Electrical discharge as an inspection method for
Imperfect Plasma Display Cells

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Abstract

The plasma display panel is a self-emitting gas discharge operated device. In this paper, the atmospheric pressure helium discharges were used to inspect the defects of PDP cells related to dielectric covered electrodes. Experiments were made to repair the identified imperfect discharge cells through designated optimized methods such as refilling with transparent dielectric glass to make a monolithic dielectric for flawless PDP operation.

Keywords: open line defect, dielectric puncture, gas discharge,

1. Introduction:

With the introduction of digital broadcast, the high definition (HD) large display devices are finding increasing popularity to display HD signal using 16:9 display format together with high resolution. The traditional CRT TVs with VGA resolution will no longer be a display option. The large format plasma display panel (PDP) [1] and LCD TVs will gain majority share in the market slowly. PDPs in particular have ability to reproduce the better natural hues making it an easy choice among other similar flat panel options. Besides the manufacturing unit requires three times lesser investment in comparison to LCD making it easier choice for new ventures. Since the price of the product is experiencing a global down trend, among the other cost effective approaches the improvement in the production yield plays a significant role.

A PDP consists of large matrix of micron-size dielectric barrier discharge (DBD) [2, 3] cells that define the TV resolution. The fabrications of the PDPs employ an amalgamated approach using both classical and modern electro-ceramic processing steps.

The conventional PDP discharge cell [1] structure formed on front and back glass plates is shown in figure 1. The front plate consists of coplanar arrangement of sustain and scan display electrodes. These display electrodes are made of transparent Indium-Tin-Oxide (ITO) material over which thin silver bus lines are provided for increasing electrode conductance. The electrodes are masked with 30-40 micron thick transparent dielectric (TD) layer for limiting the discharge current in high-pressure (300-500 Torr) discharge operation. The TD layer also protects the bus electrode sputtering by ion...
bombardment. A thin layer of Magnesium oxide (MgO) is provided over the TD layer for secondary electron emission. The back plate fabrication starts with the fabrication of the address electrodes followed by white reflecting dielectric glass covering, barrier ribs formation defining pixel-sub pixel and deposition of phosphors in the designated places. The front and the back glass plates are then sealed and the resulting panel then evacuated at 380C temperature to facilitate the degassing of the adsorbed gaseous impurities from the inner surfaces followed by filling of plasma gas (Ne + 5-10%Xe) at 300-500 Torr pressure and finally pinching off the tip tube. A panel thus made is ready for use as a display device.

During PDP operation, it is frequently observed that many discharge cells or pixels do not function properly; rather show imperfections such as flashing or arcing, no-glow or dark pixels, bright spots, and blinking pixels etc. When either voltage is raised or gas breakdown is achieved, arcing occurs at the shorted electrode locations and that phenomenon causes burning and opening of the electrodes. The weakening and/or the absence of TD layer at localized position comprising of particular discharge cells are major cause for the arcing. The presence of air bubbles (figure 2) in the TD layer also produce TD breakdown and arcing when electric field is applied. In practice, other than air bubbles and cavities, TD layer contains non-uniform layer thickness, impurity particles too. These defects can occur due to the contamination of the raw material, and inflow of the impurities etc. Also sometimes the small gap (60-100 µm) between electrodes is shorted during manufacturing process. These imperfections cause damage to display electrodes due to glow-to-arc transition at high-pressure plasma operation.

Owing to the very small dimensions visual inspection and correction of these defects are difficult. These types of plate level defects require very sophisticated equipments to detect. Earlier Lim and Park have reported an inspection method of electrodes of plasma display panel using frequency domain analysis [4].

In this work, we have used electric discharges at atmospheric pressure such as DC arcs [5] and AC dielectric barrier
discharges [2, 3] for identifying the defect positions in TD layer. The discharge method also helps open the shorted electrodes. We have used PDP electrodes itself to produce the discharge.

2. Experimental Procedure:

Different experiments were conducted for defect inspection. Initially all the bare co-planar sustain and scan electrodes of the PDP front plate were shorted separately by using copper conducting tape. This two-electrode system was attached to a high voltage DC power supply. Only few volts were sufficient to remove the shorts (if any existed as shown in figure 3) between electrodes (Electrode gap ~ 100 micron) through micro-arc formation. Now these front plate electrodes were coated with TD (Dielectric constant: 12) layer for further experiments.

Figure 3: Shorting at transparent ITO electrode pair.

2.1 Use of atmospheric pressure DC discharge

This experiment was performed to inspect the locations where either TD layer was weak or not present. The TD coated front plate was sealed using rubber gasket and silicone sealant with a bare ITO coated bottom plate allowing a gap of 1mm between the two plates. All the front plate electrodes were shorted using a copper conducting tape to make them a single electrode while the ITO coating in the back plate was the other electrode. Helium gas was passed in the system through a tip tube along a 2 mm diameter hole in the back plate corner while outlet for gas was provided at other end. Under atmospheric pressure conditions, the gas flow of 5-10 lpm was maintained between the electrodes. The helium gas was chosen to reduce the breakdown voltage [5] and getting stable blue-purple glow discharge.

The electrodes were connected to a high voltage (3 kV) DC power supply and the voltage was increased from 0V to 1.5 kV considering the maximum dielectric strength. At different potential levels, arc spots were observed only at those places where dielectric layer was weak enough to get punctured. These bright arc spots are shown in figure 4. At other locations no discharge was ignited due to capacitive coupling with strong dielectric insulation over the electrodes.

Figure 4: The arc point observation during DC discharge at atmospheric pressure in helium.
The ignited arc locations were marked and made well insulated by dielectric pasting. Further the voltage was increased to maximum 1.5 kV and the process of arc point marking was repeated. The microscopic inspection of marked locations revealed presence of small cavities and when a needle was passed through, those cavities could be physically identified. Further these cavities were filled with TD paste followed by settling and scrapping off excess material to maintain uniform thickness. The plates were then fired again at 580°C temperature. With the fired plate the experiment was repeated. No arc was observed with DC potential observed subsequently at previously marked locations as the electrodes were well insulated by then.

2.2 Use of atmospheric pressure AC discharge

This experiment was performed to validate the proper working of repaired front plate by creating co-planar discharge between display electrodes similar as in actual PDP operation. The scan and the sustain electrodes were shorted separately to make a two electrode co-planar system. A bare glass instead of an ITO coated plate was used to create a defined volume containing helium gas in it as explained in section 2.1. The atmospheric pressure dielectric barrier glow discharge [4, 5] was ignited between co-planar electrodes by applying square wave pulses of 300 volts at 20 kHz frequency. A blue-purple glow was observed throughout the panel. The appearance of glow discharge (figure 5) in the dielectric coated electrode system verifies the perfection of front plate. The presence of arcing at any further points shows presence of imperfection of TD layer that might have been missed someway during previous testing of the plate which might require further repair. Now this examined front plate is ready for making defect-free plasma display panel by sealing with suitable back plates.

**Conclusion:**

In this work it is shown that the electrical discharge can be used for inspection of the imperfect plasma display front plate. The low cost inspection and analytical approaches cited above may eliminate the need for costly inspection system such as enhanced image comparison equipments in R&D laboratories and pilot production units. This gas discharge approach as an inspection system may also be applied to other display devices manufacturing.

**References:**

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Figure 5: The atmospheric pressure glow discharge between co-planar electrodes.