Possibility of New PDP for less cost and less power

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Abstract: *Recently a surface discharge 3 electrode PDP seems to be a standard structure for us. But we should discuss whether we could achieve less cost and less power PDP with this current standard structure even in the future. Some trials for new PDP have been made continuously in Japan, China, Korea and some places in the world. These challengeable efforts will be focused and discussed here.*

1. Introduction

Since 1980's when the first color PDP television sets were put on the market, PDP and LCD has established firm positions in our daily life. A role of CRT seems to have been finished. The features of PDP and LCD, which are thin, flat, and light, have been welcomed by a market. On the other hand, the cost and power consumption of LCD and PDP are still much higher than CRT. Lower cost and lower power consumption is our eternal target, since market demand is avaricious.

2. New Structures for Lower cost

Market price of PDP is reducing 10~20% every year. At the same time, some of PDP suppliers in Japan, Taiwan and Korea have been dropped off from the survival game. It is obvious that the speed of price reduction has exceeded the speed of cost reduction.

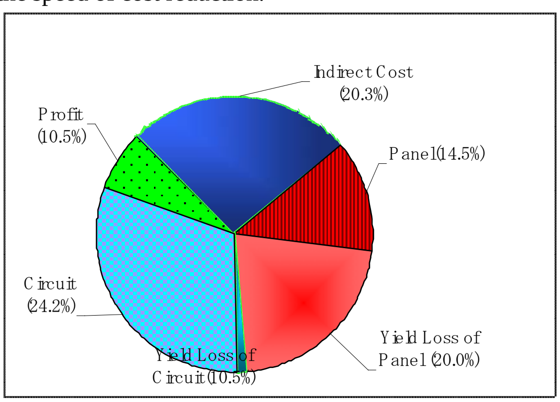


Figure 1. Cost Segmentation of 50" HD-PDP Module ('06)

Figure 1 shows a segmentation of PDP module cost. The cost of driving electronics is twice of panel costs. But since the yield loss of a panel is much higher than that of electronics, the total costs are reversed. In addition to the parts cost, the investments of production line for panels are 10 to 50 times more than for electronics. These facts tell us that it is important to improve productivity of a panel.

Some of PDP manufacturers are going to take more substrates from a single sheet glass. But such multi substrates process requires larger size of equipments and increases investment costs. As a result, it obstructs new entrants and PDP manufacturing is concentrated to limited number of giant companies. In general, this may be not an ideal situation for the PDP business in the future.

It seems that the 3 electrode surface discharge structure is standard and no chance for other new structures. Reducing steps of production processes, co-firing some printed layers has been done, and 2, 4, or 6 substrates of 42 or 50 inch are becoming taken from a single sheet glass, but the structure is still the same as previous.

In order to reduce the total PDP cost, improving productivity of a panel is necessary. There are some challengeable works for this purpose with novel structures. Two different streams for development may exist so far. One is to develop new method for rib formation, and the other may be a trial to remove thin film process from the processes of ITO electrodes and MgO layers.

1) Trials for Rib

Etched metal sheet, like a shadow mask, are tried to be used as a rib. Figure 2 shows a pixel structure using a metal mesh for rib as well as a sustain electrode. [1] The mesh made of Fe/Ni alloy is covered by a glass paste as dielectrics.

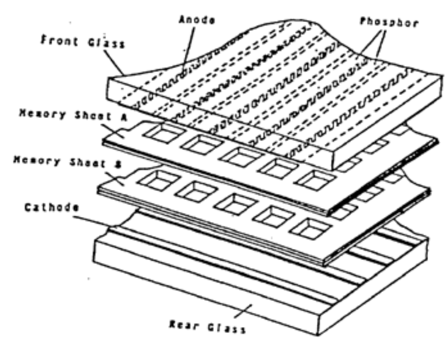
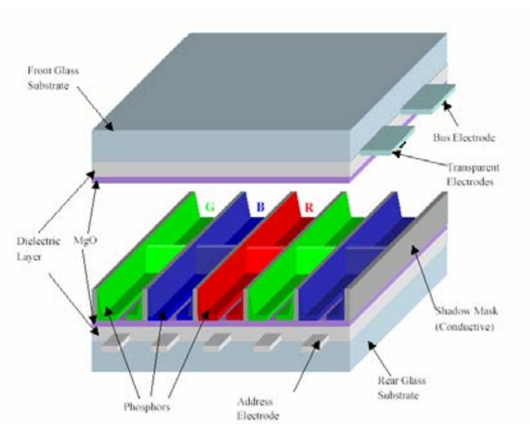


Figure 2. Metal mesh for Rib/Electrode (Euro Display'03, TT&T Corp. JP)

There are a couple of variations of panel structure using a glass covered metal mesh. One is shown in Figure 2. This panel is operated as 4 electrodes. A pair of metal sheets works as sustain electrodes. Each pixel is addressed by DC electrodes of XY matrix. Purpose of this structure is separating ribs from substrates to make processes simple. 4-electrode structure can also make the driving scheme simple. Perhaps the biggest disadvantage or issue of this structure may be a big capacitance between meshes. The other issues may be a less phosphor area, etc. Coating dielectrics on metal mesh is also not easy.

