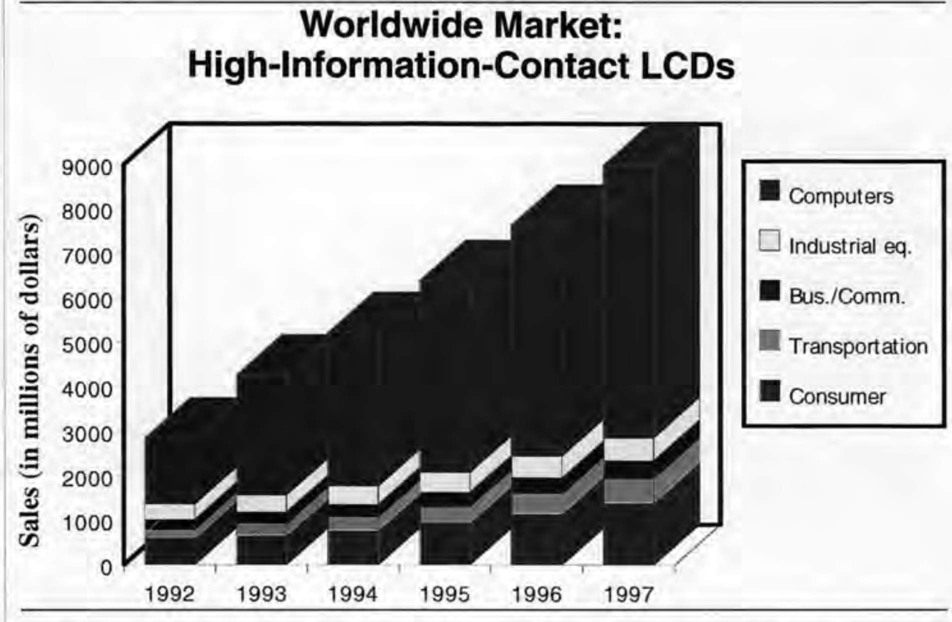

Fig. 1: Despite prices that have been slow to drop, all market projections for high-information-content FPDs indicate significant demand. (Source: Stanford Resources, Inc., 11/93.)

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Photon Dynamics

Fig. 2: Most FPDs are visually inspected by human operators.

blies to an OEM designer, now require basic physical and electronic standards if they are to reach and sustain projected market volumes. At the present stage of development, success at each level of manufacturing does not require product differentiation. An analogous situation exists with PC manufacturers, some of which are profitable despite cut-throat competition and the fact that all PCs use the same basic components.

OEM product designers and manufacturing staffs are justifiably concerned about committing a company's future to any sole-source component supplier unless the potential for creating and/or dominating a market is enormous. The FPD manufacturing industry has many parallels with the semiconductor industry and uses many of the same basic manufacturing technologies. Just as the integrated circuit (IC) has been standardized by function, package shape, size, and pinouts for power and data I/Os, FPDs must soon follow to make building FPD-based products easier and more reliable.

Will there be an application-specific FPD (ASFPD) segment of the industry that is comparable to the ASIC market of today – a segment that satisfies a need for display differentiation? Certainly, in time, after the industry can get mass-produced panel yields above today's unprofitable 50–70%.

Innovative FPD applications will drive standards

Is it too early for standards? None of the current FPD technologies permit impressive yields of consistent quality and performance. Also, for volume economies of scale in laptops – the largest user of FPDs – total system prices must drop below even today's bargain levels. Why? The entire global economy is sluggish, with an overall lack of consumer confidence and a reluctance to spend more than necessary for anything.

FPDs are used most heavily in computers (Fig. 3) – specifically laptops, notebooks, and pen-based personal digital assistants – a product class whose market is in the midst of revolutionary changes. The other primary users – industrial, business/commercial, transportation, and consumer – when lumped together roughly equal the computer market in value. If the computer industry analysts are correct, by this time next year, the new IBM/Apple/Motorola PowerPC™-based computers and workstations and the Intel Pentium™-based platforms will all be able to run MS-DOS™-, Windows NT™-, Macintosh™-, or UNIX™-based applications with just minor software changes! Computer users will be able to pick the platform and operating system independently. An obvious implication of this development is that software vendors will want to penetrate each segment of every market. That, in turn, requires some pixel and line-count standards that are compatible with CRTs and FPDs to prevent a programmer's nightmare.

Some current CRT users will inevitably want to upgrade to thin lightweight energy-efficient FPDs, but the computer video card or built-in video IC drive circuits may limit that demand if FPD producers do not start anticipating such changes now. In addition, current CRT users have come to expect sharp text and graphics at affordable prices. In the high-end versions of flat-panel displays, users rightfully expect no noticeable bad pixels and reasonably long usable lifetimes. And virtually every laptop user wants a larger usable screen.

Could NEC's UltraLite Versa™ notebook computer be a case study of standardization opportunities for FPD producers and other computer producers? The UltraLite has user-swappable FPDs (in monochrome and color), removable hard drives, a floppy drive that can be replaced with a battery for more time away from the power outlet, upgradable microprocessors and memory cards, and PCMCIA cards for modems, LANs, and (eventually) wireless networking. One can even remove the display and use it as a pen-based computer for taking notes or annotating presentations.

This is both clever marketing and a technology hedge: just swap anything that goes wrong or does not meet the customer's expectations and forget about obsolescence. Of course NEC builds both FP and CRT displays, so it has some inherent interface control. But what of computer vendors? Just to be competitive with NEC, they will need some industry standards for circuit drivers, addressing schemes, color quality, resolution, panel dimensions, and ruggedness – and any second-source manufacturers will have to match them. Users of laptops other than the Versa will wonder why their displays are not upgradeable.

With the interactive multimedia frenzy well under way, computers will have to be reasonably capable of displaying video soon – and HDTV not long after that – regardless of the country in which the system is used.

Better manufacturing approaches

FPD manufacturers are in the process of optimizing their manufacturing processes to minimize costs and improve yields while producing the highest quality possible. This dynamic is forcing a strict review and analysis of current industry production processes and quality standards against the highly leveraged – although risky – potential of differentiated product manufacturing. Short- and long-term solutions mandate better display design for manufacturing, test, and both pre- and post-assembly repair.

Common defects caused by particulates are unacceptable and avoidable because effective contamination monitoring and control techniques exist as off-the-shelf or slightly modified IC-industry solutions. Killer particles at between 0.3 and 1 μm are limiting FPD yields now, but manufacturing engineers are making rapid progress. FPD manufacturing technologies for each deposition, patterning, etch, assembly, inspection, and test step, although based on semiconductor products, have some unique requirements that equipment vendors are effectively addressing with FPD-specific tools. No wafer has the substrate area of the larger panels in production, and the uniform processing over large areas at high speeds required by display circuits has no IC parallel. As FPD customers are also IC customers, they expect solutions to come just as quickly from FPD vendors as from the more mature IC vendors – whether that is realistic or not.

Quick inspection is essential at every level of FPD manufacturing because the test/inspection results provide the feedback needed to correct problems before subsequent value-added process steps make repair prohibitively expensive. Just a few years ago innovative test, inspection, and repair systems were introduced that enable their users to quickly boost yields. Today's equipment can measure substrates prior to cell assembly, scan powered displays for defects prior to final assembly, and cut or modify circuitry for defect correction.

Other testers can evaluate both color and hue to establish grades of panels. If you want to stay in business, functional testing is best not left to your OEM customers.

Other contributing factors

Why is the standardization of FPDs so painfully slow? It's because manufacturers are forging into unknown territory as they extend existing processes while trying to build larger displays with many differing technologies. Although existing FPD technology has enjoyed massive financial investment in both R&D and manufacturing, this alone does not assure long-term viability.

The entire industry infrastructure – the builders of displays, along with their equipment and materials vendors – are developing concurrently. Equipment suppliers are building versatile products to serve all FPD technologies and are developing quantifiable standards to be competitive. Systems must be reasonably priced because the FPD market is very sensitive to overall production costs.

Today's FPDs are barely competitive with alternative technologies. FPD manufacturers are looking for competitive advantages based on manufacturing prowess. At the moment, the strongest distinction is simply the ability to deliver on time and at predictably priced displays with the quality and ruggedness to survive real-world use.

U.S. Display Consortium (USDC)

The recently formed USDC is interesting in its potential as a catalyst for improvements in both display and manufacturing technologies. This consortium – formed by industry representatives, government, and trade organizations – has a charter to develop a healthy U.S. display industry.

USDC will affect manufacturing standards and the technologies with which displays are produced. Some objectives are to improve supplier quality, spearhead a drive to establish industry standards, and disseminate the results of progress.

Photon Dynamics/Stanford Resources, Inc.

Fig. 3: *Computers – primarily laptop and notebook computers like this one – constitute nearly one-half of the market for high-information-content FPDs.*

Clearly, with low yields affecting the FPD industry worldwide, a coherent development program has merit. The program could proceed without the constraints that limit existing companies that have already made massive investments in certain technologies, plant, and equipment, and are therefore reluctant to start afresh.

Some USDC projects in the works include deposition, lithography, etching, substrate handling and finishing, materials, automated driver connections, and final test/assembly. The bottom line? Either directly or indirectly, USDC activities should produce better manufacturing yields. The USDC can also help balance the equipment/materials/FPD manufacturer/customer infrastructure, which is painfully seeking a profitable equilibrium. And perhaps, like SEMATECH, the USDC may become open to non-U.S. involvement in some form in the future.

Opportunities

FPD manufacturers that control their fabrication operations based on scientific realities rather than as an "art" will have the best chance to prosper. As the once separate fields of computing, telecommunications, education, and entertainment continue toward a seemingly inevitable merger, customers will view the products of the merging fields as appliances. The personal digital assistant (PDA) products were created as commodities. Appliance and department stores will sell them along with other mass-produced merchandise, such as computers. One characteristic that typifies commodities is low price. Today, the market demands lower prices, and lower prices mean low-cost displays are a necessity.

Conclusions

The FPD industry will stabilize as costs and quality are controlled. Lower panel costs are a prerequisite to sustained growth. Standards for fabrication, test/inspection, and repair will be established because OEM customers need standards to simplify design, manufacturing, and service requirements.

