Chapter News

(See also Page 13)

JAPAN CHAPTER wins the Editor's Prize this month for content and humor. On July 23 this chapter had two meetings at the Sharp Corporation offices in Tokyo as follows:

A. Meeting chaired by Iwao Ohishi, Chairman of SID Japan Chapter and Masao Sugimoto, Vice-Chairman, BCEE Group, IEEE Tokyo Chapter, attended by 29 SID members and 29 non-members. The program was as follows:

1. Report on the 1981 SID International Symposium

General Review	Koh-ichi Miyaji, Shibaura Institute of Technology
1.2 Session VII	Human Factors Hideo Kusaka, NHK Broadcasting Science Research Labs., Tokyo
1.3 Session X	Color CRTs CRTs Osamu Takeuchi, Sony Corp., Tokyo
1.4 Session IX	Passive Displays I Noboru Kaneko, Daini Seikosha Co., Ltd., Tokyo
1.5 Session XI	Passive Displays II Kyozo Ide, Research & Development Center Toshiba Corp., Kawasaki Co., Ltd. Tokyo
1.6 Session IV VIII	Hard Copy Non-Impact Printing and Recording Koichiro Ishikawa, Yokosuka Electrical Communication Lab., Nippon Telegraph and Telephone Public Corp., Yokosuka
1.7 Session XIII	Panel and Large Screen Displays Koichiro Kurahashi, Mitsubishi Electric Corp., Amagasaki
1.8 Session XIV XVI	Graphics and Image Processing Display Systems Yoshizo Hagino, Japan Radio Co., Ltd.
1.9 Session XV	Plasma Displays Shizuo Andoh, Fujitsu Laboratories Ltd., Lobe

2. Report on the other Conferences
2.1 Electronic Material Conference, Akio Sasaki, Kyoto Univ., Kyoto
2.2 Gordon Conference, Shunsuke Kobayashi, Tokyo Univ. of Agriculture and Technology, Tokyo

B. A second meeting chaired by Chuji Sujuki, SID Chapter Committeeman was attended by 14 SID members and 15 non-members. This meeting was primarily for young engineers and research scientists. Topics discussed included:

* Topics in author interviews at the 1981 SID symposium
* Sinclair's flat CRTs
* Application of PDPs
* Cost down of Flat Panel Displays
* Kanji Displays and Human Factors
* Penetration CRTs
* Eurodisplay '81 and Japan Display '83

Humor: Ryuichi Kaneko, Japan Chapter Secretary, sent your Editor a package of material which arrived just too late for our September/October issue. But don't ever let anyone tell you that our Japanese friends lack a sense of humor. Quoting Kaneko: As to Meeting B, the chairman, Dr. Suzuki, "seemed to be greatly annoyed because he could not cut the discussion when the closing time of the meeting had already passed several tens of minutes before."

Added Secretary Kaneko in his own handwriting in English (who among American SID members writes in Japanese?):

"Attendance paid Y500 each (about $2) for their coffee and cake. I think it will be, probably, very difficult to surpass dainty dishes of Minneapolis/St. Paul Chapter."

Remember Vern Born's picture of the magnificent spread at one of the M/SP Chapter meetings, appearing on a recent back cover of your Journal?

(Chapter News continued on page 13)

INFORMATION DISPLAY
NOVEMBER 1981
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Information Display

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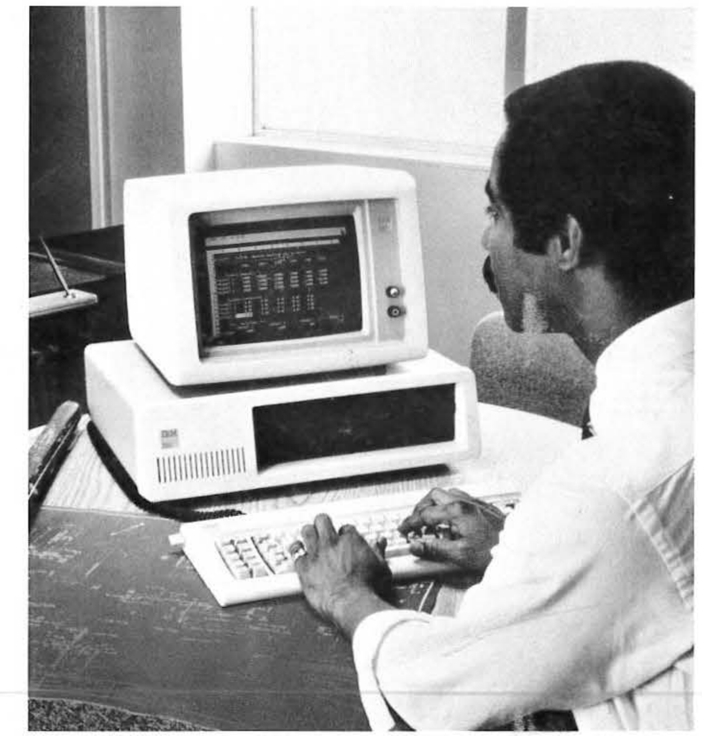

NEW IBM PERSONAL COMPUTER, announced three months ago, is designed for home, business, and scientific use. Standard features include: keyboard for data and text entry; jack for cassette attachment; five expansion slots for additional memory and display, printer, communications and game adapters; speaker for musical programming; power-on automatic self-test of system components; BASIC language interpreter, 16K memory.

The keyboard has 83 keys for data and text entry, including 10 for numeric entry and cursor control, and 10 keys for scrolling, editing, and other special functions. Access is provided for 256 ASCII and special characters.

Displays functions furnish 25 lines of 80 characters on the 11.5 inch monochrome CRT screen, plus underlining, high intensity blinking characters and reverse image highlighting, and non-display for security data. For word processing, these are upper and lower case characters.

Up to two 5.25 inch diskettes may be used, with 160 kilobytes per drive. The associated matrix printer operates at 80 characters/second with bidirectional printing on continous feed, multipart paper. Twelve type styles are available, and formats include 40, 66, 80, or 132 characters per line.

An additional option provides *communications:* an asynchronous line tying into data bases, other computers, laboratory or industrial instruments, or other products using an RS-232C asynchronous adaptor. For *games,* user-supplied joy sticks and paddles may be connected to the system.

This new IBM minicomputer has a cycle time of 410 ns for main storage, and 250 ns access time. These are 40 K of built-in ROM and provisions for 16K to 256K of user memory.

Marketing is through participating ComputerLand dealers; Sears Roebuck business machine stores; IBM product centers and the manufacturer's Data Processing Division.

FRONT COVER MATERIAL WELCOMED: Every month **Information Display** usually features one or more active members of SID and the products with which they are most closely associated. Please send a glossy print and appropriate captions so that you, too, can be on our front cover. Send your material to Ted Lucas, Editor, P.O. Box 852, Cedar Glen, CA 92321, or to our National Office Manager, June Friend, for Information Display, 654 North Sepulveda Blvd., Los Angeles, CA 90049. Next deadline for material from you is November 10 for the December issue. if you miss that, try for the January issue. NOTE: We also welcome feature articles on interesting projects.

ELECTROLUMINESCENT DISPLAYS*

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Waltham, MA 02254

Introduction

Electroluminescence is the process by which light is produced when a solid material is subjected to an intense electric field. The energy gap of the material determines the range of colors that can be obtained. The photopic response of the human eye has a maximum at 2.25 eV (green), and is lower at 1.75 eV (red) and 3.1 eV (blue). Therefore a material with an energy gap > 3eV is a potential candidate for EL covering a wide range of visible colors from red to blue. II - VI compounds in general and ZnS in particular (with an energy gap ~ 3.7 eV) have been the subject of intensive EL investigation for many decades. This article reviews the four different technologies currently employed to fabricate large area flat panel EL ZnS displays, specifically powder (ac, dc) and thin film (ac, dc) displays. The discussion of each technology is based on the following considerations:

- Life, i.e. brightness degradation versus time or catastrophic failure. The life of a display is commonly defined as the time at which brightness decreases to 50% of its original value.
- Contrast. It is important to minimize reflection in order that the presented information is not washed out by high incident ambient light.
- Color and brightness uniformity. The human eye is sensitive to yellow and green colors commonly used in EL, and will therefore easily detect differences in intensity of two adjacent EL elements. Therefore brightness uniformity must be ensured.
- Visual efficiency. This is an important parameter for large area EL displays where power consumption can be significant.
- Resolution, i.e. the number of picture elements which can be displayed.

