THE POWDER DCEL MOSAIC MATRIX DISPLAY

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Abstract—A large-area mosaic powder DCEL matrix display of about 1 m^2 has been built and demonstrated as a Chinese word-computer terminal display in the People's Great Hall in Peking. The display consists of 30 units, each of which can display one Chinese word. Under pulse voltage with 110 V, 83.5 μsec, and 100 Hz, the brightness, contrast, and power of display are 40 cd/m^2, 10:1, and 350 W, respectively. According to life testing in our lab, under pulse excitation, it can be estimated that the operating lifetime is about 5000 hours. The technology of preparing DCEL phosphors corresponding to various ZnS raw materials has been tested. The capacitance dependence of the DCEL panel on the electro-optic and technical parameters of the panel has been studied. A new forming process is adopted, which greatly improves the brightness and contrast of display.

I. INTRODUCTION

At present, the progress made in powder DCEL technology provides the feasibility of a large-area DCEL matrix display. However, efforts in this field have not yet been pursued. A DCEL matrix display with high resolution (3.15 lines/mm) and a small visual area has been developed in Great Britain, but the development of large-area DCEL matrix displays has not been reported.

Large-screen display technology is an important information display technique needed in military command and control, traffic control, production control centers, sports arenas, advertisement, information board meetings, etc. Many consumers are eagerly awaiting the realization of this technology.

There are many problems concerning large-screen display technology: design, manufacture, and the electronic circuitry. Usually, it is necessary to adopt the mosaic approach to build a large-size display of more than 1 m^2. The mosaic display is convenient in terms of replacing units damaged or deteriorated, and its preparation technology is easier. The non-mosaic large-area DCEL panel is subject to a very large pressure when there are atmosphere differences inside the panel due to heating of the panel during operation (about 1 ton/m^2, at an atmospheric pressure of 0.1 atm). Sometimes this causes the panel to break.

Mosaic panels do not experience these problems. Their problem is to cut down the gap between units of the display as small as possible, so that it appears as an entire panel. Our mosaic DCEL matrix display, about 1 m^2 with a 30-mm gap between units, has been used as a Chinese word computer terminal display. Every unit as a plug-in unit can be inserted in a frame side by side, making it convenient to change if necessary.

Recently, we have built a non-mosaic DCEL matrix display (about 1 m^2) with 168×144 pixels and developed a method which decreases the gap between units to about 3 mm. In this method, encapsulation by the sides of the panel and lead-in wire on the back are adopted.

II. PHOSPHORS

It is important to reduce the particle size. After the forming process, the high-field region is limited on the scale of one particle. Thus, reducing particle size is equivalent to increasing the intensity of field and the number of luminescent particles per unit area. The particle sizes of the phosphors are related to the ZnS raw materials. The ZnS raw material is critical in obtaining good DCEL phosphors. Commercial ZnS from various factories and batch numbers are usually not appropriate to prepare DCEL phosphors.

It was found that the technology for preparing DCEL phosphors should be different for the various ZnS raw materials. In order to enlarge the range of selecting ZnS raw material and to raise the adaptability of preparing DCEL phosphors to ZnS raw material, some techniques in reducing the particle size of phosphors have been tested. The results show that there is a technology which corresponds to particular ZnS raw materials in preparing available DCEL phosphors. Figure 1 shows the change of the particle size distribution of phosphors under conventional and corresponding technology.

III. BRIGHTNESS AND CONTRAST

The brightness and the contrast are the most important characteristics of DCEL matrix units for large-screen display. They are limited by some conditions peculiar to the large-area matrix screen such as line resistance, capacitance, and driving condition.

IV. LINE RESISTANCE AND CAPACITANCE

The time constant ($\tau = RC$) confines the drive circuit and thus limits also the brightness and constrast. When the drive pulse is smaller than eight RC time constants, the pulse waveform and pulse width are evidently changed as shown in Fig. 2.

On the other hand, large RC constants will lead to discharge problems of addressed pixels, leading to poor contrast. The capacitance of the powder DCEL panels is aobut 2000–3000 pF/cm^2. In our unit of matrix panels (24×24 pixels, the pixel area is 5×5 mm^2), the line resistance is about 1 kΩ, and the capacitance for addressing one pixel is about 12,000–15,000 pF because of the cou-