The next approach using metal mesh is shown Figure 3. [2] A metal mesh is used as a rib without coating dielectrics. Actual TV images are shown with this structure. Phosphors are coated on the wall of a metal mesh. This will be able to simplify the production process. Their first trial (2003) was made with 3-electrode structure, and next trial (2005) was made with 2-electrodes [3]. Separation of phosphor area from electrodes allowed 2-electrode structure. Disadvantages or issues to be solved may be the same with the previous trial. Handling of mesh should be careful, because opening of holes on the mesh for PDP is much larger than a shadow mask for CRT. Thermal expansion may be also an issue. But such approach is one of hopes for future.



(SID '03)

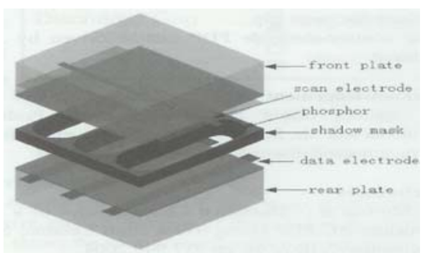


Figure 3. Shadow Mask PDP
(SID'05, South East Univ., Nanjin, CH)

Another novel trial using a ceramic mesh which has electrodes inside of a mesh is shown in Figure 4. [4] A ceramic mesh which includes scan and sustain electrode inside is separately formed. Phosphors are screen printed on a front panel as well as on a rear substrate. Gas discharge occurs wall to wall instead of co-planer discharge. Longer gap discharge is possible with this structure. Making a large and precise mesh may be difficult.

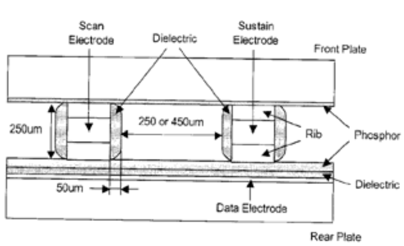


Figure 4. Ceramic Sheet with Electrode
(SID'05 Noritake, Nagoya, JP)

A couple of trials of using a direct grooved sheet glass were announced so far. The photograph on Figure 5 shows a grooved glass by sand blasting. [5] It can be also made by chemical etching. The shape of a groove by sandblasting shows V shape. It will be the best shape for transparent type PDP which makes production process easier, if we could develop good methods to groove a sheet glass, and to put thin phosphor layers on the wall.

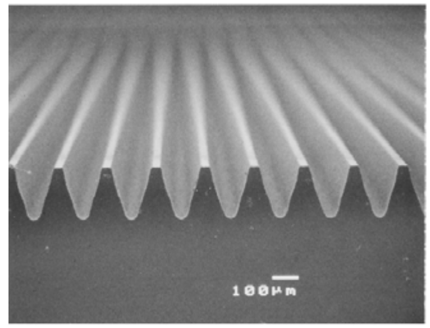


Figure 5. Grooved sheet glass for rib
(METI Japan 2006, TT&T.et al, JP)

2) Trials for exodus from Thin film process

Thin film processes for ITO and MgO require big investments for equipments and for clean rooms as well. If we could use thick film processes, like screen printing or sandblasting instead of thin film processes, we can save a big investment cost. Using ladder mesh electrodes for front electrode replacing ITO by screen printed silver was made, but still ITO is a popular process for it. Trials for MgO printing were not successful in the past.

Next trial may be one of the best solutions to make a sustain electrode without MgO. The electrode is made of a conductive cathode material instead of MgO layer.[6] We can select a material from a wide variety of cathode materials, such as Ni, Ba, LaB6, and other screen printable cathode materials. The fundamental structure is shown in Figure 6. The island shape electrode is capacitive coupled with the bus electrode under the dielectric layer. If we use this structure for transparent type PDP instead of reflecting type like a standard PDP, we can make a whole process with thick films. A thick film process requires less grade of a clean room. For instance, Ni paste can be screened in a 10,000 class clean room. It is also possible to fabricate sustain substrates in a separated process regardless front or rear. It means outside vendors can supply those substrates to PDP manufacturers. The result of this work will be published in the near future.