1. Ac EL Powder: In 1936, Destriau[1] discovered that ZnS powder embedded in a high dielectric constant material can give rise to luminescence when excited by high ac voltages. The discovery went unnoticed until the late forties when the technique underwent substantial development. The objective at that time was to develop a large area light source rather than an information display. In 1949, Sylvania made the first practical EL ZnS lamp (called Panelescent). At that time, Sylvania became a major world supplier of EL lamps with uses that included clock faces, radio dials, airstrip markers, and automobile instrument panels.

1.1 Fabrication Technique: Cu-activated ZnS powder with particle size of 1-20 μ m is usually employed. Excess Cu or Cu_xS precipitating on the surface of the crystallites is carefully washed out. Many types of EL lamps were developed and produced by Sylvania. Two types will be described here, namely the ceramic lamp and the flexible plastic lamp.

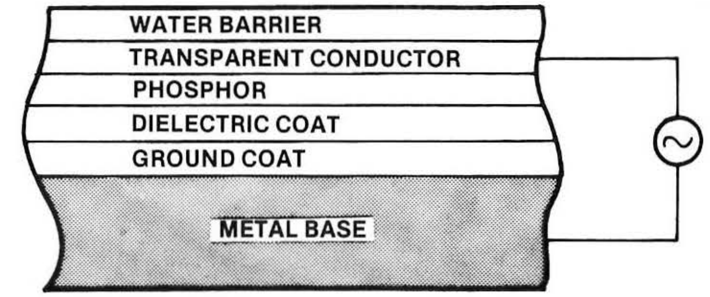

Figure 1. Typical structure of ac EL powder ceramic lamp manufactured by Sylvania.

1.1.1. Ceramic Lamp: The typical structure of the ceramic lamp is shown in Figure 1. The metal substrate is a low carbon steel. The first coat consists of a titania and cobalt bearing frit which gives excellent adhesion to the metal. This is followed by a dielectric coat. The third coat is the activated ZnS powder suspended in a special clear glass frit which has a relatively high dielectric constant. This is then followed by a very thin transparent SnO_2 electrode. The final coat is a water barrier material to protect the device from moisture.

ADVERTISERS' INDEX

*This paper is reprinted from Display Technology Review, Part I, organized and chaired by SID Treasurer Ifay Chang at Electro/81, New York City.

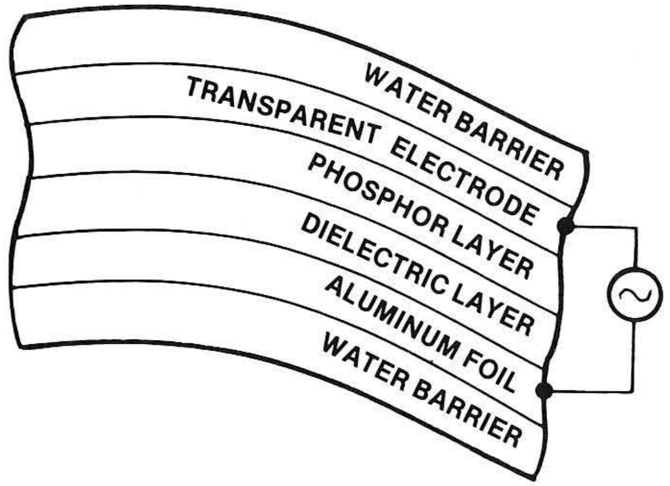

Figure 2. Typical structure of flexible ac EL powder lamp manufactured by Sylvania.

1.1.2 Flexible Plastic Lamp: A typical structure is shown in Figure 2. The substrate is a thin aluminum foil coated on a roughened side with a suspension of barium titanate in a cyanoethyl cellulose. The activated ZnS phosphor powder is also suspended in the cyanoethyl cellulose plastic dielectric. This is followed by a transparent conductive coating serving as the top electrode. A water barrier protective coating is finally applied on both sides of the A1 foil.

1.2 Performance: The ease of fabricating any size device made this technique a very attractive low cost technology. Lifetime, however, was a major concern in ac EL powder devices. Panels operating at high brightness levels degrade faster than panels operating at lower brightness. The problem of brightness deterioration is complex and can be due to Cu ion migration or as has been suggested by Lehmann[2] to the formation of sulfur vacancies on the surface of crystallites. This deterioration can be further enhanced by the presence of moisture, necessitating careful encapsulation and protection. Even with careful sealing, life improvement was limited, especially if the panel had to operate at a substantial brightness level, hampering therefore further efforts until the activity came to a virtual halt by 1965.

Figure 3 is the brightness versus voltage characteristics taken at different frequencies. The higher the frequency, the more light that can be generated. However, at 60 Hz, panels survive better than those operating at 400 Hz.

Figure 4 is a typical maintenance curve where brightness is plotted versus time.

Apart from maintenance problems, attempts to make a conventional X-Y dot matrix display proved to be practically difficult. In X-Y dot matrix displays, the nonselected EL elements are kept at a defined voltage, usually one-third of the voltage applied to the selected elements.[3] The ratio of brightness at full voltage to brightness at one-third of that voltage is known as the discrimination ratio. If this ratio is low as in the case with ac EL powder (~ 20 to 200), light will be emitted from the nondesired elements, giving rise to poor character definition and high level of cross-talk. Therefore, the requirements to establish a successful X-Y dot matrix display are:

- Highly nonlinear characteristics, perferably with well-defined thresholds.
- Steep brightness-voltage characteristics.

A solution to this problem has been proposed by Fischer[4], who combined the Lehmann hyper-maintenance, high brightness powder with thin film transistor (TFT) technology. In this case, EL elements in the X-Y matrix are each independently driven and isolated from each other, eliminating any possible cross coupling. Uniform brightness has been reported in the ac EL powder TFT driven X-Y matrix display.

A wide range of colors can be obtained if ZnS is suitably doped, e.g.:

• Cu + Br	(green EL)
• Cu + I	(blue EL)
• Cu + C1	(green or blue EL)
• Cu + Mn + Br	(yellow EL)
• CdS + Cu	(red EL)

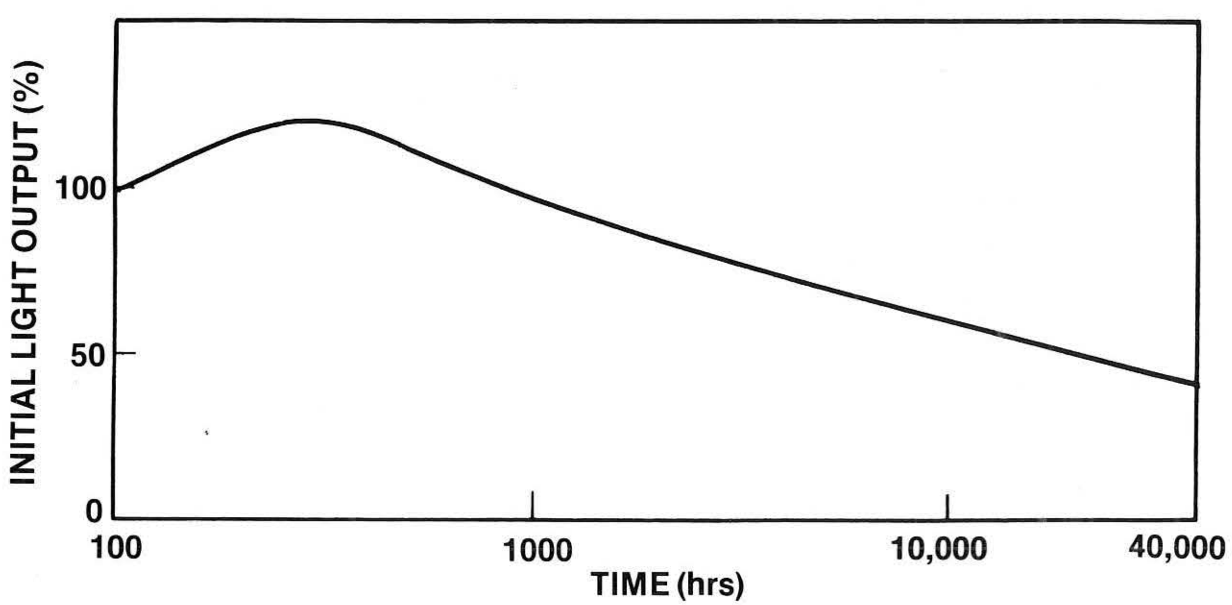

Figure 4. Maintenance of light output of a typical Sylvania panelescent lamp operating at 120 v, 60 Hz.

