TECHNOLOGIES FOR REDUCING POWER CONSUMPTION OF PDPS IN PIONEER

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Abstract

We have introduced fourth generation PDPs last year. The performance of these PDPs is the highest level among TV displays. At the same time the power consumption of them has reached to the lowest level among FPDs (Flat Panel Displays). High panel luminous efficacy and low address power are necessary for the reduction of total power consumption. Following technologies have been developed and applied to the fourth generation PDPs.

High panel luminous efficacy:
T-shape electrode, waffle rib structure, high Xe content gas

Low address power;
CLEAR driving method, etc.

1. Introduction

In the recent few years the device performance of plasma displays (PDPs) has been improved greatly. The image quality has reached to the level almost equal to that of CRTs and the power consumption has been improved to the lowest level among FPDs. From the start of our development in PDP, the reduction of power consumption has been one of the most important issues. We have developed and introduced several technologies for the power reduction.

2. Technology Trend in PIONEER

Our first generation PDP was introduced in the market place at 1997. This is the world first high-definition (Wide XGA) and 50-inch diagonal PDP. At that time we introduced T-shape electrode [1], which had been developed from the design of independent rectangular electrode, which was reported in 1995 [2]. We also introduced MLS (Multi Level Subfield) technology to compensate the effect of false contours by the subfield structure itself [3]. The panel efficacy was reached to 1.05 lm/W.

Our second generation PDP was introduced in the market place at 1999. At that time we introduced WAFFLE rib structure [4] and CLEAR driving method [5]. The panel efficacy was reached to 1.15 lm/W with the reduction of panel reflection by the use of black stripe. CLEAR driving method shoes false contour free moving image and reduced address power to the minimum level.

Our third generation PDPs were introduced in the market place at 2001. We introduced high Xenon (>10% Xe) gas and TCP address driver (without metal heat sink) [6]. And CLEAR driving method was improved and optimized. The panel efficacy was reached to 1.8 lm/W. Gradation on low luminance image was improved [7].

Last year we have introduced fourth generation PDPs. We have introduced ASC method (Address Sustain Complex method / a kind of high speed AWD method or a kind of improved ADS method) to improve CLEAR driving method (super CLEAR). and LVDS base high-speed data transmitting system to control address driver [8]. The panel efficacy was reached to 1.9 lm/W. Gradation on low luminance image has reached to the level equal to high image quality CRTs.

As shown above we have introduced new technologies both to improve the image quality and/or to reduce the power. Usually power reduction technology also improves the image quality.

3. Developed Technologies

3.1 Improvement of Cell Design

3.1.1 *Independent Rectangular Electrode*

Figure 1 shows the cell design using rectangular electrode and the emitting light pattern on the cell. This cell design shows high luminous efficiency caused by the increase of light emission from anode side.

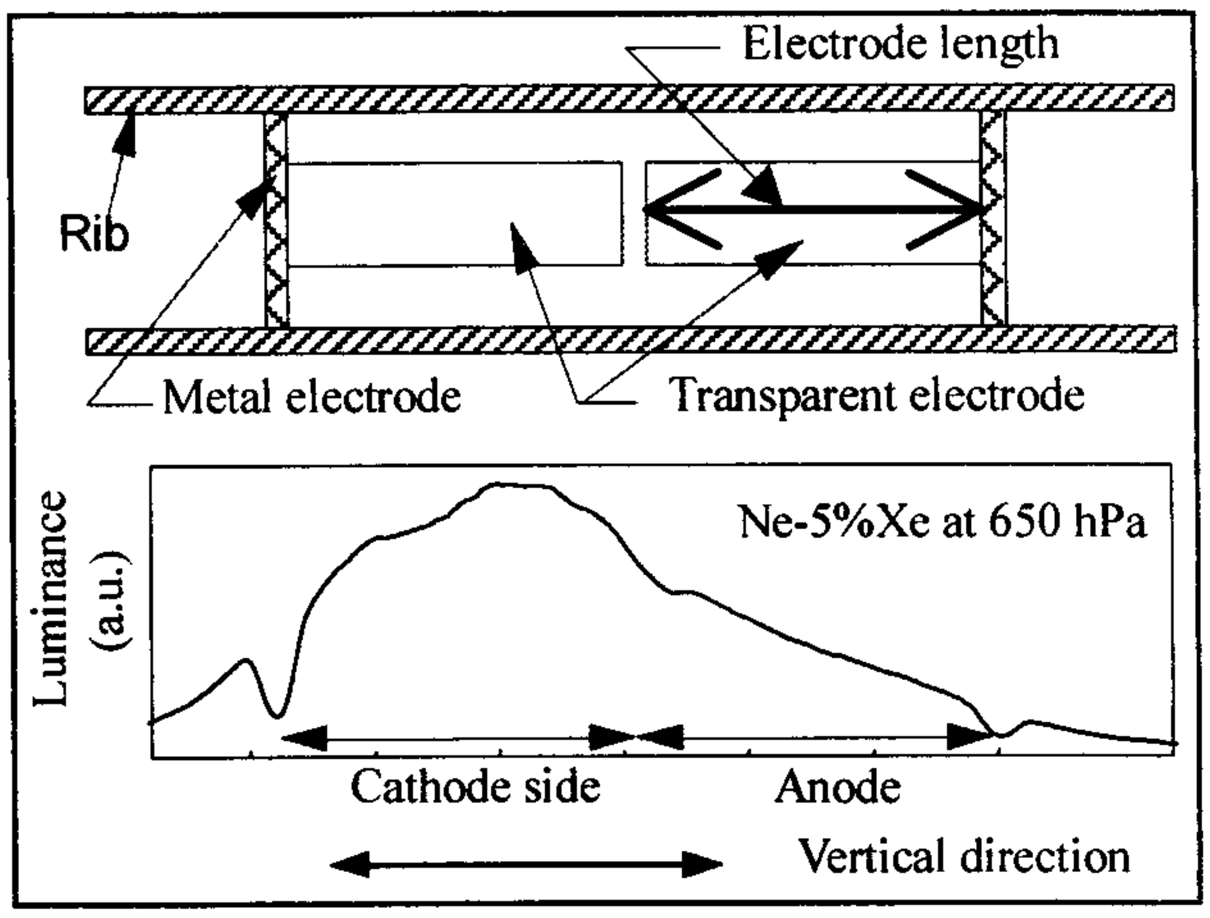


Figure 1 Dimensional luminance distribution on a pair of independent rectangular electrodes in a cell

3.1.2 *T-shape Electrode*

Figure 2 shows the cell design using T-shape electrode. T-shape electrode shows high luminous efficiency, wide driving margin and low luminance priming discharge. High luminance and high contrast were achieved.