Although standards will be set for display products and their construction materials, the standards will not preclude further innovation. Rather, they will discourage minor changes leading to significant interface issues. Technology barriers in manufacturing are being overcome, and most FPD producers realize that long-term industry health depends on easy-to-use products. Prices will be more predictable for new products as the FPD experience curve will allow manufacturers to set prices that meet the expectations of their OEM customers. ■

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CRT-Based Data Display Technology

If CRTs are such a mature technology, why are they changing so quickly?

by Richard Trueman

SINCE it was invented over 100 years ago, the longevity of the cathode-ray tube (CRT) has not been rivaled by any other active component, nor has any other active component experienced the CRT's striking and constant improvement[1] (Fig. 1). The continual re-invention of the CRT has been financed by the device's extraordinary success – which is the result of a luminance and resolution that can not be rivaled by any other display technology at comparable cost.

The pace of CRT re-invention is not slowing. Activity in the last few years has been intense, and those of us who design CRTs see an accelerating level of change over the next 2 years at least. But let's take a moment to reflect on some of the more recent improvements in CRTs and CRT-based data-display monitors.

Surface treatments

One of the fastest-moving areas in CRT technology does not involve the tube's interior structures, but the outside of its front panel. Surface treatments are needed because the CRT panel glass reflects ambient light, as does the light-colored phosphor layer deposited on the interior surface of the panel glass. The reflections reduce the "blackness" of the image background and degrade several other measures of picture quality. An ideal surface treatment would completely eliminate reflections from the CRT glass. Only the light emitted from the CRT's phosphors should reach the user, with all other light sources being attenuated. A variety of different surface treatments have been developed to accomplish this end.

Simply darkening the panel glass diminishes phosphor reflection and improves contrast. But this method does not address reflection from the front surface of the glass itself, which reflects up to 4% of the incoming light.

Manufacturers currently employ three methods to reduce reflection: (1) roughing up the surface to disperse or scatter the light, (2) using thin-film technology to create interference, and (3) using a combination of the two preceding techniques.

Fig. 1: *The CRT's longevity has not been rivaled by any other active component because it is amenable to striking and constant improvements. A dramatic and very recent example is Matsushita's color flat-panel (CFP) display (background) that consists of a matrix-addressed array of thousands of tiny CRTs. An earlier tube that embodied important improvements was RCA Victor's 10BP4 (foreground). It solved the problem of ion burn in magnetically deflected CRTs and became the best-selling TV picture tube of the 1946-1950 period. (Photograph of RCA Victor's 10BP4 tube courtesy of Peter A. Keller, see Ref. 1.) (Photograph of color flat-panel display consisting of tiny CRTs courtesy of Matsushita Electronics Corp.)*

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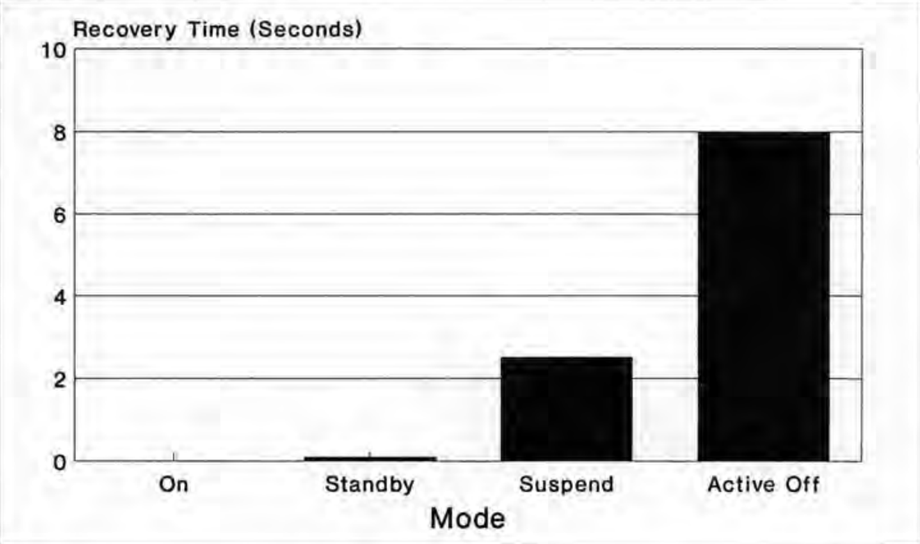


Fig. 2: The Video Electronics Standards Association (VESA) is about to release a signaling standard for putting displays into various stages of power management. Each of four modes – on, standby, suspend, and active-off – has its own level of energy savings and a corresponding recovery time.

The panel front surface can be roughed up by chemical etching, mechanical etching, or applying silica. These low-cost methods make surface reflections less objectionable by diffusing them, but because they scatter both the reflected and the emitted light they defocus the displayed image. One method of reducing defocusing with silica coatings is to reduce the silica particle size.

Anti-reflective (AR) panels use thin-film layers to create interference between light waves that reduces the intensity of reflections. Because these panels use properties of interference that are wavelength dependent, several layers must be used to diminish reflections across the visible spectrum. AR panels do not scatter light, so defocusing does not occur.

AR panels are effective but they are expensive compared with other methods. In addition to requiring several thin-film layers, AR panels have been manufactured by third-party companies and bonded to the CRT. Both of these characteristics have a considerable impact on cost and make AR panels the most expensive way of eliminating reflections as well as the most effective.

The most recent and most cost-effective approach adopted by CRT manufacturers has been to apply thin films directly to the CRT panel glass. These films have both AR and anti-static properties. The first layer is typically a material with a high refractive index and low resistivity, such as SnO_2. Subsequent layers have lower indices of refraction to establish the correct phase relationships for destructive interference. But there is a trade-off. In order to keep costs down, the number of layers must be reduced to as few as possible. This means that certain wavelengths are not attenuated, which produces the purple-blue reflections typical of integral thin-film coatings.

A few CRT manufacturers, including Matsushita, are further improving this method by combining integral thin films with silica. Minute amounts of very-fine-grain silica are added to the outermost layer of the film to scatter reflected light while having very little effect upon clarity. Thus, the combination of these two techniques produces an excellent yet cost-effective method for reducing both specular reflections and specular glossiness.

Shadow masks

Nearly all CRT manufacturers have had to replace steel shadow masks with INVAR in their high-end data-grade products. INVAR is the trade name for a nickel-steel alloy that has many of the favorable qualities of steel, but a lower coefficient of thermal expansion that resists geometric distortion of the mask called "doming."[3] This resistance to doming allows higher beam currents and brighter pictures without degrading brightness uniformity or color purity. But INVAR is not a perfect solution and is still susceptible to doming at high brightness levels – a problem that is accentuated by the flatter screens of newer CRTs. Matsushita's Advanced INVAR Mask (AIM) is one of the new approaches to doming and the additional stress placed upon the shadow mask by flatter screens. The AIM has a decreased radius compared to conventional shadow masks, so the shadow mask is actually less flat than the tube faceplate. This would ordinarily produce landing errors – electrons passing through holes in the mask would not land on the phosphor dots associated with those holes. But in the AIM, the pitch of the holes at the outer edge of the shadow mask is adjusted to compensate for mislanding.

Cathodes

As display size, brightness, and resolution continue to increase, while dot pitches and electron-beam spots grow even smaller, the cathode must supply ever-increasing current demands in modern CRTs. Recent improvements in surface analytical techniques have improved our understanding of cathode-emitter surfaces, and this has permitted significant improvements in thermionic electron sources. Impregnated cathodes (known as I-cathodes, or "dispenser cathodes") have an even longer life expectancy – about 10,000 hours when operated at 5-7 A/cm^2 – than the super-oxide cathodes they are replacing. Scandate cathodes, which operate at lower temperatures, show potential for the next generation of CRTs. These cathodes have demonstrated current densities approaching 100 A/cm^2.[4]

Power management

Although several notable innovations in chassis electronics have been introduced over the last year to improve data-display performance, none have had as large an impact upon the industry as power management. President Clinton's Energy Star™ – or "green PC" – initiative to reduce the power consumption of PCs and their peripherals has been openly embraced by the industry.

The Video Electronics Standards Association (VESA) is about to release a standard defining the signaling necessary to enable data-display devices to go into various stages of power management. In essence, there are four modes of power management: on, standby, suspend, and active-off. Each mode has its own level of energy savings and a corresponding recovery time (Fig. 2). The greater the amount of power saved, the greater is the toll exacted upon the user, who must wait longer for the display to become operational.

The most substantial power savings is accomplished by shutting down the high-voltage circuits, although other tricks are used to wring out additional watts. One method is the use of dual power supplies – known as mother-and-daughter supplies – in which the mother provides the lion's share of the power while the daughter picks up the rest. This allows the mother supply to be shut down during stand-by and active-off modes, leaving the low-wattage daughter supply to operate the signal-sense circuitry.

Moire reduction

Moire is a video distortion which causes a series of horizontal, vertical, and/or diagonal lines, which are typically but not exclusively found at the outer edges of the display. It is caused by a well-focused spot in conjunction with non-linearities in the sweep circuitry.[5] Since the spot size on lower-performance displays is usually large enough to mask any non-linearities, this phenomenon is typically found only on high-performance displays. Moire is most likely to occur when displaying pixel-on, pixel-off patterns as found in some Windows™ backgrounds.