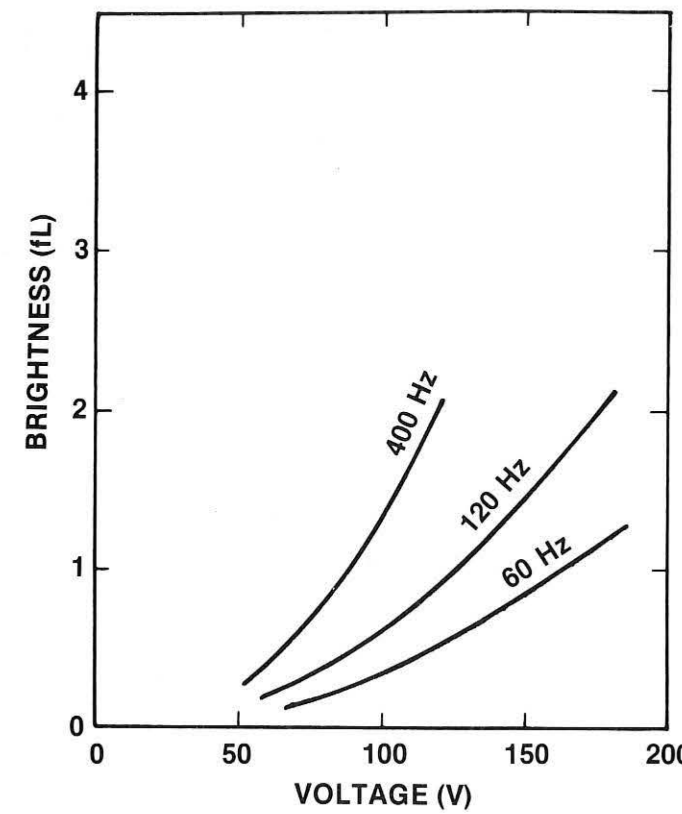

Figure 3. Variation of Sylvania panelscent lamp brightness with voltage at various frequencies.

Visual efficiency is found to depend on many parameters such as particle size and applied voltage range. Since brightness is a surface effect and the applied electric power is a volume effect, small particles might be expected to be brighter than larger particles. However, it was found that panels made from large particles are more efficient than those made from small particles, i.e., efficient and bright phosphor powder is difficult to make with small particle sizes. Moreover, there is also a voltage range where the powder panel is most efficient. Above that voltage, current increases more rapidly than brightness, resulting in efficiency reduction. Typical ac EL powder panels have efficiencies between 0.5-2 1m/W.

Due to the granular structure of the powder panel and high scattering of incident ambient light, contrast is generally poor, making legibility a problem, especially under high ambient illumination.

Many models have been advanced to explain the EL mechanism in ac EL powder devices. Originally Destriau[1] proposed impact excitation by hot electrons. Impact excitation is a majority carrier process and can therefore be observed in materials like ZnS where it is impossible to make a p-n homojunction. Fischer,[5] on the other hand, proposed that the observed EL results from double injection of carriers from the ends of p-type conducting Cu_xS precipitated along defect sites in the ZnS crystallites.

2. Dc EL Powder: Unlike ac EL powder where excess surface Cu or Cu_xS is washed out, dc EL powder crystallites are intentionally coated with high conductivity p-type Cu_xS. This technique has been developed by Vecht[6] in England. The method also has the advantage of being low in cost, and screens of any size can be produced.

2.1 Fabrication Technique: Mn-doped ZnS powder with a particle size of 0.5-2 μm is usually used. The powder crystallites are then coated with a thin layer of the conducting P-Cu_xS. This can be accomplished by simply immersing the powder in a Cu solution, e.g. $CuC1_2$. The coated powder is then mixed with a plastic binder of low concentration to prevent interference with electrical conduction. The mixture is then spread onto a glass plate covered with a transparent indium tin oxide electrode. The thickness of the deposited layer is not critical, and layer deposition can be carried out by any available method, e.g. spraying, screen printing, or even more primitively by dipping the substrate into the powder solution. After drying, an A1 metal film is deposited on top of the powder layer to serve as the rear electrode. These devices are moisture sensitive and encapsulation is therefore required. The best encapsulation method found thus far[7] consists of sealing the panel in the presence of a humidity absorbant material, e.g. a molecular sieve. This is followed by evacuating the device to 10^{-6} torr for a few hours before it is backfilled with Ar. A plastic resin can be used to decorate the panel and provide it extra protection. The typical structure of the device is shown in Figure 5.

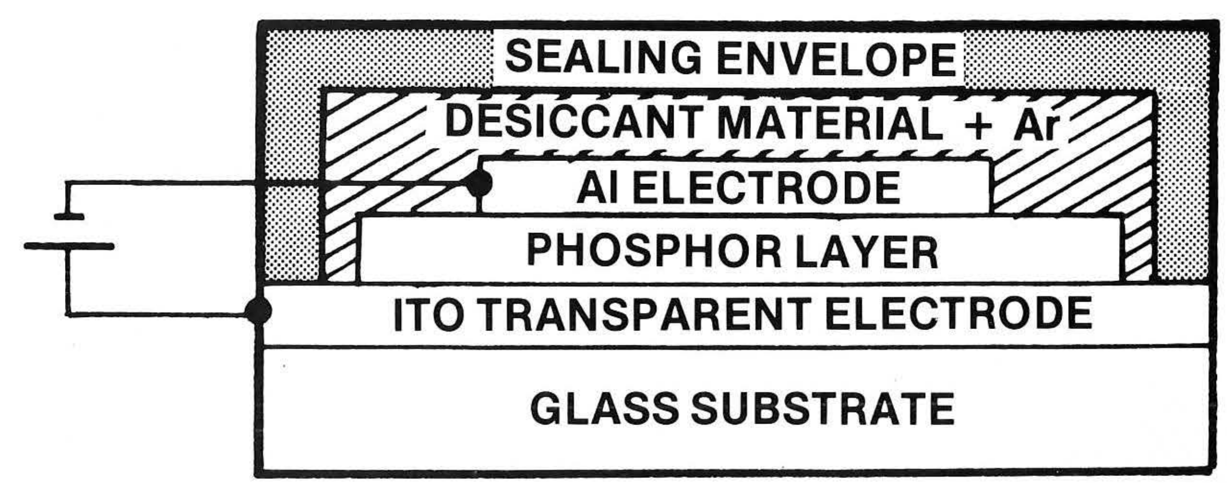

Figure 5. Typical structure of dc EL display.

MAY 11 - 13, 1982

SOCIETY FOR INFORMATION DISPLAY

SID

1982 INTERNATIONAL SYMPOSIUM CALL FOR PAPERS

SAN DIEGO, CA/TOWN-COUNTRY HOTEL

THE SOCIETY FOR INFORMATION DISPLAY INTERNATIONAL SYMPOSIUM, the only annual global forum devoted to all aspects of information display, will be held in San Diego, California, in 1982.

Original papers, not previously published or presented, covering applications, research, development and currently available materials and techniques in the topical subject areas listed below, and closely related fields, are invited.

The Ares of Interest Include, But Are Not Restricted To:

Display Devices	*Display Materials/Phosphors*	*Information Systems*
Flat Panel Displays	*Display Packaging*	*Computer Graphics*
CRT Displays	*Electronics for Displays*	*Command/Control*
Projection Displays	*Optics/Electron Optics*	*Intelligent Terminals*
Military Displays	*Human Factors/Perception*	*Interactive Displays*
Hardcopy/Printers	*Standards/Measurements*	*Image Processing/Analysis*
Videodisc/Tape	*Nonvisual Displays*	*Storage/Retrieval/Facsimile*

Submission Deadline: Monday, Dec. 7, 1981 . . .

POST-DEADLINE PAPERS: A limited number of 10-minute post-deadline papers, reflecting important new developments, will also be considered, if a 500-word summary, with pertinent illustrations, suitable for publication, is received by March 5, 1982.

Supplementary SID 82 Features

SEMINAR: Two-day tutorial authoritative lectures on display technology, with speakers selected among experts in the field of information display will also be held during SID 82 – Monday, May 10 and Friday, May 14. Featured will be in-depth talks on devices, techniques and systems.

AUTHOR INTERVIEWS: These sessions, pioneered by SID, which follow the conclusion of daytime presentations, provide a forum for extended discussions between author and audience. Demonstrations of devices and equipment are encouraged.

EXHIBITS: Highlighted, too, will be a three-day operational display of the latest equipment, components and accessories by industry from U.S. and overseas.