High luminous efficiency is caused by the same reason as the rectangular electrode. Discharge on each cell is separated not only by the rib, but also by the space between neighboring electrodes. Good separation between neighboring cells increases driving margin.

T-shape electrode shows weak and stable edge-mode discharge near minimum sustain voltage as shown in Figure 3. This weak discharge was applied to priming discharges (reset and address discharges) and reduced the priming light emission (black luminance.)

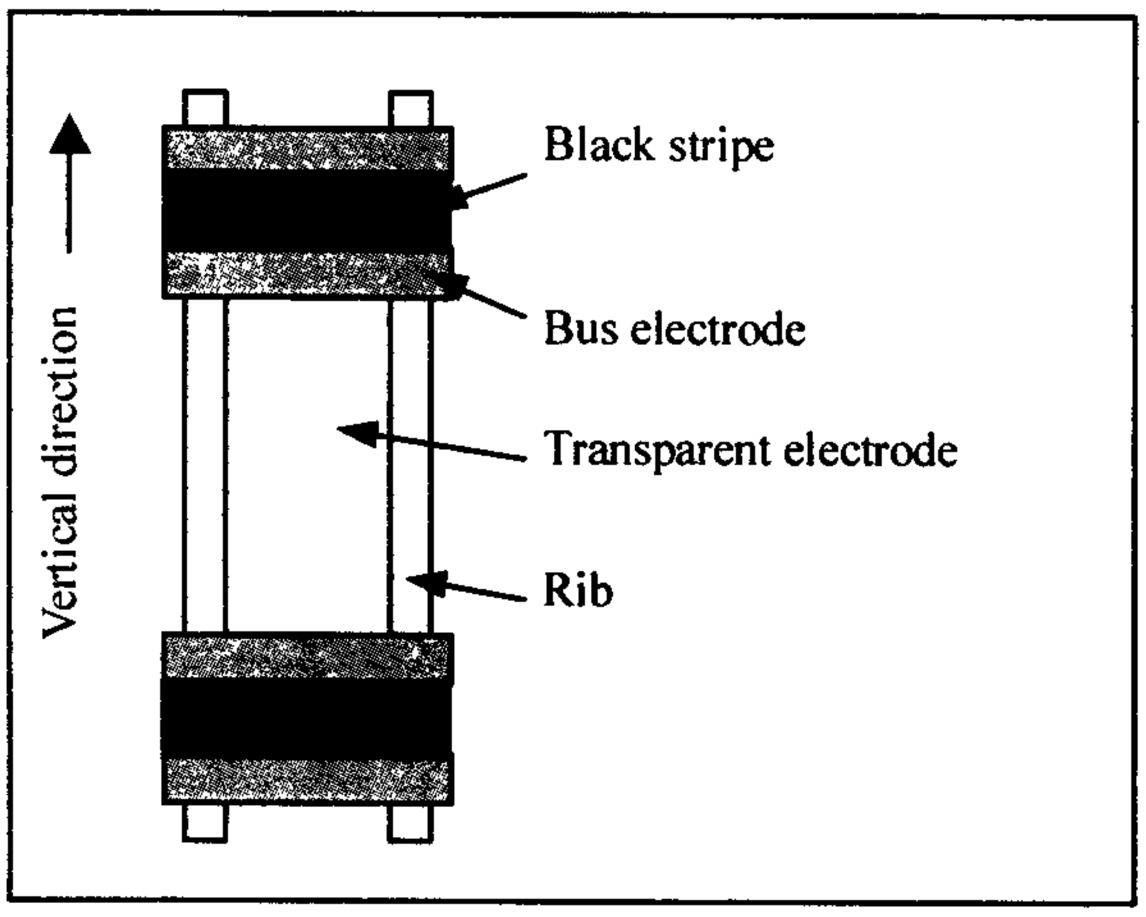


Figure 2 T-shaped electrodes

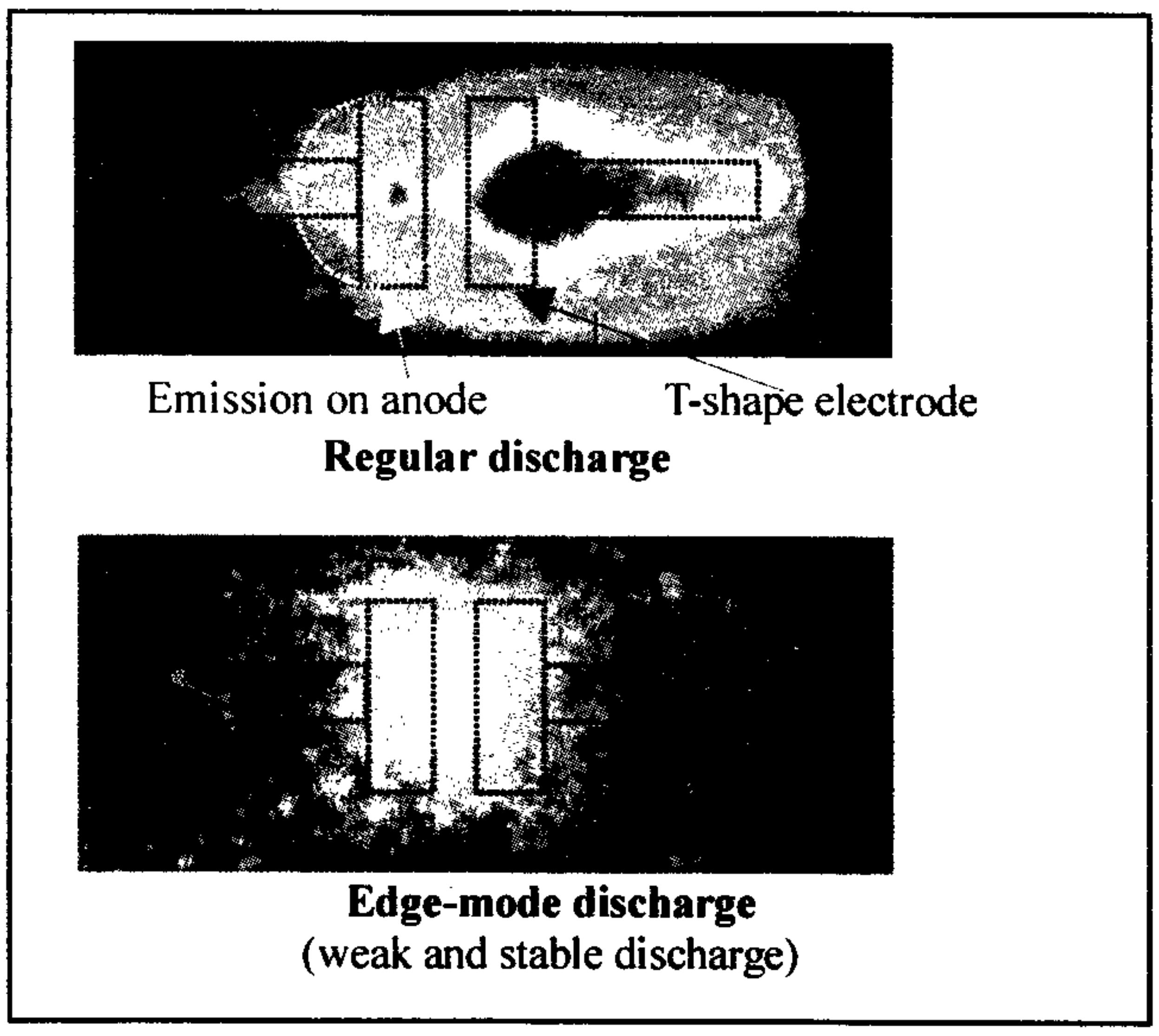


Figure 3 Regular discharge and weak edge-mode discharge on T-shape electrodes (830nm infrared image)

3.1.3 *WAFFLE Rib Structure*

Figure 4 shows the cell structure using T-shape electrode and WAFFLE rib. Figure 5 shows the SEM pictures of conventional rib and WAFFLE rib.

WFFLE rib shows following three advantages;

1) higher luminous efficiency by the increase of phosphor area on the wall of horizontal rib,

2) high bright-room contrast by black-stripe between bus electrode reducing the panel reflectance without loosing the light emission behind the black-stripe, and