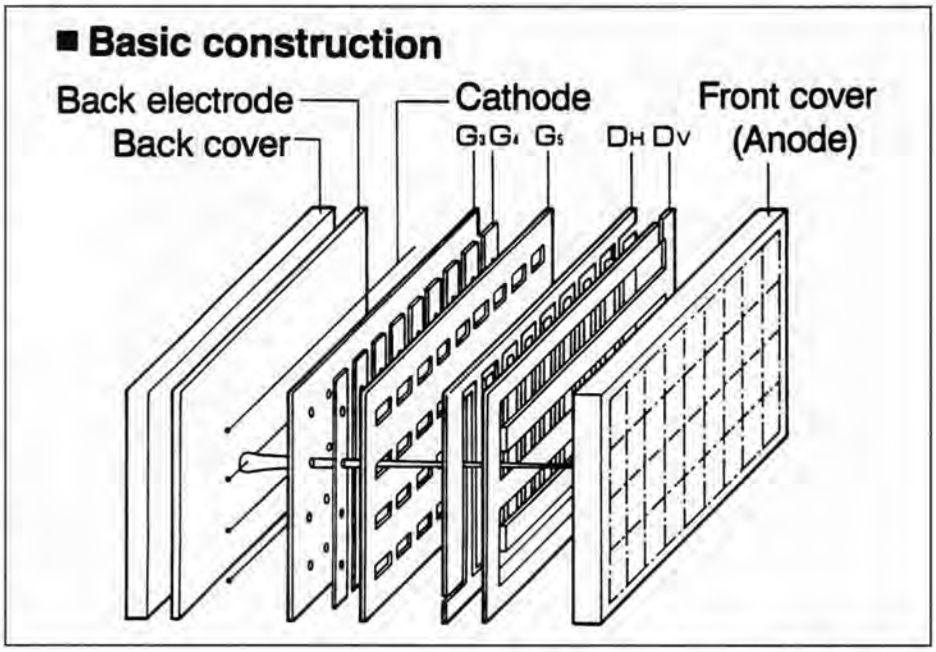
Circuits have been developed that do a nice job of reducing – and sometimes canceling – moire. We know that we can reduce moire by enlarging the spot size, but enlarging the spot size also decreases resolution. Designers have now developed a method for reducing moire without sacrificing resolution. The technique utilizes circuits that are adjustable by the user from the front panel. The circuits "wobble" the electron beam either horizontally or vertically, thereby allowing the user to selectively "grow" the spot in the direction of choice just enough to eliminate moire, yet not so much that there is any more than a minimal effect upon resolution.

Microprocessor-based designs

The microprocessor-based chassis came of age with the introduction of multi-scanning displays. The microprocessor has given display manufacturers the ability to offer higher-performance products at lower prices, and has permitted the introduction of a whole new range of user-controlled functions.

Today, microprocessor-based displays are being manufactured on lines that are almost completely automated. The microprocessor has allowed design engineers to develop chassis that are free of potentiometers (except for those that are part of the flyback) so all of the cumbersome setup normally handled by assembly-line workers can now be handled with software. Cameras monitor the CRT display while the software works in conjunction with a servo-CPU to optimize the display.

Quite apart from the moire reduction circuits discussed earlier, geometric-distortion correction and color-temperature control are becoming more commonplace. In fact, so many new functions have been introduced that some front panels have become cluttered and unintelligible. Designers have addressed this problem with a limited number of front-panel push-buttons and a small liquid-crystal display (LCD), but on-screen display (OSD) is a more elegant and economical way of pursuing the same strategy.



Matsushita Electronics Corp.

Fig. 3: Matsushita's color flat panel (CFP) is assembled from laminar elements for a thin structure and economical fabrication.

OSD places a menu of functions on the CRT from which the user can choose. It greatly reduces the complexity of operation, while further reducing the cost of introducing new functions. OSD also provides the user with feedback as to the display's status. This is especially useful when the user is, for example, adjusting color temperature without the assistance of a color analyzer. In addition, OSD can also inform the user of the format that is currently being used and the problems that may exist.

What's next?

Display manufacturers are striving to achieve more intelligent and brighter displays with higher contrast and smaller footprints. VESA members have already begun discussing a two-way communication channel between the CPU and the display that will allow the display to tell the CPU what its current and maximum scan rates are. The CPU will then select the best format, based upon the software present and the video board's capabilities. This will be a significant achievement because it will make the video board and display self-configuring. Non-technical users will appreciate auto-configuration because it will mean the end of reading technical manuals and configuring video boards. Technical users will enjoy operating with the best possible format for any particular piece of software. Finally, video-board manufacturers should realize cost savings from a reduced use of technical-assistance lines.

Let's carry this idea one step further. If we combine the communications channel with OSD, we can have keyboard control of the display. We envision a system that will reduce the display controls to an on-off switch. In the near future, all of the functions described in this article, plus many more, will be activated through software via the host system's keyboard.

Since W. Ross Aiken first conceived of the idea in 1951, manufacturers have wrestled with the attractions and difficulties of flat CRTs. In September, Matsushita introduced a flat-panel television in Japan that represents a genuinely new approach.[6] FlatVision – Matsushita's name for its flat-panel televisions and soon-to-be-introduced data displays – is a thin (approximately 4-in.) matrix of thousands

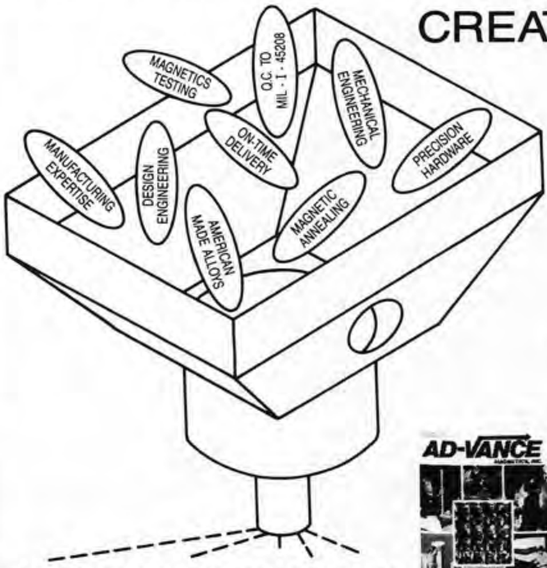
The Best of Both Worlds?

Several TV manufacturers announced high-end sets with 16 × 9 CRTs. No, HDTV isn't here yet. The extra screen width is filled by selectively stretching the NTSC image. These sets will fill their screens with the letterbox images available on some videotapes and videodiscs.

of tiny CRTs and their drive electronics (Fig. 3). It is targeted to be considerably less expensive than other technologies – such as active-matrix LCDs – offering similar specifications. FlatVision is now available in Japan and could be available in the U.S. as early as next year.

Notes

[1]P. Keller, *The Cathode-Ray Tube*, pp. 45-64 (Palisades Press, New York, 1991).
[2]H. Toda *et al.*, *Anti-Glare, Anti-Reflection, Anti-Static Coatings (AGRAS) for CRTs*, (Matsushita Electronics Corp., Osaka, Japan).
[3]B. Hartzell, private correspondence.
[4]R. T. Longo and D. R. Dibb, "Dispenser Scandate Cathode: A Progress Report," *SID Intl. Symp. Digest Tech. Papers*, 327-330 (1992).
[5]A. Morrel *et al.*, *Color Television Picture Tubes*, pp. 50-62 (Academic Press, 1974).
[6]K. Werner, "The Flat Panel's Future," *IEEE Spectrum Magazine* (November 1993). ■



Liquid-Crystal Displays

The LCD is now challenging the CRT as the world's largest-selling display – and will soon surpass it.

by John L. West

PRACTICAL MATTERS dominated the liquid-crystal field in 1993. Active-matrix liquid-crystal displays (AMLCDs) were readily available at long last in laptop and notebook computers. Companies around the world were busy forming consortia, often with government support, while others established or expanded manufacturing capacity. New applications for LCDs were touted by communications and computer companies and were prominently featured in advertisements. Technological advances were mostly incremental, offering higher resolution, better viewing, and larger screens.

The LCD market was one of the few bright spots in the global electronics industry. Despite a worldwide recession, the sale of liquid-crystal devices showed strong growth. The Electric Association of Japan reported that sales of liquid-crystal devices increased by 28% even though the overall production of electronic devices dropped by 12% in 1992. One can only speculate about the growth that might have occurred in better economic times.

The strong market reflects the performance and lower cost of both supertwist LCDs (ST-LCDs) and AMLCDs used in laptop computers. Companies are improving production yields and are therefore able to provide more displays at lower cost. While companies are still gearing up to service the rapidly expanding laptop and notebook computer market, they are also exploring a range of new applications in communications and portable computing.

John L. West is Associate Director of the Liquid Crystal Institute, Kent State University, P.O. Box 5190, Kent, OH 44242; telephone 216/672-2581, fax 216/672-2796. He is also Director of the Industrial Partnership Program for the NSF and ALCOM, a consortium of three Northeastern Ohio universities.

Technological evolution

While no real technological breakthroughs mark 1993, steady advances were made in improving the LCD. Xerox and its collaborators, Standish Industries and VCD Sciences, Inc., garnered a great deal of attention at SID '93 in May.[1] They claimed the lead in high-resolution AMLCDs by unveiling both color and black-and-white 6.3M-pixel AMLCDs – 6.3M sub-pixels in the case of the color version (Fig. 1). Xerox effectively exploited the design advantages of binary operation to achieve the high resolution. Gray scale can be introduced by standard dithering techniques. The nearly 300-lpi 13-in.-diagonal format can produce laser-quality images suitable for desktop publishing and CAD applications.