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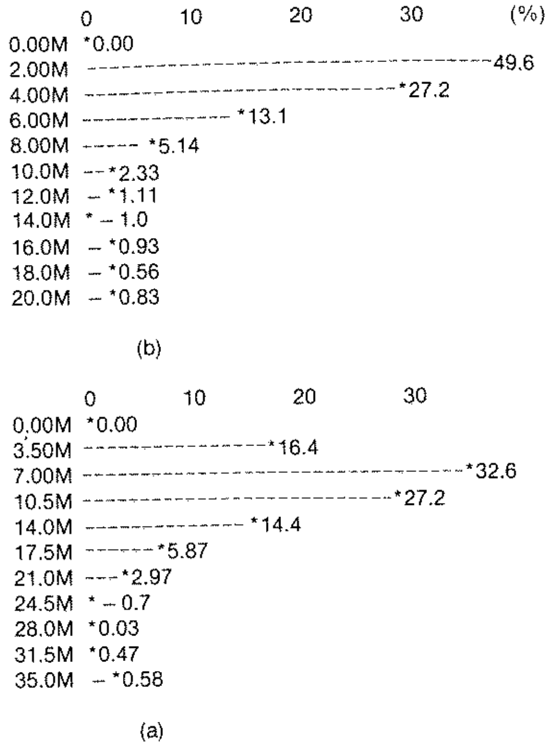

FIG. 1. Frequency distribution of DCEL phosphor particle size. (a) conventional and (b) improved.

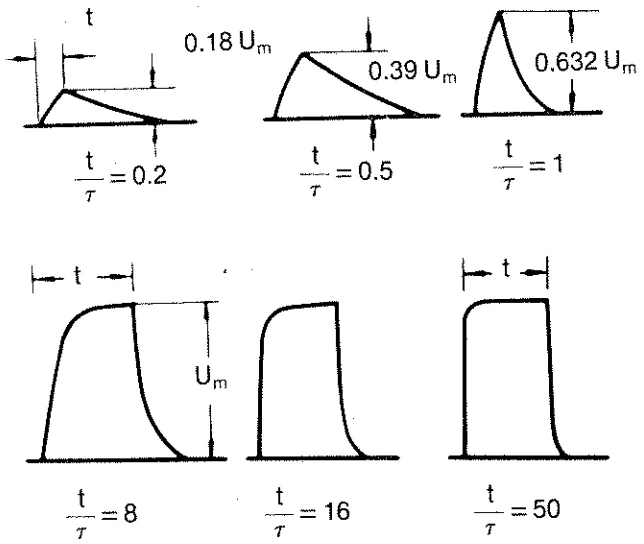

FIG. 2. Square Pulse Voltage Waveform vs t/τ.

pling capacitance of non-addressed pixels. With increasing area and the number of display pixels, the capacitance will increase, resulting in problems in the drive circuitry.

It would appear that improving the characteristics of the large-scale DCEL matrix display can be achieved by reducing the line resistance and capacitance of the matrix panel.

To reduce the capacitance of the DCEL panel, the capacitance dependence on other photoelectric and technical parameters have been studied. It appears that the capacitance of the DCEL panel depends on the voltage, the time of the formation process (Figs. 3 and 4), and the temperature of the panel. Increasing the thickness of the

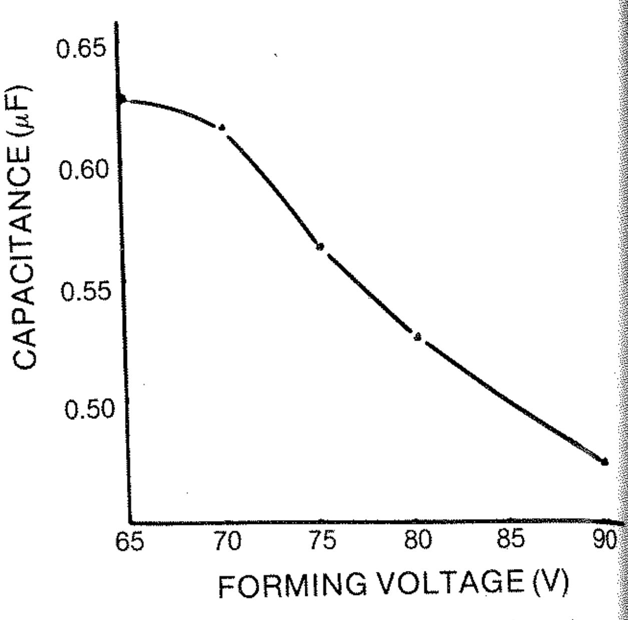

FIG. 3. Dependence of capacitance on DC forming voltage.

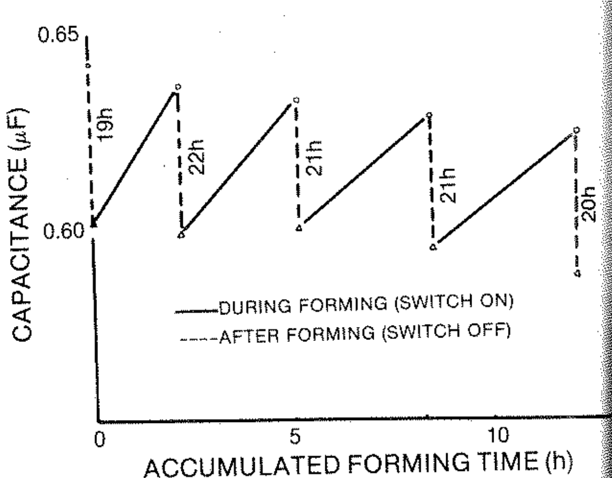

FIG. 4. Dependence of capacitance on accumulated formation ti

phosphor layer does not affect the capacitance. It app that the capacitance of the DCEL panel is mainly de mined by the thickness of the forming region in phosphor layer. The capacitance will decrease with time after formation to a stable value (Table I). Initial periments indicated that the capacitance also depends the different phosphors and their preparation. The e trical polarization mechanism of phosphors and binde which related to capacitance, is not yet known.