3) almost no light leakage through neighboring cells

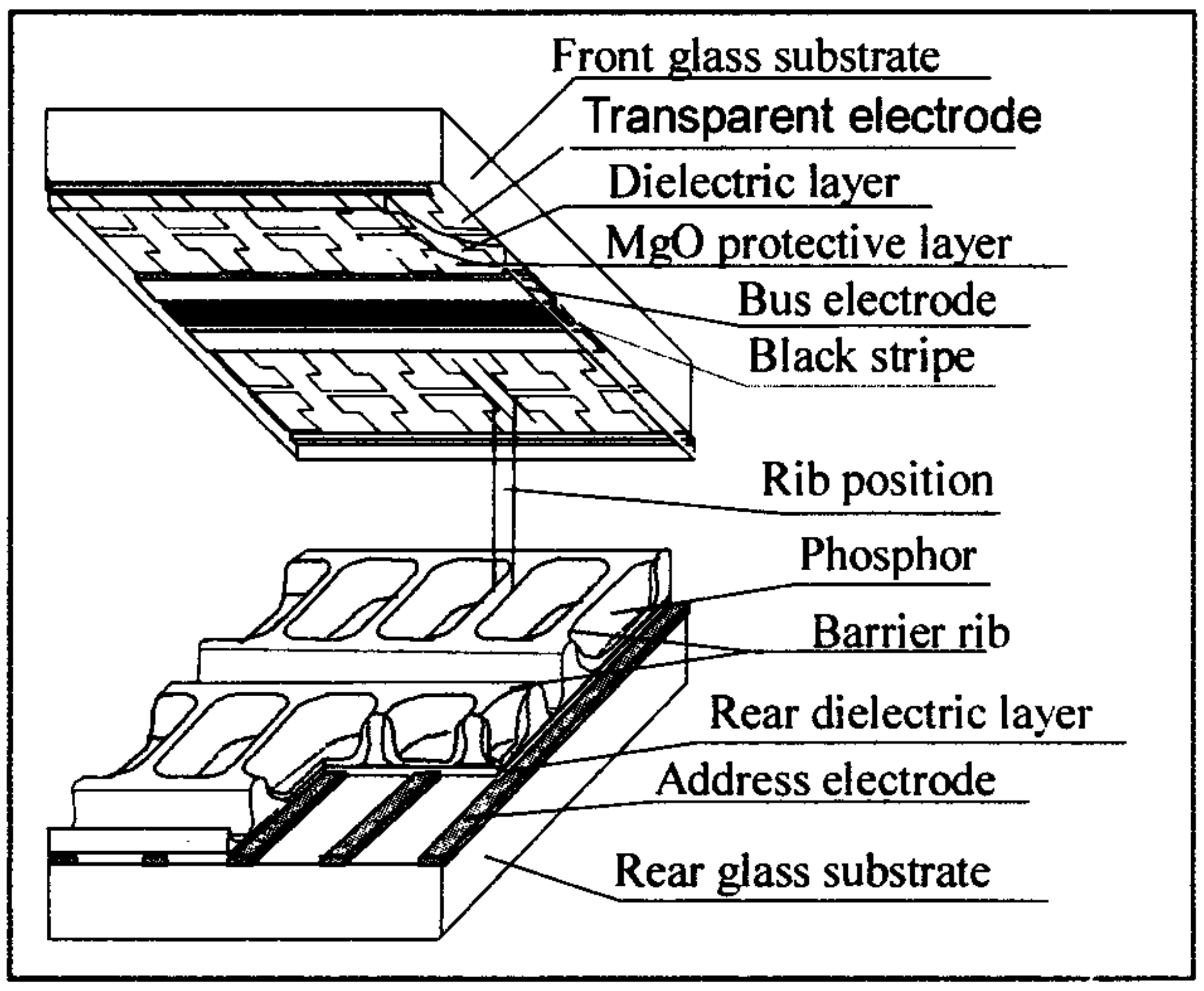


Figure 4 Cell structure using T-shape electrode and WAFFLE rib

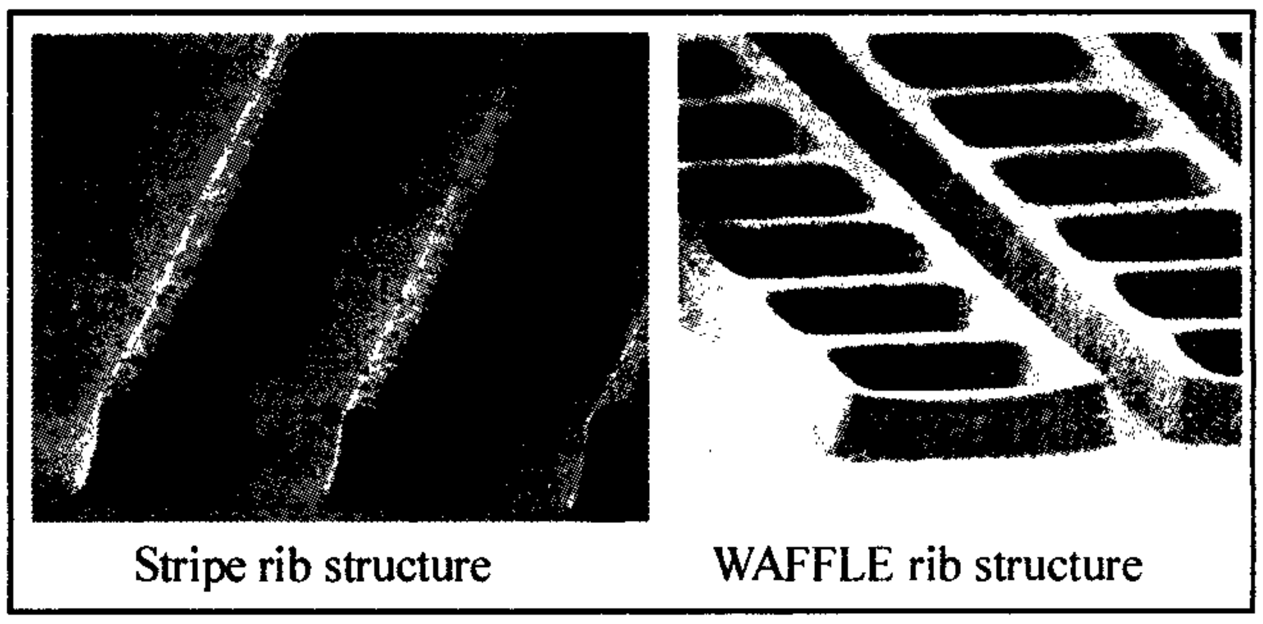


Figure 5 Difference between conventional stripe rib and WAFFLE rib

3.1.3 *High Xe Content Discharge Gas*

High Xe content discharge gas is known to be high luminous efficacy gas. Luminous efficacy increases by the increase of Xe content as shown in Figure 6, but the discharge voltages also increase as shown in Figure 7.

WFFLE rib with T-shape electrode is shown to be an optimized cell design for high Xe content discharge gas. As high Xe discharge gas increases the operating voltage and higher operating voltage increases the discharge crosstalk between neighboring cells, so good separation between neighboring cells is required for stable operation. T-shape electrode has good separation between horizontally neighboring cells and WAFFLE rib has good separation between vertically neighboring cells.