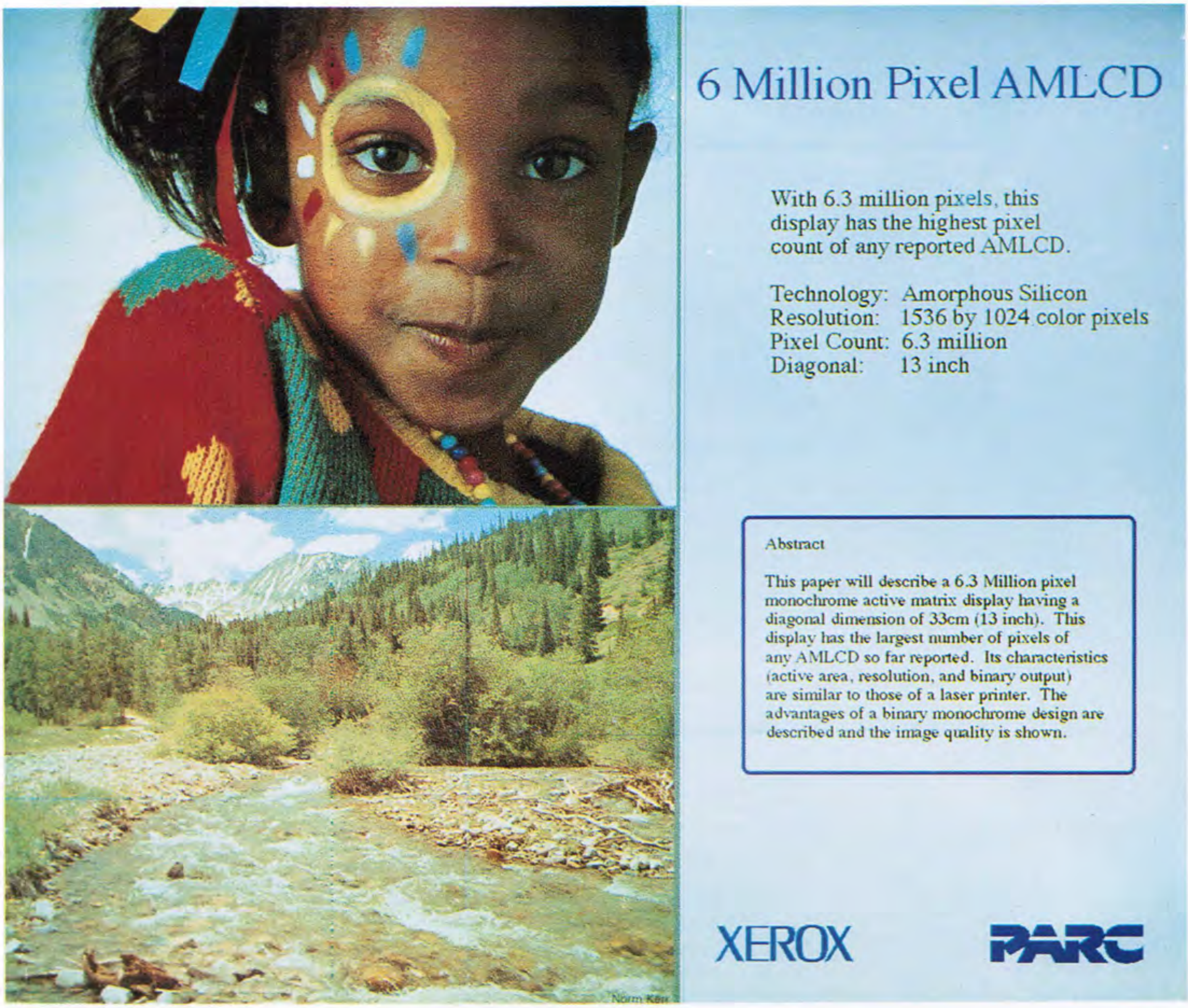
Tektronix unveiled (also at SID '93) a full-color 16-in.-diagonal VGA-resolution plasma-addressed LCD (PALCD) (Fig. 2).[2] The large format and bright image of the display is made possible by the plasma-addressing scheme, which offers the advantages of an active matrix but only requires passive-matrix tolerances. This eases the manufacturing of large-area high-resolution LCDs. PALCDs also have higher aperture ratios than their active-matrix counterparts, which makes them brighter.

Closer to the laboratory, researchers at Kent State University's Liquid Crystal Institute have demonstrated a 320 × 320 reflective display based on polymer-stabilized cholesteric textures (PSCT) (Fig. 3). Like displays based on ferroelectric materials, PSCT displays are switched between two stable states: a planar reflecting state and a focal conic transparent state. Unlike ferroelectric displays, gray scale is easily achieved with these new materials. The PSCT materials do not require polarizers because they utilize light reflected from the cholesteric planar state. PSCT displays are easily viewed in dim to bright ambient light, so backlights are not required.

The road to commercialization for ferroelectric liquid-crystal displays (FELCDs) is turning out to be a rocky one. Canon promised commercial introduction in 1993, but the displays have yet to reach market. Probable reasons: difficulty in controlling alignment and sensitivity to mechanical shock.

Active-matrix goes public

Color active-matrix displays finally appeared on store shelves in numbers and at a price where they were a practical option for the consumer looking to buy a laptop or notebook computer. Promises and prototypes of these displays have been the talk of SID conferences for years. AMLCDs were commercially available prior to 1993 but their astronomical price (greater than $7000) and scarcity made them curiosities limited to the computer connoisseur and largely unknown to the general public. Advertisements for active-matrix full-color LCD laptop and notebook computers were few and far between – even in January of 1993 – and consumers soon found that an advertisement didn't always mean the computers were available. By summer 1993 the availability of AMLCDs increased, and more than a dozen companies offered them in their laptops and notebooks. Calls to a few distributors found computers with AMLCDs in stock – or at least readily available. The quality of ST-LCDs has improved in response to the AMLCDs, with compensation layers



Xerox Corp.

Fig. 1: *At SID '93, Xerox, along with its collaborators, Standish Industries and VCD Sciences, Inc., claimed the lead in high-resolution AMLCDs by unveiling 6.3M-pixel AMLCDs in both color and monochrome. The nearly 300-lpi 13-in.-diagonal format can produce laser-quality images suitable for desktop publishing and CAD applications.*

offering more brilliant color and better black-on-white displays.

The consumer must now weigh the cost/performance ratio when selecting a portable computer. A $1500–$2000 cost differential separates computers with the low-end black-and-white ST-LCD from the high-end full-color active-matrix display. Consumers are quickly educating themselves in the advantages and disadvantages of each display option.

The growth of the LCD market is still closely tied to the laptop computer, but the number of potential applications is quickly growing. It seems that everyone is touting the coming communications revolution. You have probably seen the commercial from AT&T showing portable faxes and phones incorporating liquid-crystal screens that let you send messages or participate in teleconferences from the beach. Knight Ridder is planning to distribute an electronic newspaper that will be read on a hand-held tablet, likely utilizing a liquid-crystal screen. If these new applications are successful, earlier forecasts for the size of the market may prove conservative.

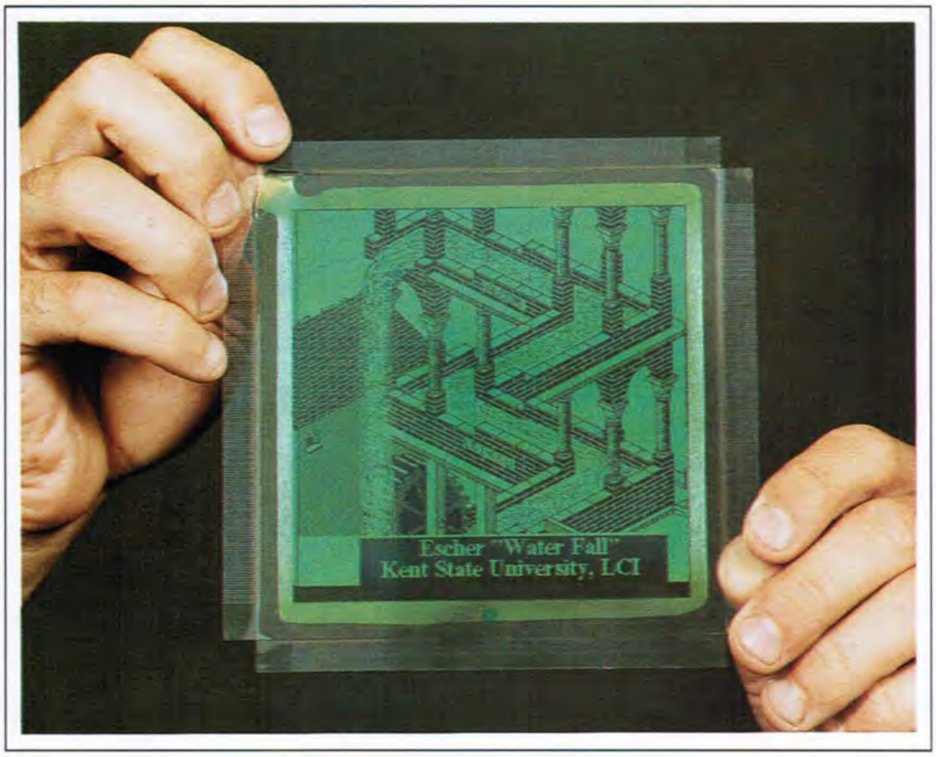
Working together

Japanese companies hold a commanding lead in the production of LCDs and deserve the credit for advancing LCD technology to the point where it now challenges – and is predicted to soon surpass – the CRT as the largest selling display. With the success of the LCD confirmed, companies in the Far East, the United States, and Europe that were once content to purchase LCDs are now at least considering in-house production.

Companies are typically forming joint ventures and consortia, often with government encouragement and support, as a means of spreading the risk involved in active-matrix manufacturing. The Government of Taiwan is expected to supply $100 million over the next 4 years to a new TFT-LCD consortium, consisting mostly of companies in Taiwan, but also including Philips and several Japanese

Tektronix, Inc.

Fig. 2: *At SID '93, Tektronix unveiled a bright full-color 16-in.-diagonal VGA-resolution PALCD. Plasma addressing offers the advantages of an active matrix but only requires passive-matrix tolerances, which eases the manufacturing of large-area high-resolution LCDs.*



Liquid Crystal Institute

Fig. 3: *This prototype reflective 320 × 320 multiplexed polymer-stabilized cholesteric texture display was fabricated at the Liquid Crystal Institute, Kent State University.*

flat-screen display vendors.[3] The consortium will support LCD research and production.

In the United States, ARPA (formerly DARPA) provided major support for U.S. industries to conduct research and produce high-resolution LCDs. They have awarded a multi-year contract to fund the U.S. Display Consortium. Headed by Xerox and AT&T, and representing producers and suppliers, the consortium will fund projects to develop equipment and materials for flat-panel-display production.

ARPA has also funded OIS, a wholly-owned subsidiary of Guardian Glass, to establish an active-matrix production facility.

In Europe, Philips, Sagem, and Thomson have formed a joint venture, Flat Panel Display, to produce LCDs for computers and televisions. This joint venture plans production volumes large enough to serve the broad consumer market.

Companies are joining together to share the risk and rewards inherent in production of high-resolution LCDs. There are too many joint ventures and cooperative agreements to list in this article, but they are a sign of both the promise and the remaining uncertainty of the LCD market.