Mailing: U.S. authors should send their abstract and technical summary to: Leonard Klein, Palisades Institute, 201 Varick Street, New York, NY 10014. Overseas authors should also send one copy of their abstract and technical summary to Leonard Klein, as well as to one of the following appropriate overseas program advisors: Europe – C.J. Gerritsma, Philips Research Laboratories, Eindhoven, Netherlands . . . or . . . W. Proebster, IBM Germany, Box 210, Boeblingen, West Germany. Asia – K. Miyaji, Shibaura Institute of Technology, 3-9 Shibaura, Minatoku, Tokyo, Japan . . . or . . . S. Kobayashi, Tokyo Univ. Agri. Tech., Nakamachi, Koganei, Tokyo 184, Japan.

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Walter Goede, Symposium Program Chairman, Northrop, 2301 W. 102th St., Hawthorne, CA 90250 . . . Tel.: 213-418-4592

Additional information on Preparation Guidelines may be obtained at the National Office. Tel: (213) 472-3550.

2.2 Performance: When a dc voltage is applied to a virgin device (positive to ITO), high current is found to pass through the structure. This current is termed the forming current and is attributed to the high conductivity of the P-Cu_xS surface coating. After a certain period of time determined by the initial input electric power, the current drops and the current-voltage characteristic changes to rectifying. This is accompanied by the appearance of yellow-orange luminescence characteristic of Mn emission localized at the positive electrode. The localization of emitted light is known[7,8] to arise from Cu ions migrating from the anode and depleating the narrow emitting region of its P-Cu_xS coating. Therefore, after the forming process, the device can be regarded as being composed of two regions between the two outer electrodes. These regions are:

a. n-doped ZnS (insulator, narrow emitting region).
b. p-type region where the ZnS:Mn particles are masked by the P-Cu_xS coating. This region extends to the cathode.

As long as a constant dc voltage is applied across the device, Cu ion migration proceeds indefinitely and the thickness of the light-emitting region increases accordingly. It seems that the speed of the Cu ion migration depends on how the Cu_xS coating was introduced. It has been found that[9] heat treating at 105°C results in a substantial improvement in the life of the display. More life can be obtained from these devices when they are pulse operated at low duty cycles and more than 3000 hours at more than 20 fL have been reported thus far. Abdalla, et al.[7] have found that the life of these devices can be greatly enhanced, if after the the forming process the dc voltage is replaced by ac. Figure 6 is a photograph of a fixed information EL panel converted from dc to ac.

A typical brightness versus voltage characteristic is shown in Figure 7. The B-V curve is steeper than that of ac EL powder devices, implying a higher discrimination ratio of $\sim 10^3$.

After the forming process, the anode side of the device has a high resistivity while the rest of the device is highly conductive. Therefore, any attempt to make an X-Y dot matrix display will result in continuous EL lines instead of the desired EL dots, i.e. the panel suffers from 50% cross-talk. This, however, can be eliminated if the cathode electrodes are physically separated; e.g., by scribing all the way through to the extended cathode.

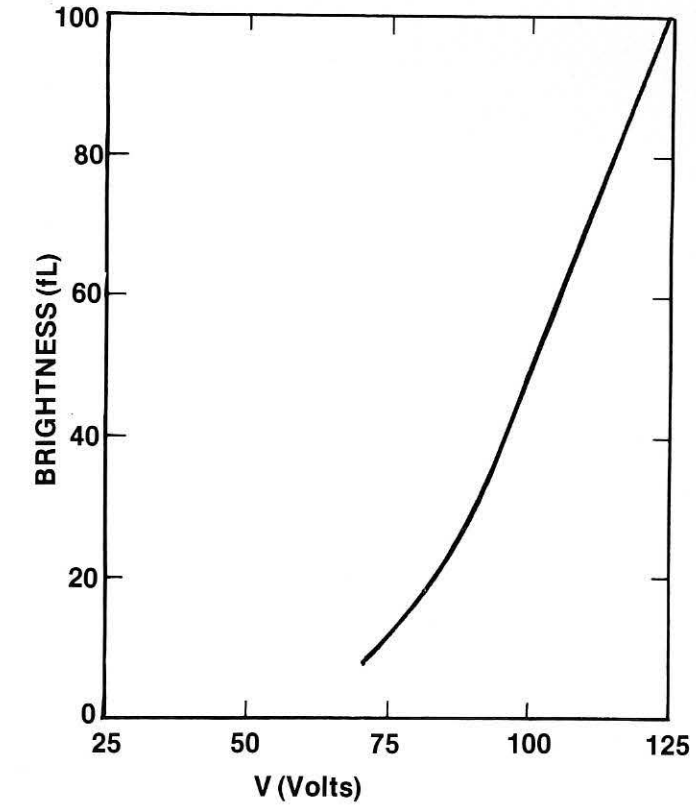

Figure 7. Brightness versus voltage characteristics of a dc EL powder ZnS:Mn, Cu display made by C.N.E.T. in France.

This limits the maximum attainable resolution and more than 40 lines/inch is difficult to achieve because of powder peeling. Impressive alphanumeric displays with good uniformity and more than 80 characters are currently produced by Phosphor Products in England.[10] Low resolution TV displays have also been reported.[11]

The visual efficiency of these devices is typically between 0.1 to 0.4 1m/W. The reason for the low efficiency could be due to the incompatibility of the P-Cu_xS/ZnS:Mn heterojunction interface. Contrast is

Figure 6. Photograph of dc formed and ac operating ZnS: Mn,Cu powder EL display made by C.N.E.T. in France.

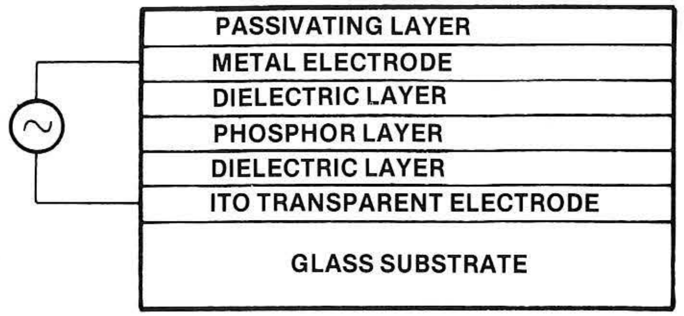

Figure 8. Typical structure of ac EL thin film device.

low, but since the devices can be operated at high brightness levels, optical filters can be implemented to enhance the contrast. The brightness decay time of these devices depends on the Mn concentration. At high Mn concentrations, > 1 wt %, two decay times have been observed:

- A short time, ~ 0.1 to 0.2 ms, attributed to the formation of Mn^{+2}-Mn^{+2} ion pairs.
- A long time, ~ 1 ms, associated with single Mn^{+}.

At lower Mn concentrations, only the long decay time[12] is observed.

Alkaline earth sulfides such as CaS and SrS, doped with rare earths, were explored for different colors. These materials are known to be very hygroscopic and stability could be a problem.

Abdalla et al proposed a model to explain the EL mechanism[8]. The model is based on the creation of a reverse-biased heterojunction between the narrow luminescing region (n doped ZnS) and the rest of the device (basically P-Cu_xS). Electrons are tunnel-injected from P-Cu_xS and accelerated by the high electric field to impact and excite the Mn luminescent centers, giving rise to the observed yellow-orange emission.

3. Ac EL Thin Films: A number of research organizations are engaged in the development of ac EL thin film displays. In particular, GTE is involved in the development of manufacturing capability for ac EL devices employing ZnS thin films. The advantage of these displays are their high attainable brightness, their excellent stability[15], and their simplicity of fabrication.

3.1 Fabrication Technique: The typical structure of the device is shown in Figure 8. The process by which successive layers are deposited can be any of the available methods for thin film deposition, e.g. sputtering, electron beam evaporation, thermal evaporation, or a combination. The devices are mositure sensitive, and passivation and encapsulation are therefore crucial. Dopant materials widely used in ZnS include particularly Mn (yellow-orange) and TbF_3 (green).