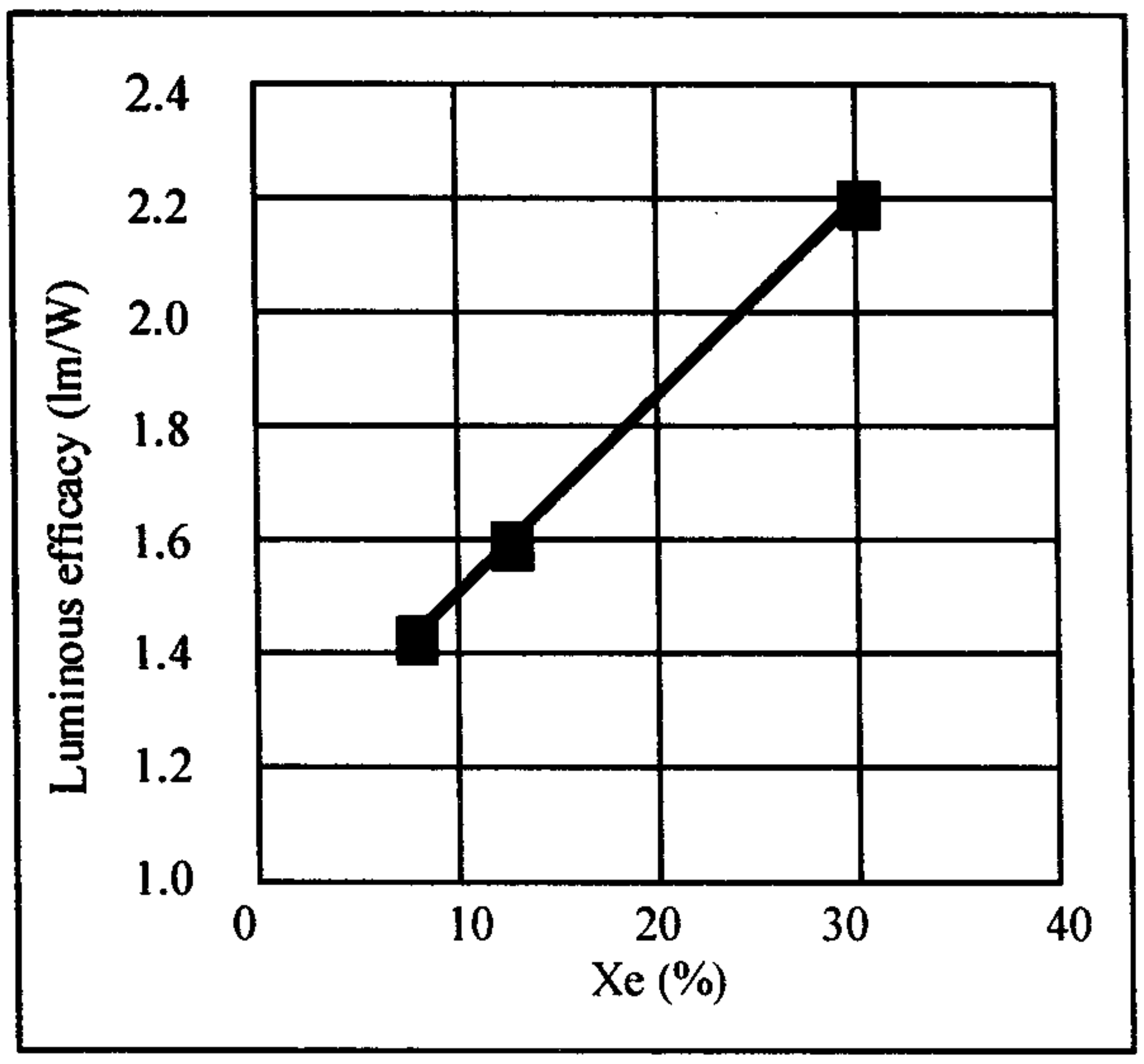


Figure 6 Relation between Xe content and luminous efficacy

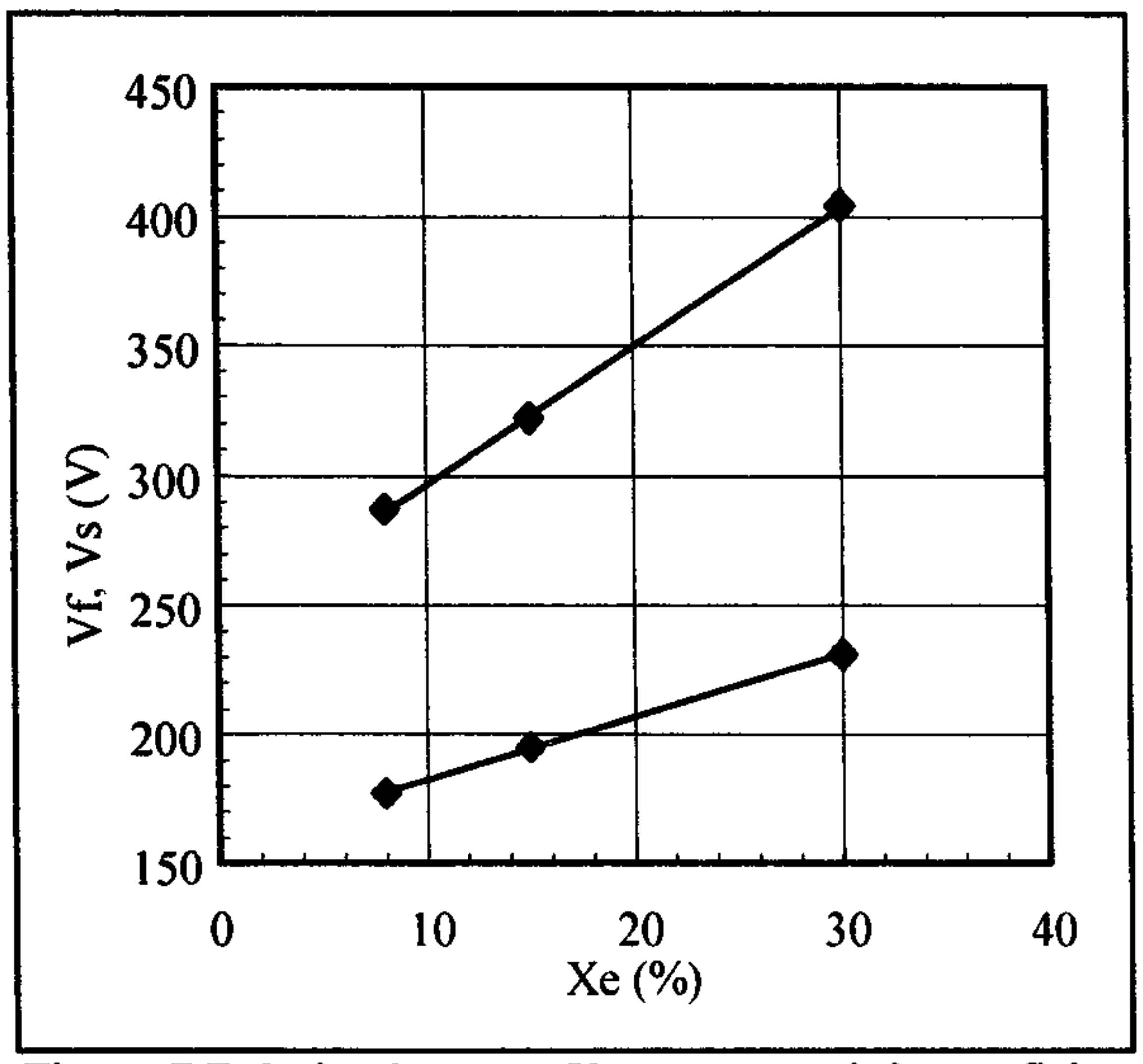


Figure 7 Relation between Xe content, minimum firing voltage Vf and minimum sustain voltage Vs

3.1.4 *Panel Performance*

By using these technologies, the panel luminous efficacy has reached to 1.9 lm/W at our fourth generation PDPs. Based on the high luminous efficacy, panel luminance has reached to 1000 cd/m^2 and the power consumption has reached to the lowest level among FPDs. The progress of panel performance and the applied technologies for the reduction of power are listed in Table 1. Table 2 shows the dimensions of panels.

Table 1 Performance of third generation PDPs

	1st generation (501HD)	**2nd generation (502HD)**	**3rd generation (503HD)**	**4th generation (504HD)**
Panel peak luminance	350 cd/m^2	560 cd/m^2	900 cd/m^2	1100 cd/m^2
Darkroom contrast ratio	220:1	560:1	900:1	1000:1
Luminous efficacy	1.0 lm/W	1.15 lm/W	1.8 lm/W	1.9 lm/W
Power consumption (HD-TV set)	495 W	470 W	380 W	380 W
Average Power (on-air TV)	----	---	80%	70%
Technologies applied for the reduction of power	T	T, WAFFLE & CLEAR	T, WAFFLE, High Xe & CLEAR	T, WAFFLE, High Xe & CLEAR
When	1997	1999	2001	2003
Panel size	50-in.	50-in.	50-in. & 43-in.	50-in. & 43-in.

Table 2 Panel dimension

	50	43
Screen size	50-in. diagonal	43-in. diagonal
Screen area (Horizontal x Vertical)	1098.2 mm x 620.5 mm	952.3 mm x 536.1 mm
Aspect ratio	16:9	16:9
Addressability (Number of Pixels)	1280 x 768	1024 x 768
Pixel Pitch (Horizontal x Vertical)	0.858 x 0.808 mm	0.930 x 0.698 mm

3.2 Improvement of Driving Method

From the start of our development, our goal has been high image quality. So dynamic false contour was one of the most important issues.

At first, we tried to compensate false contours by compensation signal (reported at 1997), but this method needed very large electronics for video processing. Then we developed MLS (Multi Level Subfield) technology and applied it to our first generation PDPs. Figure 8 shows the subfield structure of MLS. In this method, the subfield structure is reversed in time with each neighboring lines (Odd lines have a reverse subfield structure of even lines), and compensate false contour of each neighboring lines together. MLS method reduced false contours, but this method was not good at luminance and power consumption.

Then we developed CLEAR driving method.