Looking ahead

The future of LCDs now seems secure. The commercial introduction of full-color AMLCDs is proceeding well. If, as expected, the cost of high-resolution displays falls with large-scale production and improved yields, these displays will be used in an increasing array of applications. The large number of companies around the world considering LCD production, both active matrix and supertwist, indicates the central role LCDs will play. Consumers are choosing computers largely by the quality of the display, and this trend promises to spread to phones, faxes, and a variety of new devices.

To reap the rewards of these markets, companies are deciding they must produce LCDs. I expect the number of companies fabricating LCDs to grow. How many more companies will plunk down the $300 million to $1 billion required to be a real player in this field is not clear.

The Japanese companies that have invested heavily in AMLCD production over the last decade will certainly control the market for the near future. New technologies involving liquid-crystal or other materials may ultimately supersede the AMLCD, but until that happens LCDs will dominate the market.

Notes

[1]R. Martin *et al.*, "A 6.3-Mpixel AMLCD," *SID Intl. Symp. Digest Tech. Papers*, 704 (1993).

[2]T. S. Buzak *et al.*, "A 19-in. Full-Color Plasma-Addressed Active-Matrix LCD," *SID Intl. Symp. Digest Tech. Papers*, 883 (1993).

[3]Following developments in the LCD marketplace over the last year has been simplified with the *Flat Panel Display Hotline*, a monthly newsletter written by William C. O'Mara of O'Mara & Associates, which is offered via SEMICOMM. ■

calendar

Display Technology

SID '94. The Society for Information Display's Annual Symposium, Seminar & Exhibition. Jay Morreale (SID '94), Palisades Institute for Research Services, Inc., 201 Varick Street, Suite 1006, New York, NY 10014. 212/620-3371, fax -3379.
June 12-17, 1994 San Jose, CA

The 14th International Display Research Conference. Sponsored by SID. Palisades Institute for Research Services, Inc., Ralph Nadell (IDRC '94), 201 Varick Street, Suite 1006, New York, NY 10014. 212/620-3341, fax -3379.
October 10-13, 1994 Monterey, CA

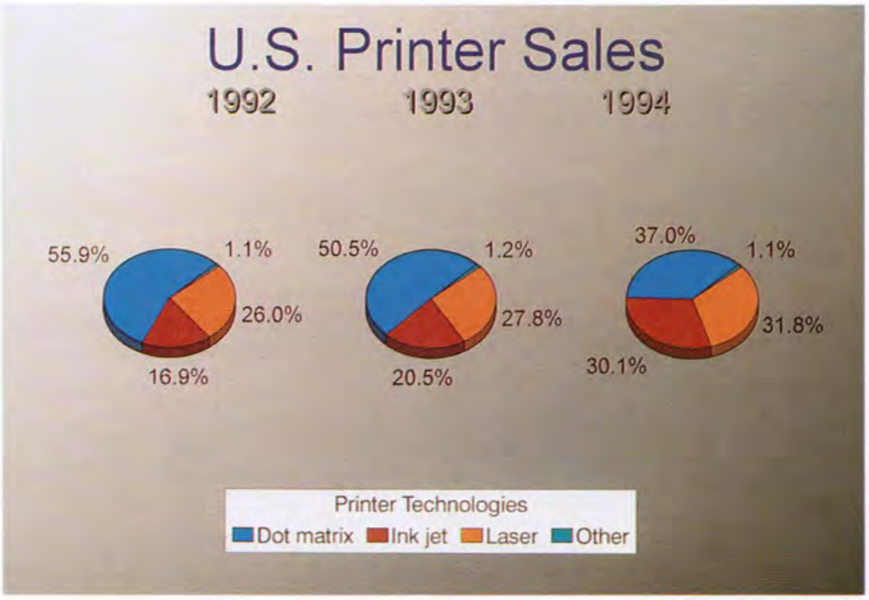
Imaging/Graphics/General Interest

1994 ISCC Williamsburg Conference on "Colorimetry of Fluorescent Materials." Ms. Ginny Baca, Hunter Associates Lab, Inc., 11491 Sunset Hills Rd., Reston, VA 22090. 703/471-6870, fax -4237.
Feb. 20-23, 1994 Williamsburg, VA

CeBIT '94. Hannover Fairs USA, Inc., 103 Carnegie Center, Princeton, NJ 08540. 609/987-1202, fax -0092.
Mar. 16-23, 1994 Hannover, Germany ■

data bank

Printers: Sales and Leading Manufacturers



Total U.S. Printer Sales
1992: 9,817,360
1993: 10,282,340
1994: 10,352,000

Data courtesy of BIS Strategic Decisions, Norwell, Massachusetts

Leading printer manufacturers
(Rankings based on 1992 U.S. unit sales.)

Rank	Dot matrix	Ink jet	Laser
1	Epson	Hewlett-Packard	Hewlett-Packard
2	Panasonic	Canon	Apple
3	Okidata	Apple	Okidata
4	Star Micronics	Eastman Kodak	Panasonic
5	Citizen	Lexmark	Lexmark
6	Lexmark	Star Micronics	Epson
7	Apple	Digital	Texas Instruments
8	C-Tech	Olivetti	NEC
9	ALPS	Brother	Digital
10	Digital		QMS

Note: Data courtesy of BIS Strategic Decisions, Norwell, Massachusetts.

Edited by JOAN GORMAN

Flat-panel PC

APF, Greenville, South Carolina, has introduced the APF4000 series of flat-panel PCs that integrate a full-function 486DX2 PC at 66 MHz, an active-matrix color TFT flat-panel display, a 170-MB hard drive, and a 1.44-MB 3.5-in. floppy drive into a compact unit weighing only 14 lbs. The APF4000 leaves a 9 × 10-in. footprint and consumes less than 40 W. The system features a 10-in. 64,000-color TFT-LCD, with power, keyboard, COM, mouse, and printer ports easily accessed at the rear of the unit. The APF4000 is priced from $6995 with stock to 30-day delivery.

Information: APF, Sales Department, P.O. Box 25126, Greenville, SC 29616-0126. 803/244-4416, fax 803/879-2030.

Circle no. 1

Low-temperature laser annealing system

XMR, Inc., Santa Clara, California, has introduced the ELA 9100, an excimer laser annealing system that provides a production-ready process for low-temperature annealing of active-matrix liquid-crystal display (AMLCD) substrates. Unlike conventional annealing processes, the ELA 9100 does not subject the substrate to high temperatures, enabling display manufacturers to use glass instead of quartz substrates for making high-quality high-resolution polysilicon thin-film transistor (poly-TFT) displays. The new turnkey system can be readily added to existing flat-panel-display production lines and consists of two major components: an XMR 150-W XeCl excimer laser and a beam delivery/substrate handling system. The ELA 9100 directs the laser beam to the substrate through an optical train and beam homogenizer. The homogenizer converts the beam from a quasi-Gaussian intensity profile to a spatially uniform "top hat" profile. The rectangular beam is then scanned over the substrate. Substrates are automatically loaded and unloaded by a cassette-to-cassette handling system for throughput of up to twenty 450 × 360-mm substrates per hour.

Information: Diana Zankowsky, XMR, Inc., 5303 Betsy Ross Drive, Santa Clara, CA 95054. 408/988-2426.

Circle no. 2

Ultra-miniature LED displays

Hewlett-Packard Co., Palo Alto, California, has introduced a new family of ultra-miniature seven-segment LED displays that provide full 8-mm character height in a compact package. The combination of larger character size and smaller package dimensions makes this new family of LED displays applicable for temperature controllers, timers, and digital panel meters; typical consumer applications include various appliances with LED readouts for time, temperature, and other numeric information. These compact displays are available in either gray or black surfaces, and in standard, high-efficiency, and super-efficient colors of AlGaAs red, orange, yellow, or green. They offer a combination of high light output, high peak-current capability with evenly lighted segments, and mitered corners on segments for a pleasing appearance.

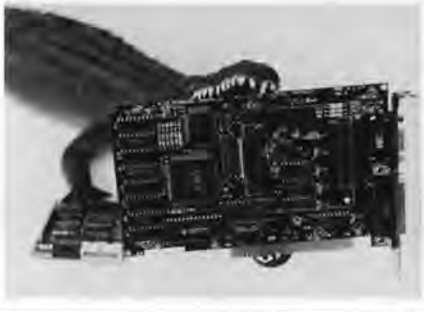
Information: Hewlett-Packard Co., 5301 Stevens Creek Blvd., P.O. Box 58059, Santa Clara, CA 95052-8059. 800/537-7715 ext. 7891.

Circle no. 3

Universal flat-panel controller board

Allus Technology Corp., Houston, Texas, has introduced the "Allus-in-One" universal flat-panel controller board that offers an easy-to-use plug-and-play solution for driving any flat-panel technology. The combination of specialty modules and a software-sensing technique allows for automatic configuration - no set-up required, no switches to switch, no jumpers to set, no special cables or software to configure. The QUAD controller feature allows up to four Allus-in-One boards to exist in the same system bus, allowing four flat panels or CRTs to display different information simultaneously. Other features include IBM compatibility, gray-scale generation on monochrome panels, and support of resolutions up to 1280 × 1024. Also available is the "Boot," a universal single-board computer with a flat-panel controller that can be mounted to the back of any VGA flat panel as well as interfaced to all flat-panel technologies.

Information: Ms. Kay Murrell, Allus Technology Corp., 12611 Jones Road, Houston, TX 77070. 800/255-8748 or 713/894-4455, fax 713/894-6709.



Circle no. 4

Color VGA plasma panel

Thomson Tubes Electroniques, Velizy, France, has introduced the TH 7675A, an eight-color VGA ac-plasma flat-screen display panel primarily intended for industrial data processing and ruggedized military applications. The TH 7675A is a 640 × 480-dot display with an RGB color pixel pitch of 0.4 mm and a 13-in. diagonal. The white area brightness is 50 cd/m^2. The panel combines RGB-phosphor color and the inherent qualities of ac-plasma flat-screen technology that include ruggedness and a stable flicker-free high-contrast image with a viewing angle of over 160°.

Information: Hélène Maggiar, Thomson Tubes Electroniques, B.P. 121, F-78148 Velizy Cedex, France. 33-1-30-70-35-00, fax -35.