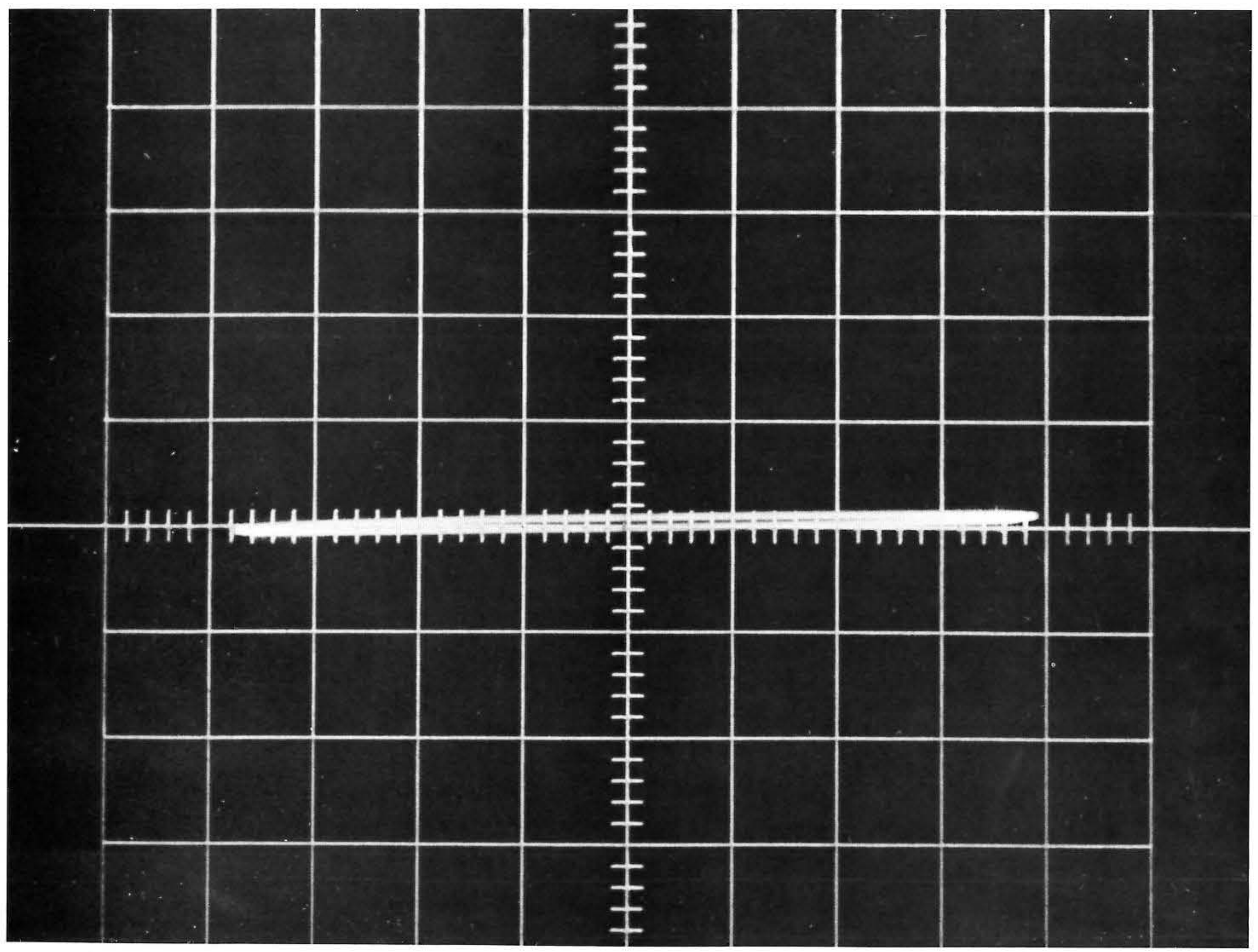

Figure 9a. Charge versus voltage plot below the onset of electroluminescence of a green (ZnS:TbF_3) ac EL thin film device.

3.2. Performance: The successful operation of these devices depends on the quality of the insulating layer, i.e. its dielectric strength. Below the threshold voltage necessary for EL, the ZnS phosphor layer is insulating. Therefore, the applied voltage is distributed among the differrent layers according to their thicknesses and dielectric constants. A plot of charge Q versus voltage is shown in Figure 9a where the device behaves almost like a low loss capacitor and the observed charge is due to dipole charges at the various interfaces. When the applied voltage increases above the threshold voltage, charge is transported from one side of the phosphor layer to the other side and returns back upon voltage reversal. This gives rise to the observed hysteresis in the Q-V plot shown in Figure 9b. It is interesting to note that increasing the voltage bias above threshold results in a substantial increase in the amount of charge while the voltage seems to be almost clamped. Assuming that the observed charge arises mainly from the ZnS phosphor layer, the extra voltage increase, above threshold, must therefore be accommodated by the two outer insulator layers. Important parameters can be deduced from Q-V plots, such as efficiency and power dissipation.[16]

The dielectric strength of the insulator can be increased by increasing its thickness; however, the required voltage to drive the display must also increase.

The voltage required to drive the display can be reduced without further reduction of the thickness of the insulator layer by:

- Using an insulator material with higher dielectric constant.[17]
- Using a phosphor layer with lower band gap.[18]

3.3. Contrast Enhancement: The device shown in Figure 8 is highly reflective. Under ambient illumination, the brightness of the device has to be increased by increasing its voltage, in many cases, close to breakdown. Soxman and Ketchpel[19] found that contrast can be enhanced by a dark layer behind the emitting layer. In order that such a layer be effective to enhance the contrast, the following requirements must be fulfilled:

- High absorption coefficient (in the visible).
- Low reflectivity (proper index of refraction).

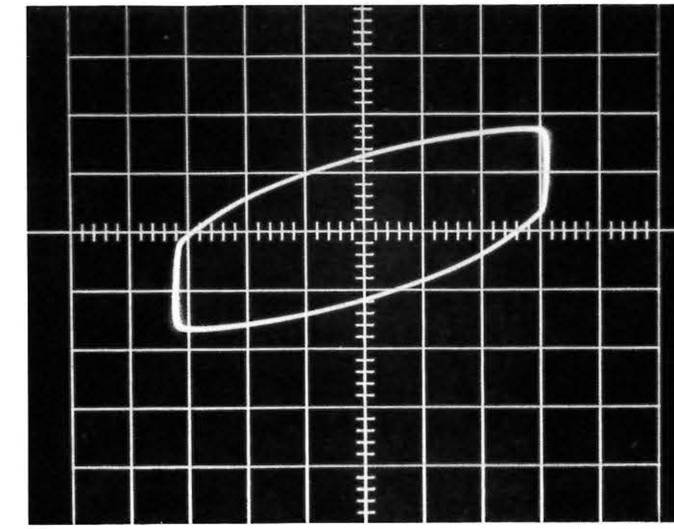

Figure 9B. Charge versus voltage plot during luminescence of a green (ZnS:TbF_3) ac EL thin film device.

At GTE considerable efforts have been devoted to the preparation and study of a stable and suitable dark layer. Depending on the preparation conditions, dark layers can have a range of values; typical values used are:

- Absorption coefficient ~ $10^6 cm^{-1}$.
- Diffuse reflectivity ~ 1%.

This dark layer is routinely implemented in GTE thin film EL displays. Figure 10 is a yellow-orange EL display fabricated by the GTE Lighting Products Group at Salem, MA. The use of the dark layer has the added advantage that the required voltage to drive the display can be lower since the display can be highly legible at low brightness levels under high ambient illumination; e.g. with a brightness of 20fL, the display maintains acceptable contrast under 10,000 fc.

The reported visual efficiency when Mn is used as a dopant is typically between 0.5 and 2 1m/W. The addition of the dark layer reduces the efficiency to almost half that value.

Figure 10. An ac EL (ZnS:Mn) thin film display made by GTE Lighting Products Group at Salem, MA.

Figure 11 shows the brightness versus voltage characteristics for a green EL display ($ZnS:TbF_3$) with a dark layer and a single dielectric. This results in a display operating at lower voltages than that reported by other workers. Increasing the frequency results in increasing brightness. The decay time of rare earth doped ZnS is usually shorter than that of Mn, resulting therefore in less efficient devices. Typical efficiencies in $ZnS:TbF_3$, ac EL thin film devices are 0.05 to .03 1 m/W.

When Mn is used as a dopant the shape of the B-V characteristic is found to depend on the Mn concentrations. Above 1 wt % hysteresis (memory) has been observed. This phenomenon has been attributed by Yoshida, et al.[21] to polarized charges released from deep trap levels situated at 0.8 ev below the conduction band of ZnS. The release of charge from the trap level and subsequent recombination is responsible for the observed memory. Marello, et al.,[21] however, related this effect to a filamentary conduction process leading to bulk differential negative resistance, hence hysteresis.