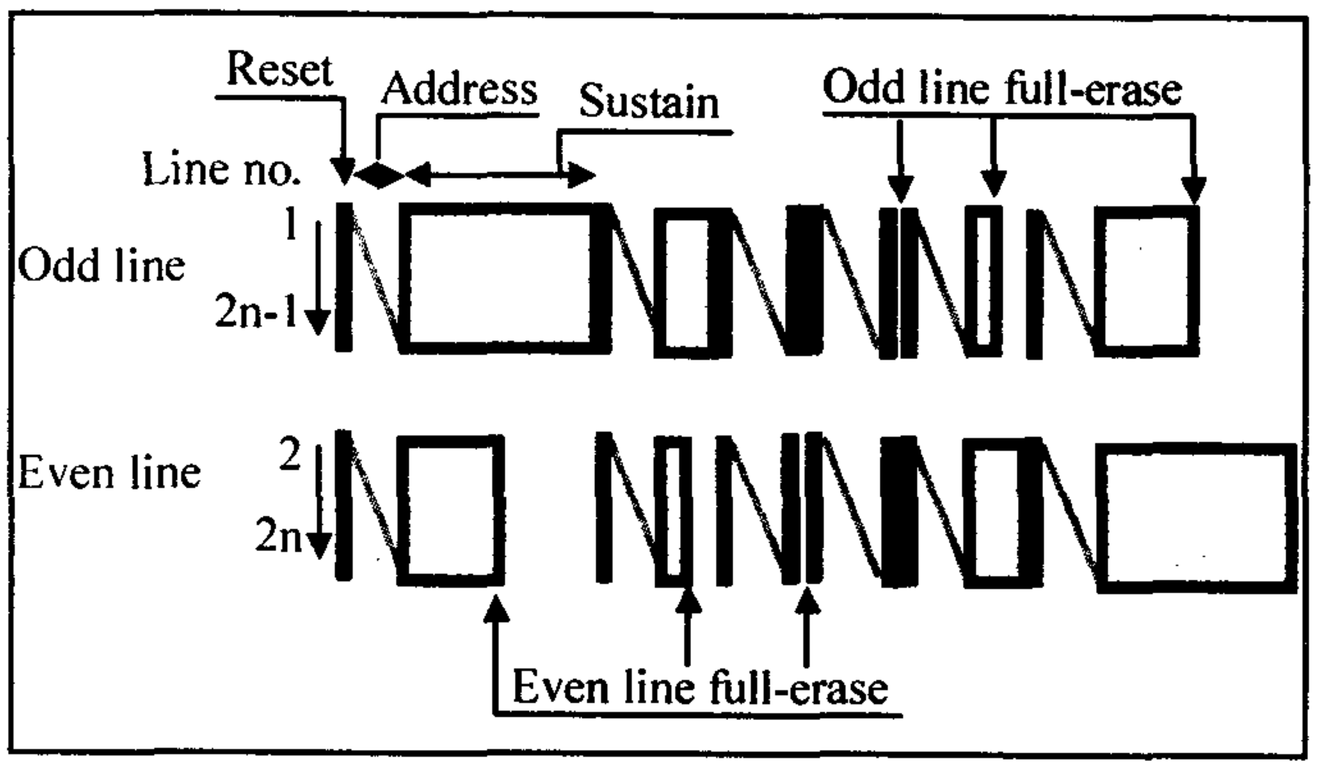


Figure 8 Subfield structure of Multi Level Subfield (MLS)

3.2.1 *CLEAR Driving Method*

CLEAR has a unique subfield structure and uses only one addressing in each line within a TV field as shown in Figure 9. Moving image is free from dynamic false contours and gradation on low luminance image has improved greatly by the subfield structure.

It also has reduced addressing power by the use of only one addressing within a field and reduced the total power consumption to the lowest level among FPDs. As shown in Figure 10, the reduction of address power allows small address drivers without metal heat sink

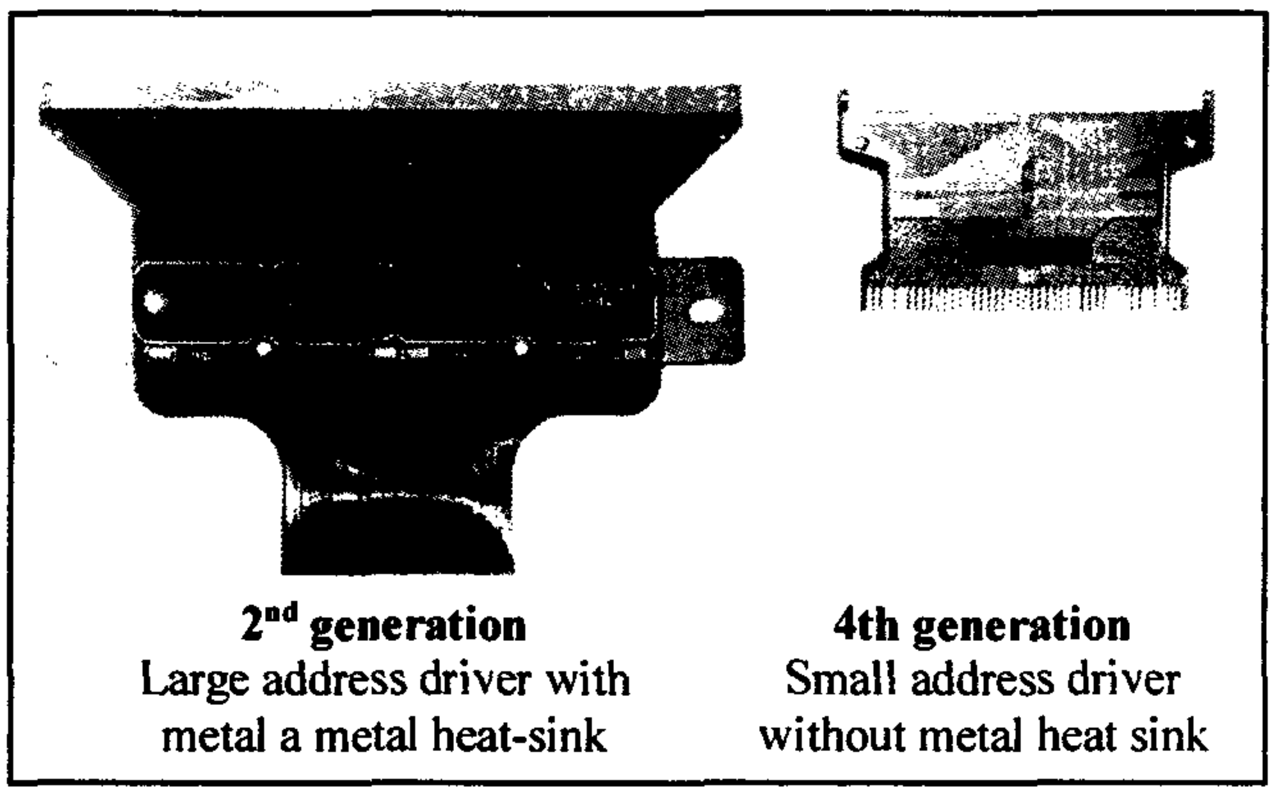


Figure 10 Address drivers of 4th and 2nd generation PDPs
Low power addressing of CLEAR driving method has reduced the heat of address driver.