Circle no. 5

Gyro-sensed stereoscopic HMD

Vista Controls Corp., Santa Clarita, California, has introduced their See-Thru Armor® Helmet that provides unrestrained gyro-sensed head position and stereoscopic color video using active-matrix color LCDs. The helmet is equipped with both see-through and see-below video presentation options. It can also be used in a virtual-reality mode by pulling down an opaque screen in front of the video presentation. The unit, which is a modified SPH-5 helmet, allows land-vehicle operators to "see through" the armored protection of their land vehicle while simultaneously viewing control displays inside the vehicle. During non-combat activity, when the operator's head is outside the vehicle, graphic data such as tactical vehicle status and data-link information can be projected on the screen. During battle, four cameras supply an integrated 360° digital view of the battlefield to multiple users inside land vehicles such as an M109 howitzer or an M1A2 tank. Helmet sensors computerize and communicate a particular vehicle operator's view of outside terrain to commanders of other vehicles, who can also view the inside of his tank. The gyros permit real-time view of the exterior terrain. Multiple cameras provide independent video to two color LCDs, which project a stereoscopic image to the operator.

Information: Mike Nemechek, Vista Controls Corp., 27825 Fremont Court, Santa Clarita, CA 91355. 805/257-4430.

Circle no. 6

New LCD fluids

Standish LCD, Lake Mills, Wisconsin, has introduced two new series of LCD fluids. The new first-minimum LCD fluids provide a 20% improvement in viewing TN-LCDs from an off-center perspective and represent a substantial increase in viewer convenience. They incorporate a very low birefringence fluid and controlled cell spacing to achieve a very wide viewing angle with no nulls in the center. Applications include outdoor, extreme-temperature, or off-direct-center installations. A new series of extreme-temperature LCDs includes the H-4137, which operates in temperatures colder than ice (-131°F/-55°C) and hotter than boiling water (221°F/105°C). Applications include process and foundry controls, avionic and military devices, ovens and/or moisture-removal equipment, and enclosed equipment subject to a "greenhouse" effect. The H-4184 extreme-cold-temperature fluid is suitable for freezers, scientific and research instrumentation, portable communications equipment, and avionic and military equipment. Both series of fluids are available in standard LCD configurations or as a custom display package.

Information: Walter A. Bruenger, Marketing Manager, Standish LCD Division, Standish Industries, W7514 Highway V, Lake Mills, WI 53551. 414/648-1000, fax -1001.

Circle no. 7

Touch screens for CD multimedia

Interaction Systems, Inc., Watertown, Massachusetts, has announced the availability of Crystal Clear™ touch screens for Philips Consumer Electronics CD-I multimedia players, such as the CD-I 220, 605, and other players using either an 8- or 9-pin RS232 cable. The user can then set communication parameters and operating modes that best suit his particular software application. Touch screens are available for the 14-in. Philips/Magnavox CM135 as well as other popular multimedia monitors. Capacitive touch screens utilize a conductive coating to detect touches on the display. Crystal Clear™ has a clear-glass non-reflective hermetically sealed surface producing better than 95% light transmission, with less than 0.5% reflection. The hermetic seal permits operation in environments of up to 100% humidity with condensation. Pricing for OEM orders and large direct accounts starts at $495 for a 14-in. Crystal Clear™ touch-screen kit. Kits are available in a wide variety of curved- and flat-glass sizes from 9 to 20 in. Optional factory installation is also available.

Information: Bob Maher, Interaction Systems, Inc., 86 Coolidge Avenue, Watertown, MA 02172. 617/923-6001, fax -2112.

Circle no. 8

Stereo 3D graphics for PC market

StereoGraphics Corp., San Rafael, California, has introduced its CrystalEyes® PC™ system for most popular desktop system platforms, including IBM PCs and compatibles, and some Apple Macintosh and Amiga computers. CrystalEyes® PC™ is the first true stereo viewing product designed for desktop PC users. The system combines stereo electronics and an infrared emitter in a single small package which sits atop the monitor, and includes the patented CrystalEyes® shuttering liquid-crystal eyewear in a new teal color. The stereo electronics converts a non-stereo-ready PC into a state-of-the-art graphics platform for true 3D stereo visualization, increasing the user's ability to analyze complex computer graphics and intricate detail. Typical applications for mainstream desktop users include mechanical design, CAD/CAM/CAE, molecular modeling, animation, medical imaging, and digital mapping. A single cable ensures easy installation without opening the computer. CrystalEyes® PC™ will be available for shipment early in January, 1994, at a U.S. list price of $1300 for the model CE-PCE or $2695 for the CE-PCE-17M, which is bundled with a 17-in. stereo-ready monitor. As an inducement to new 3D stereo users, the company is offering a special introductory price of $985 for the CE-PCE or $2380 for the CE-PCE/17M.

Information: Wil Cochran, StereoGraphics Corp., 2171 East Francisco Blvd., San Rafael, CA 94901. 415/459-4500, fax -3020.

Circle no. 9

Desktop projector

Proxima Corp., San Diego, California, has announced the Desktop Projector™, a compact portable high-performance system which is smaller, lighter, and easier to use than other data and video projectors. Data from a computer can be projected onto a large screen and changes can be made in real time. Less than 6 in. high and weighing just 18 lbs., it features a built-in light source, interactivity, advanced ergonomics, and the ability to project up to 2 million colors. Lenses and mirrors are hidden from view for transport or storage. Three models, which are compatible with both PC and Macintosh computers, are offered: the Desktop Projector™ 2800 high-performance video-ready active-matrix multimedia projector accepts all three international video formats and power sources, as well as S-VHS, and carries a U.S. suggested retail price of $8995. The Desktop Projector™ 2700 is a high-performance active-matrix color projector, with video and audio as an option, suitable for business presentations, workgroup meetings, and training presentations. The Desktop Projector™ 2300 is the first self-contained color projector to break the $5000 price barrier. Its color-stripe super-twisted-nematic LCD technology projects 24,389 true colors and is priced at $4995. It features fast mouse tracking and can project QuickTime or Video for Windows, making it affordable for the training or education presenter.

Information: George Wilson, Proxima Corp., 6610 Nancy Ridge Drive, San Diego, CA 92121-3297. 619/457-5500, fax -9647.

Circle no. 10

Deflection yokes for virtual environments

Celco-Constantine Engineering, Mahwah, New Jersey, has introduced a series of CRT deflection yokes for virtual environments designed for commercial and MIL-SPEC applications for 1- and 0.5-in. helmet-mounted displays. Made in the U.S.A., the Celco HM series high-resolution CRT deflection yokes are designed for very high-speed applications where losses are critical to system performance. The ruggedly built deflection yokes are available in a full range of inductances.

Information: Celco-Constantine Engineering, 70 Constantine Drive, Mahwah, NJ 07430. 201/327-1123, fax 201/327-7047.

Circle no. 11

Intrinsically safe touch terminal

Deeco Systems, Hayward, California, has introduced the first full-size touch display terminal in an "intrinsically safe" form for use in combustible, flammable, and explosive environments. The terminal does not require large gas-filled packages or explosion-proof outer boxes that have small difficult-to-read displays. The units are certified to Factory Mutual standards for the U.S. (Class 1, Div. 1, Groups C & D, T4). The ST2220IS has also been tested as intrinsically safe against the requirements of BS5501, parts 1, 7, and 9, by SIRA, the British test and certification organization. SIRA has given the product a rating that enables its use in the most hazardous environment (Zone 0). The ST2220IS is a two-part system featuring a small footprint and a full-size display panel. The controller enclosure portion of the system is installed in a "safe" area and houses a standard Deeco C320 controller, a power supply, and an intrinsically safe barrier. The display enclosure is used in the hazardous area, and houses a reflective LCD flat panel (suitable for daylight or well-lighted applications), support circuitry for the panel, and a SealTouch IR touch system (providing an easily accessible interactive operator interface). The display enclosure, with conduit cover, is rated for NEMA 4/12 (IP65). Pricing for the ST2220IS is $5895 in volume quantities. Delivery is 90 days ARO.

Information: Melissa May, Deeco Systems, 31047 Genstar Road, Hayward, CA 94544-7831. 510/471-4700, fax 510/489-3500.

Circle no. 12 ■

continued from page 4

been creating new information, saving it, and moving it around since cave-man days. Nicholas Negroponte of MIT was recently quoted in a newspaper article as saying, "People thought of themselves as being in the newspaper business, or movies, music, and so on. But they're really not anymore. They're in the bit manufacturing business." Wow, is that all there is to the Information Age? Isn't that like saying that all the great books ever published were produced by "word manufacturers"? Doesn't it matter just a little what kind of information those bits or words are carrying?

Let me suggest that ***the Information Age will be characterized by a society that devotes more time to information creation and processing than it does to meeting its needs for food, shelter, safety, and manufactured goods.*** While this statement is not nearly as "sound-bitey" or "newsworthy" as the one made by Prof. Negroponte, I think it better characterizes how the Information Age will supplant the Industrial Age.

Information in various forms will be the commodity of the Information Age. But what do you do with the shopping bag full of stored bits you bring home or receive over your modem? Well, we need to be able to display and understand them, to manipulate and organize them, to use them to create more information, to play with them, to copy what we have done, to transmit them to someone else, and to combine them with other things we have created or are yet to create.

Several months ago, in a column about ARPA, I used the phrase "Displays are Windows into the Information Age." Now, can you see why I am so enthusiastic about the future of display technology? Displays are absolutely critical to making the Information Age happen. We need today, and will need for many years to come, all kinds of new and better displays and I/O devices. We need high-resolution ones. We need big hang-on-the-wall ones. We need lightweight low-power ones to carry around.

Most of all, the world needs ***all of us*** innovating and working hard to make these great things happen. Now, if we can just get more of our innovative ideas into seriously funded development programs and then into products and manufacturing, we may not need to be as concerned about jobs and survival as we have had to be in the last few years.

This month, there is all kinds of interesting industry news to tell you. Let me begin with a short summary of a visit I made to Tektronix in the middle of October. After years of thinking about it, **Tektronix** appears to be getting out of the components business. The Integrated Circuits Operation, the Hybrids Operation, and three business segments of the

Display Operation have been put up for sale, while the CRT plant itself is apparently scheduled for closure in 1995 or '96. The avionics display business, the plasma-addressed LCD technology group, and the display products group are all looking for a new home. **Richard Hockenbrock**, GM of the Network Displays & Display Products group, gave me a good overview of how they are building the business in spite of this period of high uncertainty. **Bill Stein** and **John Moore** showed me a demo of their latest plasma-addressed LCD panel. They are making a very serious effort to try to quickly transition this technology from the laboratory into a marketable product.