The high discrimination ratio ($\sim 10^4$ for 3:1 voltage) permits the operation of high density uniformly bright dot matrix displays.[22,23]

4. Dc EL Thin Films: An attractive goal in the field of large area EL displays is a panel that can be driven at low dc voltages compatible with the existing IC circuits. Low voltage dc EL has been observed by many workers in Zns:Mn, Cu thin films.[24 25] The reported lifetime, however, did not exceed a few hours. Recently, Abdalla and Thomas[26,27] reported that stable low voltage dc EL can be achieved in co-evaporated ZnS:Mn,Cu films. A summary of the method and some of the recent results will be described in the following section.

4.1 Fabrication Technique: Elemental Zn, S, Mn and Cu are each independently co-evaporated from BN cells

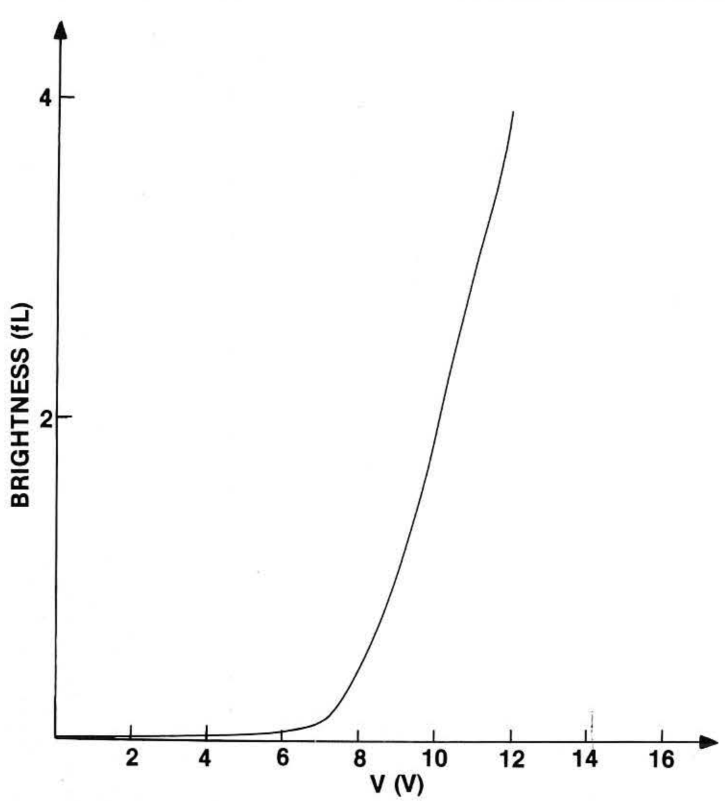

Figure 12. Brightness versus voltage characteristic of dc EL thin film made at C.N.E.T. in France.

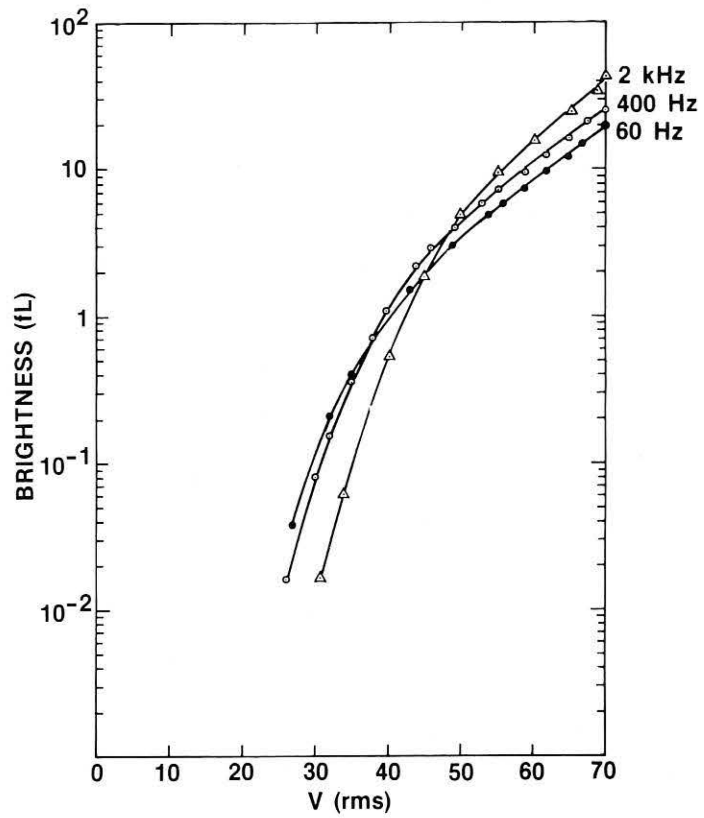

Figure 11. Brightness versus voltage at various frequencies for a green $ZnS:TbF_3$ ac EL thin film device made at GTE Laboratories, Waltham, MA.[3]

onto a heated ITO-covered glass substrate. The substrate temperature during film deposition is kept at 450°C. High sulfur overpressure is always maintained for the following reasons:

- Maximize film stoichiometry.
- Ensure that Cu is introduced into the film as $P\text{-}Cu_xS$.

Metallic Cu has the drastic effect of making the device extremely inefficient and with short life.

The thickness of the deposited layer is not critical (5-20 μm). The deposited layers are usually annealed for one hour at the deposition temperature. This is found to enhance the crystallinity of the deposited layer and improve the luminescence properties of the device. After cooling down to room temperature, a metal electrode is deposited on top of the layer to form the rear electrode. Finally, the device is encapsulated similar to that previously described for dc EL powder devices. The typically structure of the device is shown in Figure 5. This structure is similar to that of dc EL powder devices.

4.2. Performance: These devices resemble in many aspects powder dc EL displays, especially with regard to the required forming process and the localization of EL in a narrow region close to the positive electrode. Toward the end of the forming process, the device emits appreciable light ($\sim$ 5850 A°) at low voltages. Figure 12 is a plot of the brightness versus voltage, where the steepness of the characteristic becomes noticeable at higher voltages, and a discrimination ratio of more than 10^4 is typical.

The visual efficiency is typically between 0.1 and 0.2 1m/W. By careful optimization of the dopant concentrations, an increase in the efficiency is expected; however, the $P\text{-}Cu_xS/ZnS$ interface might be a limiting factor.

The life of these devices is found to be greatly extended if they are driven with low duty factor pulses. Figure 13 shows the variation of brightness with time of operation.

X-Y dot matrix displays with good brightness uniformity and no cross-talk have been achieved[28] by deposition through metal masks. Figure 14 is a photograph of such a display where certain EL elements have been lit.

High Cu_xS content gives the device a dark appearance which is found to enhance the contrast; i.e. at a brightness of 10 fL and ambient illumination of 2300 foot candles, the measured contrast ratio is 3:1.

Conclusion

The preceding sections have shown that there is a wide range of available techniques to produce large area EL displays, and that certain technologies are viable for practical display applications. The areas recommended for further development efforts include work on efficiency and reliability and innovation in multicolor displays.

Acknowledgements

I would like to express my thanks to F. J. Reid, L. Riseberg, and P. Haugsjaa for their helpful and critical comments. Thanks are also due to D. Baird and B. Budinger from GTE Labs for fruitful discussions and for permission to discuss results prior to publication. I am grateful to H. Hidler, L. Hope, J. Plumb and T. Sentementes of the GTE Lighting Products Group for providing data and photographs of ac EL displays.

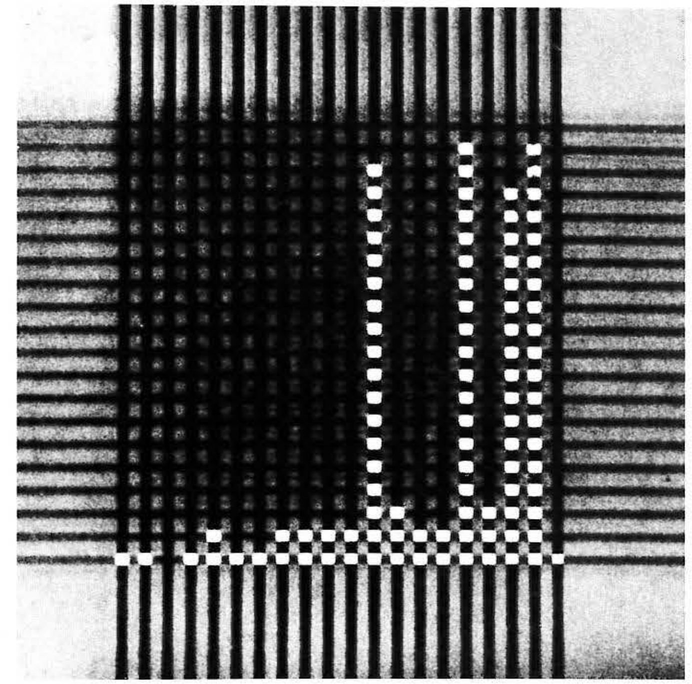

Figure 14. X-Y dot matrix dc, EL, ZnS:Mn, Cu thin film display made by C.N.E.T. in France.