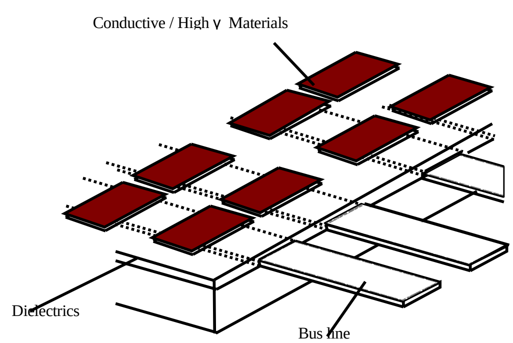


Figure 6. Isolated Conductive Electrode instead of MgO (METI Japan 2006, TT&T.et al, JP)

3. New Structures for Lower power

In these couple of years, total power of PDP TV sets was gradually going down. But such power reduction was performed by material selection, improvement of power saving circuits, increase of phosphor area, and so forth, while no changes on fundamental panel structure. Current efficacy of a PDP panel may be 1.5~2.0 Lm/w, and our goal is 5.0 Lm/w to achieve the total power of 100w for a 50" television set

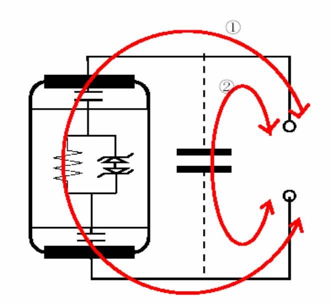


Figure 7. Equivalent circuit of AC PDP

Figure 7 shows an equivalent circuit of a pixel. A current flow①which is a discharge current is consumed in a pixel. A current flow②which is caused by a stray capacitance between electrodes is used to be a big loss of power, but the energy recovery concept [7] solved the problem. Remaining issue is how to reduce the power consumption of a current flow①.

PDP is working based on a gas discharge phenomenon like fluorescent lamps. But the efficacy of PDP is still lower than 2 Lm/w, although 60~80Lm/w for fluorescent lamps.

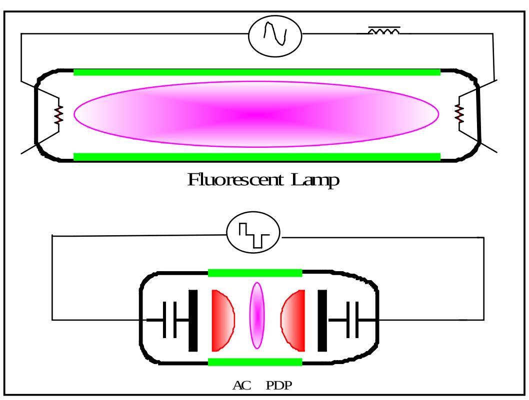


Figure 8. Difference between FL and PDP

We can find some basic differences between FL and PDP, shown below.

	FL	PDP
Gas	Hg	Ne/Xe
UV length	Long	Short
UV source	Positive Column	Negative Glow
Pressure	< 1.0Torr	400Torr
Discharge Gap	< 1 mm	100mm<
Cathode	Hot	Cold
Voltage	High	Low
Current density	Low	High
Frequency	High	Low

If we could use Hg as a dominant discharge gas, we can use the same phosphor with FL, but it may not be possible because of lower vapor pressure of Hg. We need higher gas pressure for a smaller pixel size of PDP. The biggest difference is a cathode. A cathode of FL is a hot cathode, so called as a filament, which emits electrons. PDP uses a cold cathode, which requires ion bombardment on a cathode surface to extract secondary electrons from a cathode. It causes a big voltage gap, so called as a cathode fall, to make a big electric field in front of a cathode. Most of power losses of gas discharge are generated in this cathode fall. Perhaps we cannot apply a hot cathode as an electrode of PDP, but we will be able to find high gamma materials. If we could replace MgO by a different high gamma material for an electrode, power loss in a cathode fall could be reduced. Positive column can generate more UV than negative glow, because of higher energy of plasma in the positive region. To get high energy plasma, higher voltage is necessary. We should select optimized parameters considering some conditions, like driving conditions, pixel sizes, gas, etc. Length of discharge gap is important to get a positive column, because the gap should be longer than a total thickness of negative glow and Faraday dark. It is said minimum 0.3mm of length is necessary for it under a condition of 400 torr of Ne/Xe gas mixture.