On that same trip, I was also able to visit with **Steve Hix** of **In Focus Systems** and to participate in the official opening ceremonies of the new **Motif** facility for making active-addressed LCDs. Motif is a joint venture between **Motorola** and **In Focus Systems**, and to emphasize that partnership, it is managed by **Henry Lewinsohn**, who came from Motorola and **Paul Gulick**, who was with In Focus. In one year, these folks have put together a complete facility for making the new active-addressed LCD panels and are now testing the production process. I expect that by the time you get to read this column, they will be in full-scale operation.

One of my objectives in writing this column is to provide you with timely information. There is, of course, the normal delay time in getting a magazine together and printed. For instance, while I am writing this column over Thanksgiving week, you will not get to read it until early January. This month, however, I am going to make an exception and include a description of an event that took place last June. It makes for interesting reading in spite of the elapsed time. It was sent to my by **Alan Lewis** of **Xerox PARC.** Here is some of what he wrote.

"Between June 7th and 10th 1993, groups of engineers from various companies came to Washington to demonstrate the fruits of their ARPA-funded display development work. This 'High Definition Display Showcase' involved demonstrations at four locations, including the White House and the Pentagon, and the displays on show included the 6.3M-pixel AMLCD from **Xerox**, the **Texas Instruments** deformable mirror video projection system, **Planar's** 10-in. full-color 640 × 480 EL display, a 1024 × 768 full-color plasma video monitor from **Photonics Imaging**, and two 3-D systems from **Dimension Technology** and **Reveo**."

(The first day's show was mostly for ARPA personnel.)

"The second day's show took place at ARPA headquarters in the 'Enterprise Room' which we decided got its name because the internal decor resembles that of the Starship. The normal sounds of the demonstration systems going together were punctuated by occasional cries of 'Beam me up, Scotty!'

"On the third day, Wednesday, the show moved to the White House. We took all the equipment over late in the afternoon on Tuesday, and arrived in convoy at the White House gates for security checks. Unfortunately, this turned out to be the night of the Congressional Barbecue, so we had to wait for the security agents to come and let us in. We were all stuck outside on the road for about three hours in temperatures of over 90°F and 90% humidity with our packing cases opened waiting for the 'Canine Security Operatives' (dogs) to come and sniff everything. Finally, we were allowed in (although there was also some argument about leaving a U-Haul truck on the White House grounds overnight) and the show was set up again. During the next day, the displays were seen by (among others) Jack Gibbons (OSTP), Bo Cutter of the National Economic Council, and John Deutch, the Under Secretary of Defense for Acquisition. Bill Clinton passed the demo room just as we were packing up to leave. 'Looks great,' he said."

Thanks, Alan. Nice story.

SI Diamond Technology, Inc. and **Microelectronics and Computer Technology Corporation (MCC)** have agreed to cross-license and pool technologies that will form the basis of new flat-panel displays utilizing the electron-emitting characteristics of diamond. SI Diamond expects to begin manufacturing flat-panel displays in limited quantities, using the diamond-based field-emitter technology, as early as the first half of 1994 in 5000 $ft.^2$ of existing facilities leased from MCC in Austin, Texas. **SI Diamond** has also signed a letter of intent to acquire **Emerald Computers, Inc.** of Portland, Oregon. Emerald develops and manufactures integrated computer control systems, operator interface terminals, and industrial consoles that use flat-panel displays in factory automation and process control applications. The key people at SI Diamond are **Robert H. Gow**, president and CEO, and **Howard K. Schmidt**, founder and COO.

Optical Imaging Systems, Inc. (OIS) has selected **Curtis J. Casey** as Vice-President, Business Development, Marketing and Sales. Mr. Casey's earlier career experiences were with Delmo-Victor, Textron, Inc., and Kaiser Electronics.

Another new Vice-President of Sales has been appointed by **Photon Dynamics. James Ellick** comes to this position with prior experience at Fairchild, Applied Materials, and Alameda Instruments. The people at Photon Dynamics were particularly impressed with Jim's knowledge of both the IC industry and the FPD equipment industry.

Schott Glass Technologies, Inc. of Duryea, Pennsylvania, has appointed **Stephen P. Krenitsky** to the position of Vice-President, Operations. He has been with Schott since 1971, when he began as a design engineer. **Schott Fiber Optics' Opto-Electronics Components Group** has selected **Normand O. Allard** as its Director of Marketing/Sales. The **Schott Group** (Mainz, Germany) employs more than 18,000 people worldwide. The Group's headquarters in North America, called the **Schott Corporation**, employs nearly 1800 for the manufacture and distribution of fiber optics, special glass, instruments, and crystal ware.

Semiconductor Systems, Inc. of Fremont, California, has appointed **James D. McKibben** to the position of Director of Marketing & Sales for the flat-panel display and multichip module (MCM) market sector. SSI manufactures customized high-performance resist processing equipment for silicon wafers, thin-film heads, and flat-panel displays. They provide systems for cleaning, photoresist coating, developing, and polyimide processing.

To conclude this month's industry news segment, **Voice Processing Corporation** of Cambridge, Massachusetts, has appointed **Julie Donahue** as President and COO and **Anthony Blandon** as Director of Product Development. Donahue was most recently with Dun & Bradstreet Software, Atlanta, Georgia, and Blandon moved over from Digital Sound Corporation in California.

Contributions to and comments about this column are always welcome. You may call me in person at 302/733-8927, or fax me at 302/733-8923. If you prefer the mail, send your information to Jay Morreale, Palisades Institute for Research Services, Inc., 201 Varick Street, Suite 1006, New York, NY 10014.

letters

To the Editor:

It was most interesting to read in your September editorial about the "dramatic," nay, "explosive" trend from 14- to 15-in. colour monitors. Towards the end of 1992, we monitor market analysts, seeing a remarkable penetration growth of 15-in. units from 1.1% of the total ***Western European*** colour monitor market in 1991 to a predicted 5.7% in 1992, naturally expected an even greater increase to around 11% in 1993 and well over 20% in 1994. Surely, we reasoned, that extra inch and, as you say, much more actual usable screen area would mean that the European end-user would happily pay that diminishing extra payment for a 15 in. and make our predictions come true.

Alas, oh for hindsight-foresight or even a better crystal ball. Even though sales of datagraphic monitors are still increasing in Europe, albeit at a slower rate and in line with PC sales, in ***recessionary*** times when it comes to saving the local equivalent of a dollar or two, be it DMark, Franc, £, Lire, or Peseta ... especially Lire or Peseta, then a new 14 in. is quite good enough, thank you. After all, comparing oranges with oranges, a ***modern*** 14-in. microprocessor controlled monitor, operating at a "flicker-free" Super VGA resolution, with MPRII, and overscan to fill the viewable screen, compares very favorably, even in workspace area, with its equivalent 15-in. counterpart – and is still quite a bit cheaper!

Thus, 15-in. monitors have had a sabbatical and actually took 4.9% of the total ***Western European*** colour monitor market in 1992 and 5.5% in the first half of 1993. The CDT is now around 70% of the cost of the monitor. And the 15-in. tube, and thus the monitor using it, is always expected to be more expensive than the 14 in. Bearing these important cost factors in mind, we now confidently predict that the 15 in. will take 6.4% of the European colour monitor market in full-year 1993, nearly 11% in 1994, and over 16% in 1995 – well, fairly confidently.

Interestingly, we were somewhat reassured to find that the 17-in. penetration share, for a different set of reasons, did rise from 0.9% in 1991 to 4.2% in 1992, and 7.7% in the first half of 1993. With the price of 17-in. monitors also dropping very rapidly and being really the ideal size for both PC windows and low-end CAD applications, we expect the European penetration of 17-in. models to reach 8.5% in full-year 1993, over 13% in 1994, and nearly 20% in 1995.

– Bryan Norris
BIS Strategic Decisions, Ltd.
Bedfordshire, U.K.

To the Editor:

On page 30 of your September 1993 issue you report on the revocation of the anti-dumping duty on AMLCDs, quoting the Commerce Department spokesman as follows: "Final determination was made because the order was no longer of interest to the AMLCD industry. None of the parties objecting to revocation of the duty was a producer of AMLCDs."

What a huge joke this is! Japanese tactics for years have concentrated on preventing the emergence of a viable U.S. AMLCD industry by intimidating potential investors and by first threatening with dumping, followed by actual dumping of active-matrix displays – in sample quantities only, but that did the trick.

The sequence of these events reminds me forcefully of the great Thurber fable, "The Rabbits Who Caused All the Trouble." As you may know, the rabbits caused a lot of trouble, such as earthquakes, lightning strokes, and floods, and so were eventually eaten up by the wolves. Since they had been eaten, the affair was a purely internal matter for the wolves. The other animals warned that they might possibly unite against the wolves unless some reason was given for the destruction of the rabbits. So the wolves gave them one: "They were trying to escape, and, as you know, this is no world for escapists."

Thurber's moral was: *Run, don't walk, to the nearest desert island.*

– T. P. Brody
Active Matrix Associates
Pittsburgh, Pennsylvania

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

Compiled by Howard L. Funk
H. L. Funk Consulting

U.S. Patent No. 5,243,419; Issued 9/7/93
Soft Coding for HDTV
Inventors: Faryar, A F; Knauer, S C; Kustka, G J; Matthews, K N; Netravali, A N; Petajan, E D; Westerink, P H
Assigned to: AT&T Bell Laboratories

Blocks of HDTV picture information are selected for transmission at a plurality of channel rates of an HDTV transmitter. The size of each block of HDTV picture information is dependent on a target-distortion parameter for the HDTV picture information. As a result of this selection, a portion of each block of HDTV picture information is transmitted at the lower channel rate, with the result that the HDTV transmitter range is maximized, while maintaining a picture quality for the resulting HDTV video image.

U.S. Patent No. 5,247,363; Issued 9/21/93
Error-Concealment Apparatus for HDTV Receivers
Inventors: Sun, H; Zdepski, J W
Assigned to: RCA Thomson Licensing Corp.