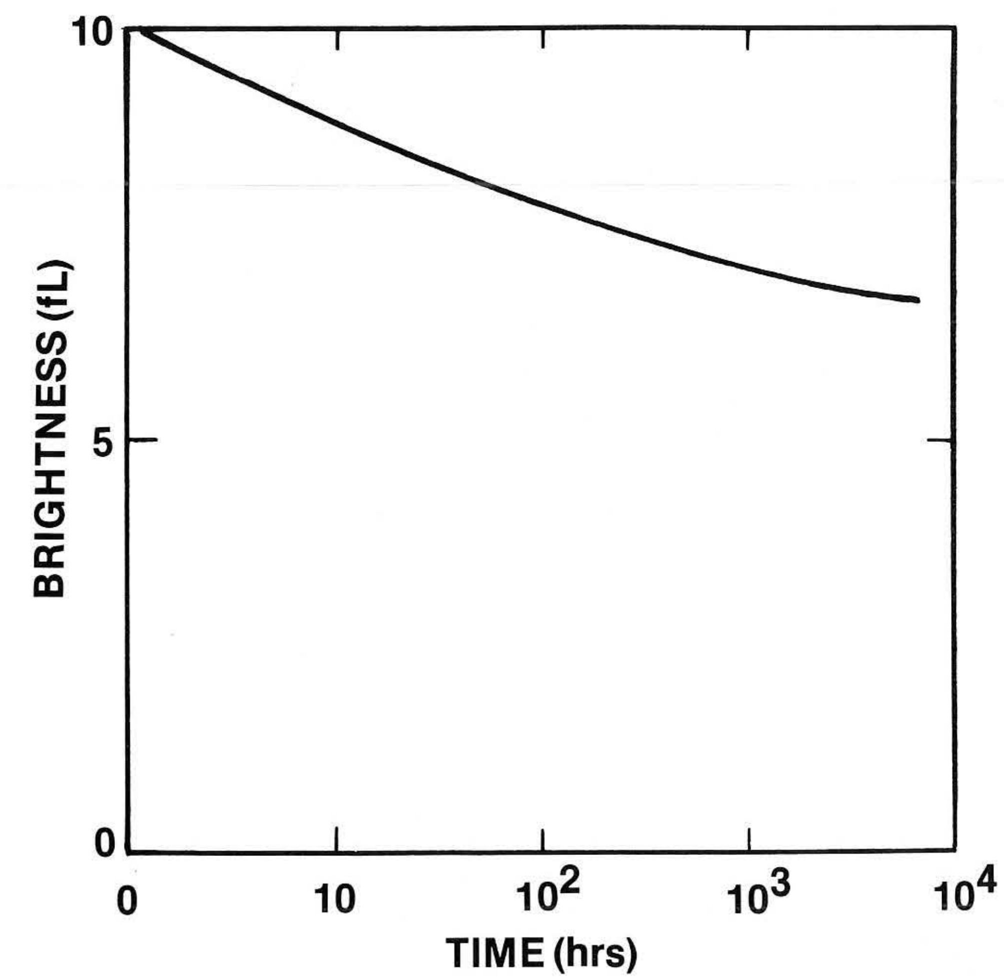

Figure 13. Maintenance characteristics of a ZnS: Mn,Cu dc EL thin film device driven by 5 s 45 V pulses at a repetition rate of 1 kHz.

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CHAPTER NEWS (continued from page 24)

MINNESOTA/ST. PAUL CHAPTER on September 18 enjoyed a discussion of "Show & Tell on Countal Vision I" by John C. Schultz of 3M. He described how this real time, full color image processing system with interactive color control and masking has many potential applications in medical, commercial and military imaging.

SAN DIEGO CHAPTER, with Chairman Dwain Keller presiding, saw and heard a presentation on data displays by Gene Ornstead and Ed Van Dusen of Conrac Corporation, Covina, CA. This well-attended meeting was interesting indeed, reports George Unangst, Chapter Vice-Chairman. The speaker also described a recent Conrac publication.

"Raster Graphics Handbook". The book gives a very good overview of graphics systems and includes details of generally-used display techniques. Clear diagrams of everything from the inside "how" of the Tektronix DVST to the various CRT configurations for color displays are included, as is a section on SIGGRAPH software standards.

DELAWARE VALLEY CHAPTER on October 15 enjoyed a discussion of the scanning electron microscope (SEM) by Steve Bujoilts of SPS, with Robert Martin of that firm as host and tour guide.

The basic operating principles of the SEM and electron microprobe were discussed, followed by a demonstration of the units' capabilities. The presentation specifically focused on the use of the SEM and electron microprobe in failure analysis.

A tour of SPS' mechanical testing facilities was also provided.

MID-ATLANTIC CHAPTER on October 6 in the Burroughs Building auditorium enjoyed an exceptional program attended by a large number of SID members and non-members. The topic was a technical report and discussion of display research presented at the European Display '81 Conference-Munich, Germany, and attended by the SID members who spoke at this meeting, as reported by Ames Giordano, Chapter Secretary.

The following five speakers discussed Eurodisplay '81:

Frank Asterino; Dr. Ifay Chang; Dr. Allen R. Kmetz; Jim Ogle; and Dr. John van Raalte.

NEW ENGLAND CHAPTER on June 19 found SID Chapter Chairman Thomas B. Cheek, Vice President of Engineering, Advent Coreporation to be a most enlightening speaker on "Trends in Consumer Television." He described how television has been considered a mature industry with only minor technical changes occurring from year to year. Not so any longer. The old concepts of broadcast stations and TV receivers has been joined by cable TV, satellite transmissions, video cassette recorders, video disc players, large screen TVs, stereo sound, and teletext services. This talk provided an overview of these new developments and offered an insight into how they will affect the entertainment industry.

SID CALENDAR
DECEMBER 1981 to JULY 1982

1981		
December	1	Honors and Awards Nominations Deadline (Submit to I. Reingold, ERADCOM, DELET-B, Fort Monmouth, New Jersey 07703)
	7	Abstract Deadline for SID 1982 International Symposium (Submit to Leonard Klein, Palisades Institute, 201 Varick St. New York, NY. 10014)
	15	Nominations for National Officers and Regional Directors Due. (Submit to B. J. Lechner, Nominations Committee Chairman)
	15	Bylaws Recommendations Due
1982		
January	4	Proceedings, Volume 22, No. 4, 1981, Mailed
	20	Quarterly Chapter Rebates Mailed
	20-21	SID 1982 International Symposium Program Committee Meeting, Town & Country Hotel, San Diego
	22	National Board Meeting, Town & Country Hotel, San Diego, CA
February	15	National Ballot Mailed
March	5	Post-Deadline Papers for SID 1982 International Symposium
April	1	Proceedings, Volume 23, No. 1, 1982, Mailed
	12	National Ballot Return Deadline
	20	Quarterly Chapter Rebates Mailed
May	9	Executive Committee Meeting
	10	National Board Meeting, San Diego, CA.
	10-14	SID 1982 International Symposium, Town and Country Hotel, San Diego, CA.
July	1	Proceedings, Volume 23, No. 2, 1982, Mailed
	20	Quarterly Chapter Rebates Mailed

GREETINGS TO NEW SID MEMBERS!

Each month you'll find a roster of new SID Members, listed by Chapters with the Chapters in alphabetical order. If your name — or a friend's — should have been listed and was inadvertently omitted, please let June Friend or your Editor know immediately. We'll make amends in the next issue. See the front cover for your choice of addresses to which to send vital data.