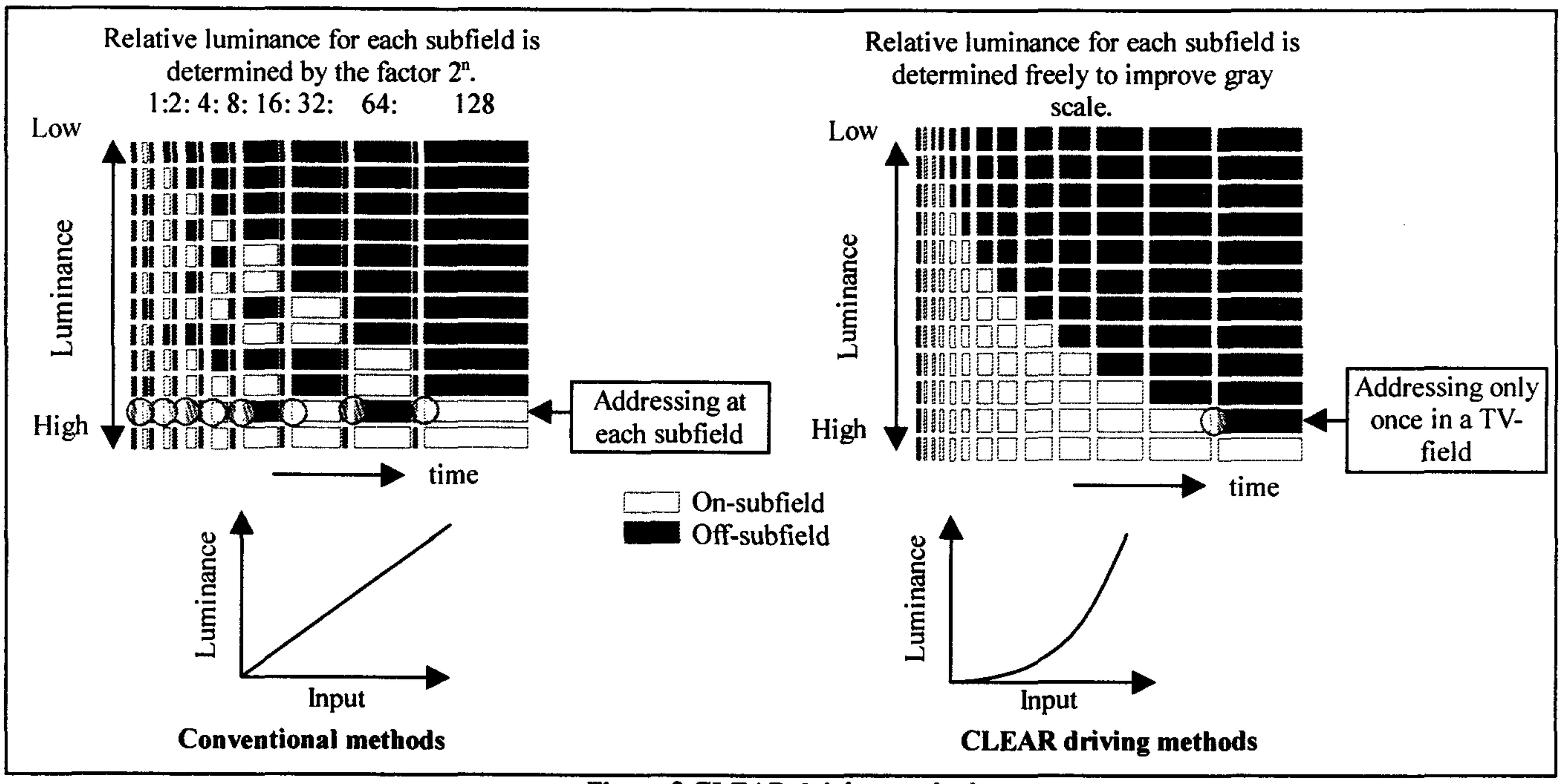


Figure 9 CLEAR driving method

In conventional method, light strength of each pixel is determined by a selection of the On-subfields and the On-subfields are dispersed. Dispersed On-subfields arrangement causes dynamic false contour. In CLEAR method, light strength of each pixel is determined by the time when the pixel is erased and the On-subfields are arranged continuous. Continuous On-subfield arrangement is free from dynamic false contour.

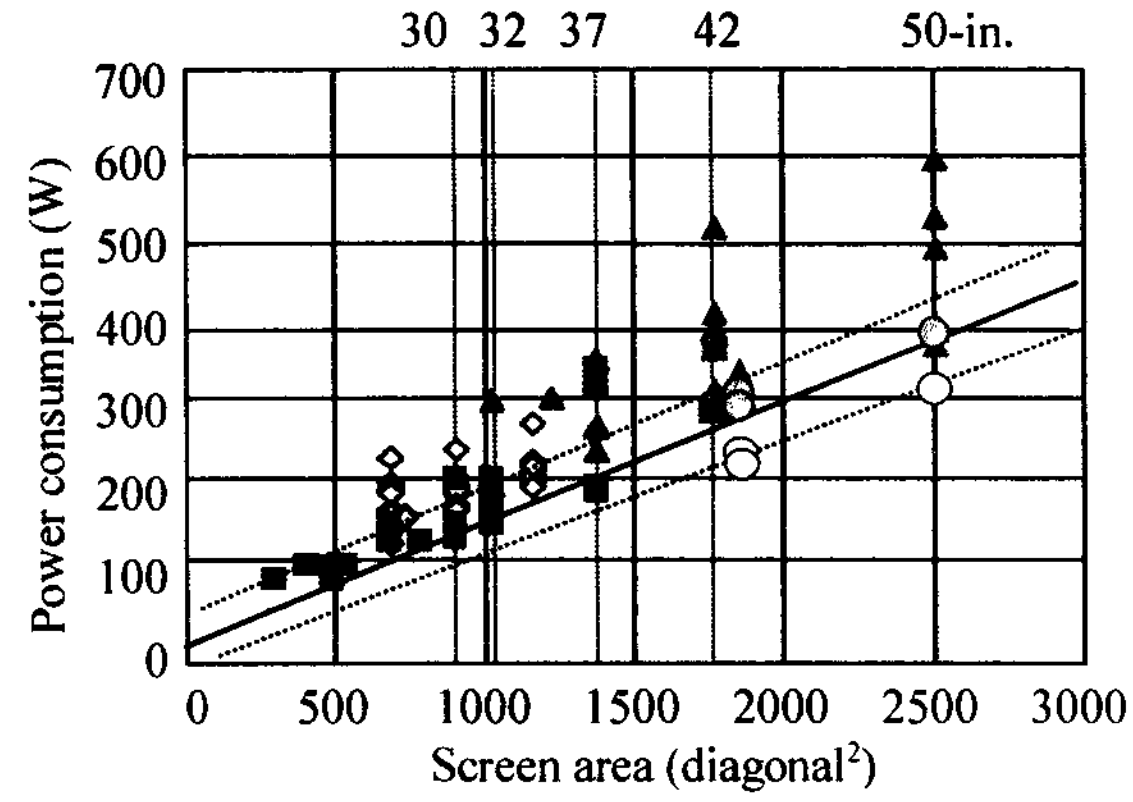
As addressing power is related to the number of the addressing, so the addressing power is reduced much by the use of CLEAR.