V. FORMING PROCESS

The pulse characteristics of DCEL matrix panels controlled by the voltage and formation time. After mation in the conventional way under 60 V, the brightn and contrast of the DCEL matrix panel under given op tion conditions are still inferior for large-area DC matrix panels. An improved formation method was tes which can increase the brightness of the large-area DC

TABLE I. Capacitance changes of the DCEL panel with time after formation.

No. \ C (μF) \ Date	Sept. 11	Sept. 13	Sept. 15	Sept. 20	Sept. 24
84 11-6-2	0.710	0.708	0.705	0.700	0.699
84 11-6-3	0.721	0.717	0.715	0.709	0.709

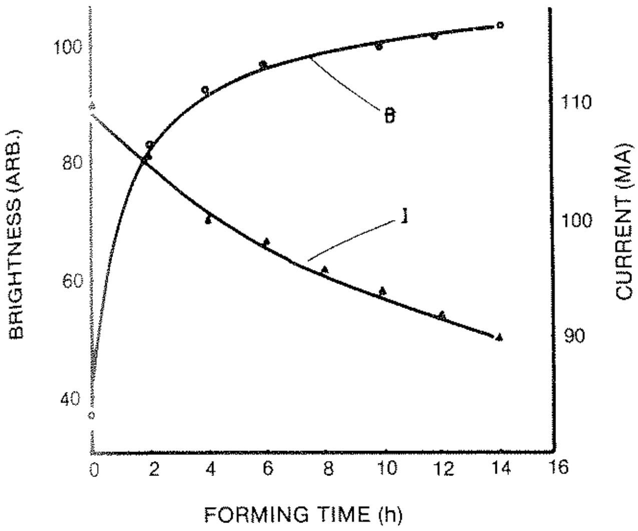

FIG. 5. Variation of brightness and current as a function of time under improved formation.

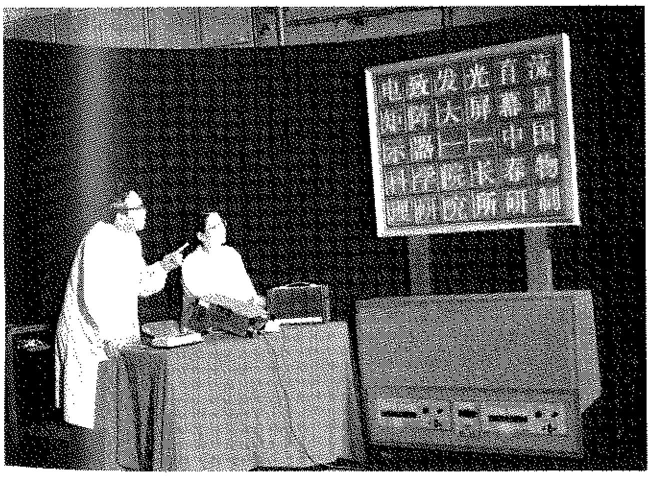

Photo 1. Large-area DCEL mosaic matrix display.

matrix panel up to several times (Fig. 5) and improve the contrast. This method is one of the keys to the success of the large-scale DCEL matrix display. The mechanism of the improved formation method has been studied.

VI. RESULTS

Our mosaic DCEL display consists of 30 units of matrix panels which are assembled side by side, arranged into 5 rows by 6 columns. Each of the 30 units can display a Chinese word, and altogether can read out 30 Chinese words (Photo 1). The area of each unit is 160×160 mm^2, including 24×24 pixels. The pixel size is 5×5 mm^2; the gaps are 0.4 mm. The total area of the display is 960×800 mm^2.

Under a pulse voltage with 110 V, 83.5 usec, and 100 Hz, the display characteristics are as follows:

Brightness: about 40 cd/mm^2
Contrast: 10:1
Power: 350 W

This type of display is convenient to watch in terms of large size and visual angle. It can be observed by several hundred people in several tens of meters, when illumination is about 100 lux.

VII. CONCLUSIONS

A large DCEL matrix display has been successfully operated. A large DCEL simulated display of 3 m^2 will be completed soon in our lab. Initial results show that the powder DCEL is promising for the large-area screen display. Further efforts in the circuit design and development of the panel and phosphors are necessary to improve the present characteristics.

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