Trials of using a positive column for UV source were made even for DC PDP. [8] [9]

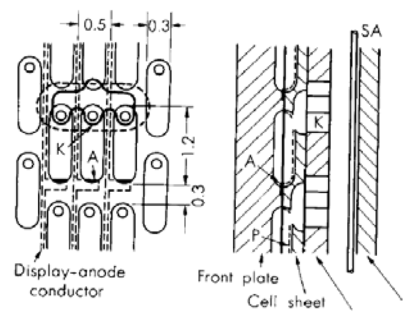


Figure 9. Positive column pixel of DC PDP (NHK Tech.Report 1977, Tokyo, JP)

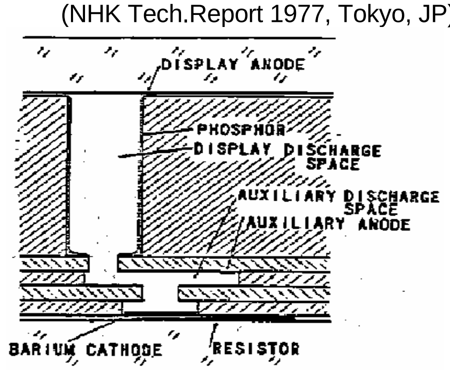


Figure 10. Vertical Positive column pixel of DC PDP (SID'86 Hitachi, Tokyo, JP)

Figure 9 and Figure 10 show pixel structures of works by NHK and Hitachi respectively. A couple of trials for positive column discharge were made with DCPDP in the past. These two trials applied 1.0~1.5mm gap in horizontal or vertical. Since DCPDP has big loss at a current limiting resistor, efficacy is not so high in general.

Recently a lot of trials for long gap discharge were made with AC PDP. [10] [11] [12]

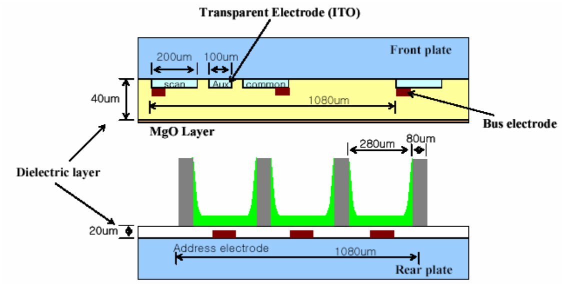


Figure 11. Longer gap with auxiliary electrode (IDW2005, Sejong Univ./KAIST, KR)

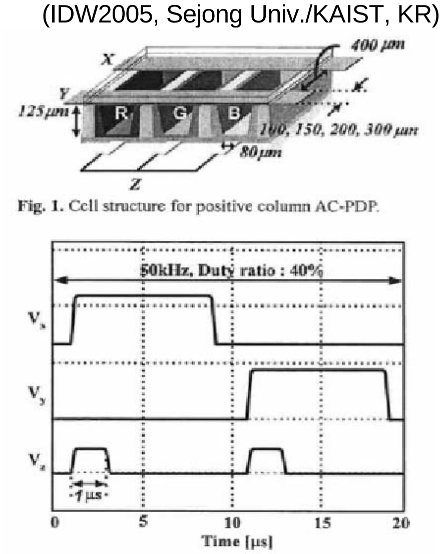


Figure 12. Longer gap with auxiliary pulse (IDW2003, Kyungpook National Univ., KR)

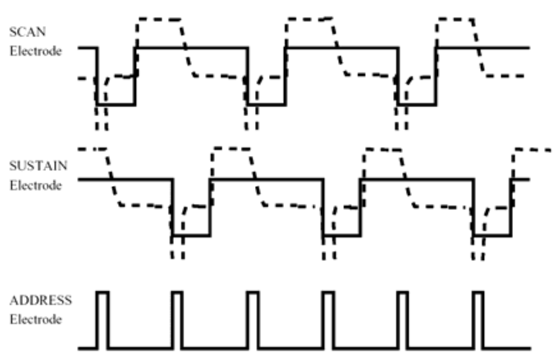


Figure 13. Trigger pulse applied to Address electrode during sustain (J Patent 3479900B, TT&T Corp., JP)

Higher voltage is necessary for long gap discharge. At the same time, there is a limitation of driving voltage for driver ICs. We should optimize parameters, such as a structure and dimensions of a pixel, mixture and pressure of gas, and driving schemes. Most of trials were made to make driving voltage lower. Some of studies are focused on electrode structures with an auxiliary electrode. Figure 11 shows one of those trials. The auxiliary electrode, which is placed between a scan and a sustain electrode, works as a trigger electrode. Figure 12 shows another trial to start discharge in a long gap. The structure is the same with a standard 3-electrode PDP. Trigger pulses are applied to address electrodes during sustain. The trigger pulse should be small not to prevent sustain discharge, not to result phosphor damage by ion bombardment. A lot of papers have been published with the same works. This driving scheme of trigger pulses during sustain has been patented to TT&T Corporation, shown in Figure 13. [12]

4. Conclusion

Lower cost and lower power consumption may be our eternal targets. The cost of electronics parts is higher than that of a panel. Although the cost of electronics parts is highly depending on production volume, the cost of a panel is not so simple, because of big investments required to increase production capacity. Continuous efforts to develop new PDP structure and process must be necessary.

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