4. Power Consumption of PDP TV

Figure 11 shows the power consumption of CRT, LCD and PDP TVs. (Here CRT TVs are HD-models.) The solid line is the lowest level among them and the line means also the lowest of FPDs.

1) Power consumption of TVs is related to the screen area. Larger screen TVs are larger power consumption.
2) The power consumption of LCD-TVs is a little smaller than that of CRT TVs.
3) The power consumption of fourth generation PDP TVs is on the line of the lowest level, while that of other PDP TVs is larger than that of LCD-TVs.

In Figure 11, the average power consumption of fourth-generation PDP TVs is also plotted. The power consumption of LCD-TVs is almost not changed by the displaying image, for the reason that panel-driving power is small and almost all the power is used by constantly lighting backlights. But the power consumption of PDP TVs is changed by the displaying image as shown in Figure 12. It is shown that the actual power consumption of fourth-generation PDP TVs is lower than that of LCD-TVs, and the lowest among FPDs



(TVs larger than 30-in. are including digital HD tuner.)

Figure 11 Power consumptions of CRT, LCD and PDP

5. Summary

From the start of our development in PDP technology, the reduction of power consumption has been one of the most important issues. High panel luminous efficacy and low address power are necessary for the reduction of total power consumption. We have developed and introduced several technologies for the power reduction as follows:

High panel luminous efficacy;
T-shape electrode, WAFFLE rib structure, high Xe content gas and

Low address power;
CLEAR driving method.

By these technologies the power consumption of our fourth-generation PDPs is the lowest among FPDs. At the same time, the image quality of them has been improved to the top level among TV displays. These technologies also play the main role in the improvement of Image quality.

We will continue to develop and improve technologies for the reduction of power consumption of PDPs to realize extra low power large area PDP TVs in near future.

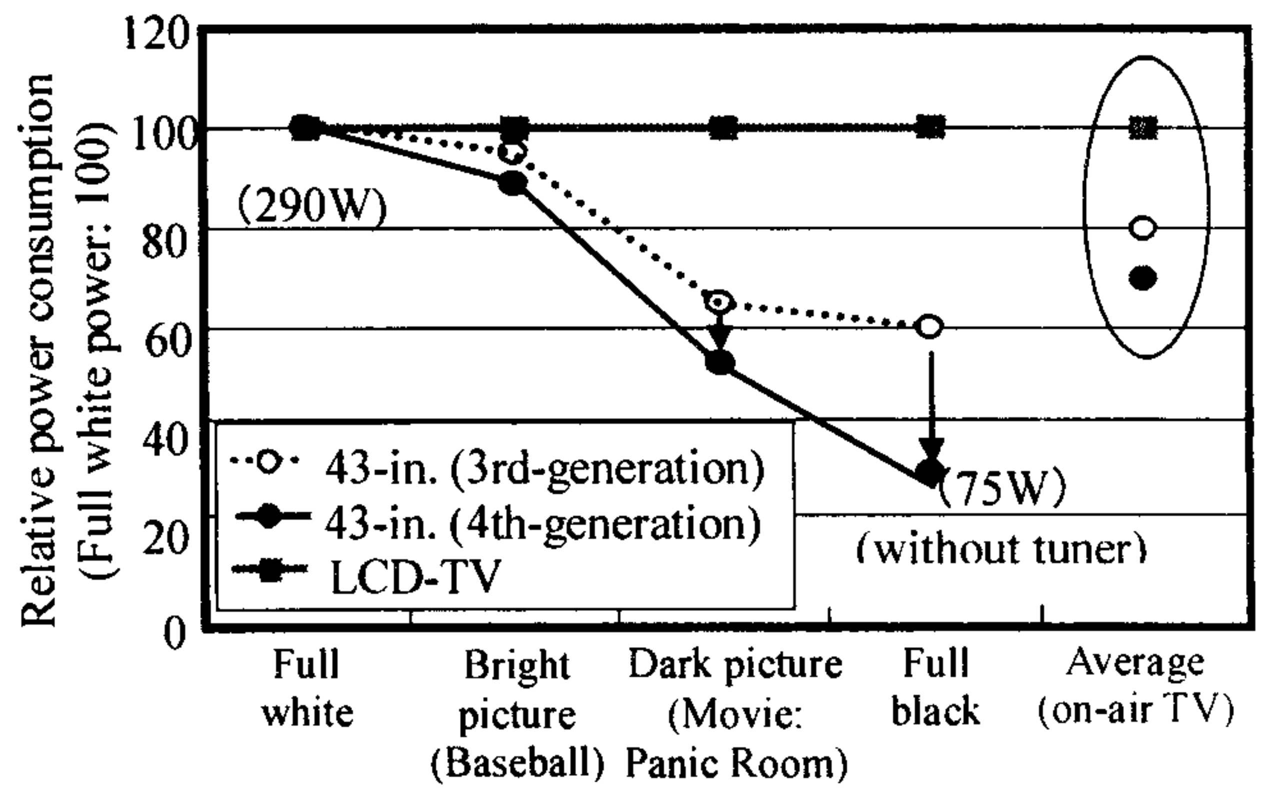


Figure 12 Reproducing image and power consumption

6. References

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