Image reproduction is improved in an MPEG-like television receiver by inclusion of post-processing adaptive error concealment. Compressed video signal is examined to determine blocks of video signal containing errors, and error tokens are generated for identifying corresponding blocks of decompressed pixel values. Pixel values adjacent to the decompressed blocks of pixel values containing errors are examined to generate estimates of the relative image motion and image detail in the area of such blocks. The block of pixel values is replaced with temporally displaced co-located blocks of pixel values or interpolated data, depending upon whether the estimate of image motion is lesser or greater than the estimate of image detail.

U.S. Patent No. 5,235,424; Issued 8/10/93
Automatic-Gain-Control System for a High-Definition-Television Signal Receiver
Inventors: Kelly, K M; Wagner, T M
Assigned to: General Electric Co.

A high-definition-television receiver, including analog and digital signal-processing circuits receives an analog high-definition-television signal representative of digital television information. The received signal contains narrow-band high-priority information and low-priority wide-band information. An automatic gain control (AGC) signal is developed from the received analog signal by means of a root-mean-square amplitude detector.

Used with permission of IFI-Plenum Data Co.

U.S. Patent No. 5,245,413; Issued 9/14/93
Method and Apparatus for Generating a Spiral-Curve Television Test Pattern for Testing Advanced Television Systems
Inventors: Bohmert, J; Teichner, D
Assigned to: North American Philips Corp.

A test pattern suitable for testing high-definition-television signals is described as well as a method and apparatus for providing such a pattern on a television display apparatus. A plurality of color signals are stored in a memory device (look-up table) and each pixel of the display screen is correlated to a point on a spiral curve in order to determine a rotational angle which is used as an address for one or more of said color signals which are displayed at that pixel location. In this manner, a spiral shaped test pattern is generated having spiral color (or monochrome) segments corresponding to a spiral curve.

U.S. Patent No. 5,243,629; Issued 9/7/93
Multi-Subcarrier Modulation for HDTV Transmission
Inventor: Wei, L-F
Assigned to: AT&T Bell Laboratories

A high definition television (HDTV) signal is transmitted by a multi-subcarrier transmission scheme in which each subcarrier is used to carry a different class of HDTV information.

U.S. Patent No. 5,247,353; Issued 9/21/93
Motion Detection System for High-Definition-Television Receiver
Inventors: Cho, H-D; Jung, H-M; Lee, J-H; Park, W-S
Assigned to: Samsung Co Ltd, Korea

A motion area detector capable of simple detection of a moving picture-area in a HDTV receiver of a multiple subsampling transmission system is disclosed. The motion area detector includes a still-picture processor for reproducing a still picture from a picture signal applied into the detection circuit of the receiver, a moving-picture processor for reproducing a moving picture from the picture signal, a mixer for carrying out a linear mixing operation between the still picture and the moving picture, and a motion detector for detecting a motion area from a mixed picture signal of the mixer and from the still picture signal reproduced by the still picture processor and for providing information concerning a mixing ratio between the still picture and the moving picture.

U.S. Patent No. 5,240,748; Issued 8/31/93
Method of Manufacturing a Display Window for a Display Device
Inventors: Niestadt, M; Van Esdonk, J M A
Assigned to: U S Philips Corp

To reduce reflection at the surface of a CRT display window, the surface is provided with a pattern of irregularities formed by ultraviolet laser radiation. Preferably the inside surface of the display window of the CRT is treated with the pattern of irregularities followed by a phosphor pattern over the treated surface. In one embodiment, a transmission grating is used to pass ultraviolet radiation to form the irregularities.

U.S. Patent No. 5,240,447; Issued 8/31/93
Flat-Tension-Mask Front-Panel CRT Bulb with Reduced Front-Seal-Area Stress and Method of Making Same
Inventors: Capek, R G; Fondrk, M T; Greiner, S M
Assigned to: Zenith Electronics Corp

Accelerated thermal upshock rates in the exhaust cycle of a CRT envelope are attained for a tension-mask CRT having a shadow mask supporting a rail frame affixed to the front panel. The actual corners of the rail frame are chamfered or left open to provide an increased separation distance from the corners of the funnel seal area. Panel fracturing stresses generated in the funnel seal area corners during upshock are thus alleviated allowing for faster CRT throughput during manufacture, without increasing the size of the CRT components.

U.S. Patent No. 5,245,326; Issued 9/14/93
Calibration Apparatus for Brightness Controls of Digitally Operated Liquid-Crystal-Display System
Inventor: Zalph, W N
Assigned to: International Business Machines Corp

A TFT-LCD has a PEL matrix in which the drain lines of the different TFTs are supplied with different drain voltages to achieve a preset number of gray scales. The different drain voltages are set during factory calibration through use of a test PEL having substantially the same characteristics as the PELs viewable by a user. The characteristics of the test PEL are first measured, the values of drain voltages for achieving the different gray scales are mathematically derived from the measurements, and such values are stored in the display system. The specific manner in which calibration is done is by measuring output voltages of a photodiode located next to the test PEL as a function of different drain voltage inputs and constructing a unique transmissivity versus drain voltage for the subject display. Calibration is accomplished by a factory tester or by a built-in calibration system.

U.S. Patent No. 5,233,331; Issued 8/3/93

Inking Buffer for Flat-Panel-Display Controllers

Inventors: Comerford, L D; Levy, L I
Assigned to: International Business Machines Corp

An intelligent subsystem separately supports inking functions in order to allow stroke-ignorant software to be supported in a stylus-driven environment. This subsystem thus provides the inking capability missing in existing flat-panel-display controllers. Separate inking functions are incorporated into the subsystem in order to support inking management functions which do not corrupt the display refresh buffer as it is understood by existing application software. The subsystem makes no assumptions about the application's awareness of stroke data as an input modality. Instead, the subsystem assumes that a conventional display subsystem also exists in the system. The subsystem utilizes the strobes and clocks generated by the conventional display controller to generate addresses in a memory which has physically separate address and strobe lines from the display refresh buffer. The content of this added memory is used to control the source of input to the data lines of the display. The invention can be generalized to allow any number of planes to be added to a display system providing access to that display system by any number of asynchronous processes such as inking.

U.S. Patent No. 5,247,376; Issued 9/21/93

Method of Driving a Liquid-Crystal-Display Device

Inventor: Wakai, Y
Assigned to: Seiko Epson Corp, Japan

A method of activating a matrix LCD formed with column electrodes intersecting row electrodes and liquid-crystal material therebetween in which liquid-crystal pixels are defined at the intersections of the row and column electrodes. The column electrodes are provided with voltage waveforms of high and low magnitude corresponding to display data. The row electrodes are supplied with a sequential scanning signal of activating magnitude. During one data output period, a signal for the data about the selected rows is delivered with one polarity and then switches to the opposite polarity N number of times (where N is a positive integer) during the same data output period to prevent crosstalk in the column electrodes.

U.S. Patent No. 5,247,375; Issued 9/21/93

Display Device, Manufacturing Method Thereof, and Display Panel

Inventors: Aoyama, T; Mochizuki, Y
Assigned to: Hitachi Ltd, Japan

A display device such as an LCD device is provided which comprises a single substrate, a plurality of thin-film semiconductor elements provided on the substrate, a plurality of display elements whose pixel display is controlled by the semiconductor elements, and electrodes for driving the display elements. The substrate includes a display zone having the thin-film semiconductor elements arranged in the display elements as well as a non-display zone. The non-display zone has a display scan drive circuit area and a display signal drive circuit area. The thin-film semiconductor elements are formed in both zones. A distance between the display signal drive circuit area and the semiconductor elements of the display zone on the substrate is physically arranged so as be larger than a distance between the display scan drive circuit area and the semiconductor elements of the display zone. In the display device, the multiplicity of semiconductor elements are formed on a glass substrate having one side of several or more inches so that minimum processing dimensions of the semiconductor elements in the display zone are smaller than those in the non-display zone.

U.S. Patent No. 5,247,289; Issued 9/21/93

Liquid-Crystal-Display Device with Commonly Connected Capacitor Electrodes

Inventor: Matsueda, Y
Assigned to: Seiko Epson Corp, Japan

An LCD device is provided with a storage capacitor relative to each pixel electrode, and a common electrode is electrically connected to the storage capacitors of adjacent pixel structures between pairs of adjacent scan lines comprising paired odd and even numbered scan lines. With the utilization of this common electrode structure comprising commonly connected capacitor lines, the number of common electrodes necessary for electrically connecting storage capacitors of the pixel structures can be reduced by one-half and the number of the source electrodes connecting portions of the TFTs can be reduced by one-half as compared with the conventional technique utilizing a single storage capacitor per pixel structure. Therefore, a high aperture ratio can be maintained in spite of a decrease in pixel pitch to form a more dense pixel array. The common electrode lines could alternatively be formed between pairs of adjacent signal lines rather than pairs of adjacent scan lines, i.e., the common capacitor connection of the storage capacitors by the common electrodes is primary and the directional orientation of the common electrodes is secondary.

U.S. Patent No. 5,247,224; Issued 9/21/93

Color Cathode-Ray-Tube Shadow-Mask Assembly

Inventor: Bae, S-S
Assigned to: Samsung Electron Devices Co Ltd, Korea

A color CRT shadow-mask assembly includes a panel having a screen; a shadow mask positioned within the panel; a frame supporting the shadow mask; and a self-compensating hook spring which is fixed to the frame within the panel, suspending the shadow-mask assembly within the panel, the hook spring including a fixed planar portion welded to the frame, a coupling part for receiving a stud pin, and a connecting part connecting the coupling part with the fixed planar portion, wherein the distance between the planar portion and the coupling part increases with the distance from the connecting part whereby the fixed planar portion of the hook spring welded to the frame is inclined at a predetermined angle relative to the coupling part. The bending portion between the connecting part and the fixed planar portion is plastically deformed with a smaller force and the angle between the connecting part and the planar portion is smaller than in the conventional hook spring so that the resilience at the bend is not decreased so much. Through the resilience at the bend, the shadow mask frame assembly is flexibly and resiliently supported and the hook spring withstands vibrations better. ■

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