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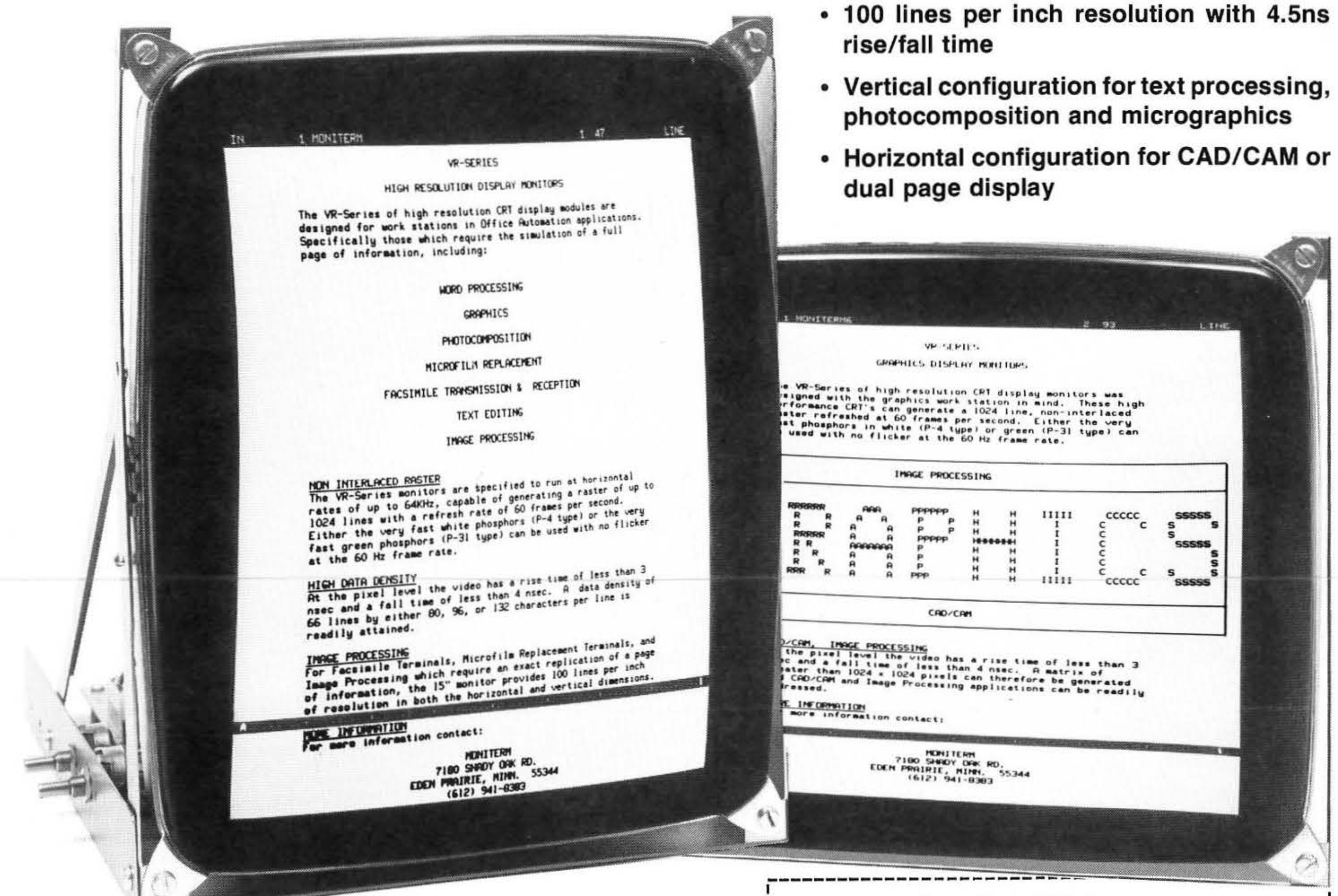

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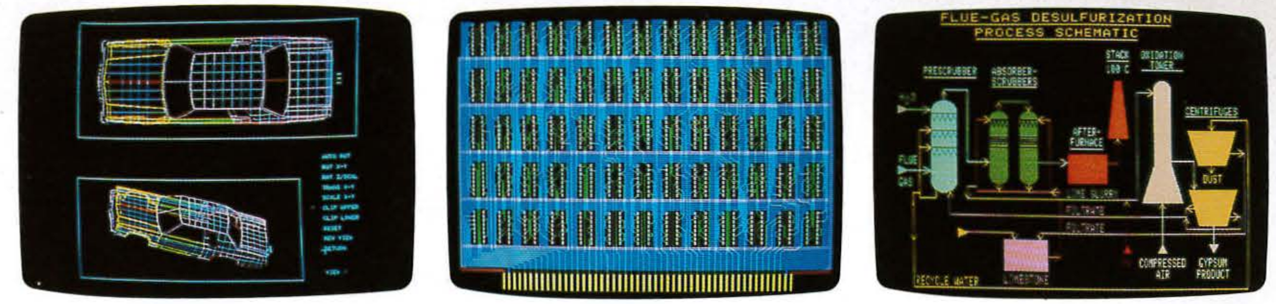

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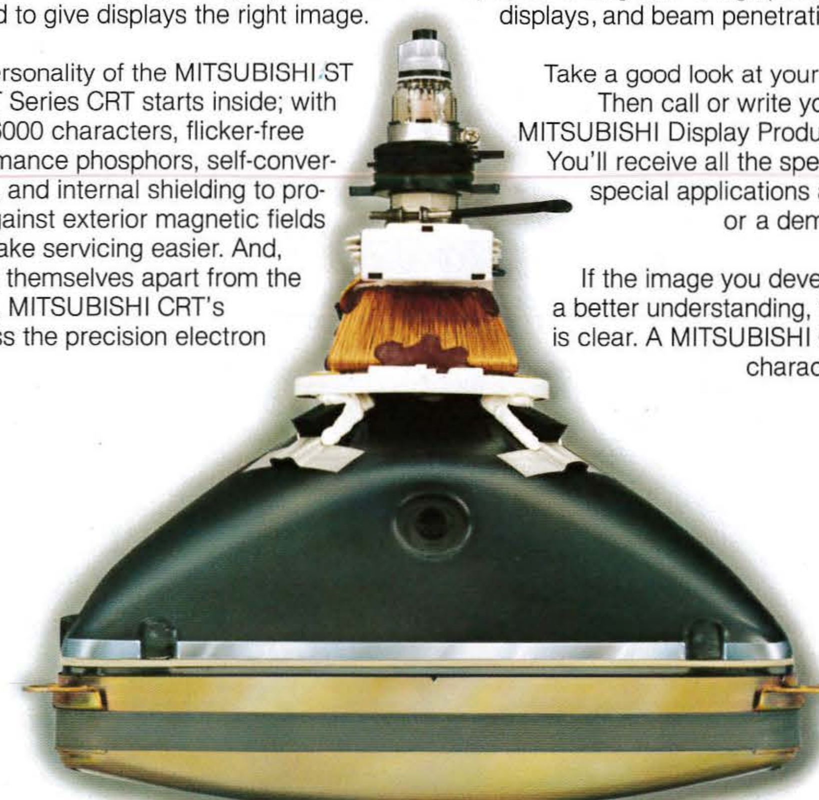

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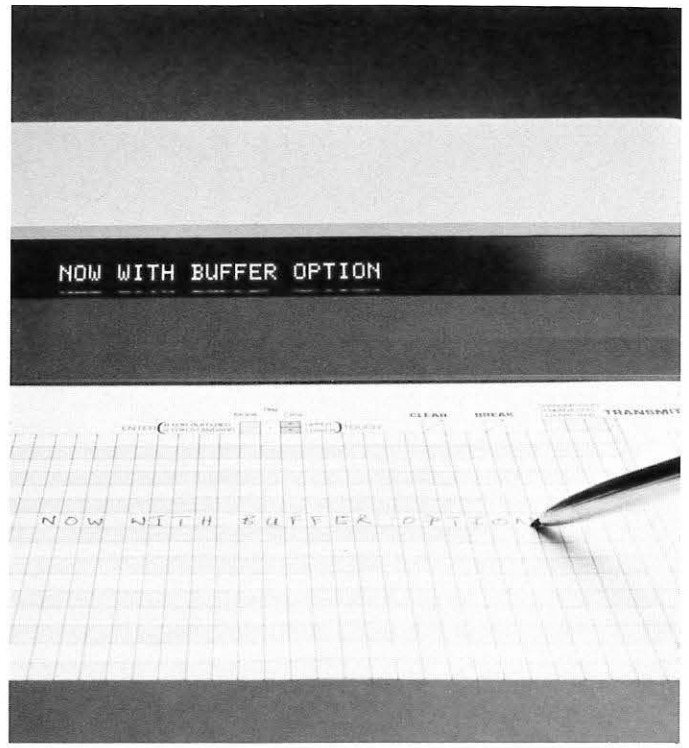

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