2.2: Large Area Flexible Plasma Displays

Carol A. Wedding, Jeff W. Guy, Daniel Wedding
Imaging Systems Technology, Toledo, OH. USA

Abstract
Imaging Systems Technology (IST) is engaged in a multiyear research and development effort to produce flexible monochrome and color plasma displays using Plasma-spheres. Plasma-spheres are hollow microspheres encapsulating an ionizable gas mounted on rigid or flexible substrates. Plasma-sphere displays promise advantages over conventional plasma displays including low cost manufacture, high yield, long life, ruggedness and flexibility.

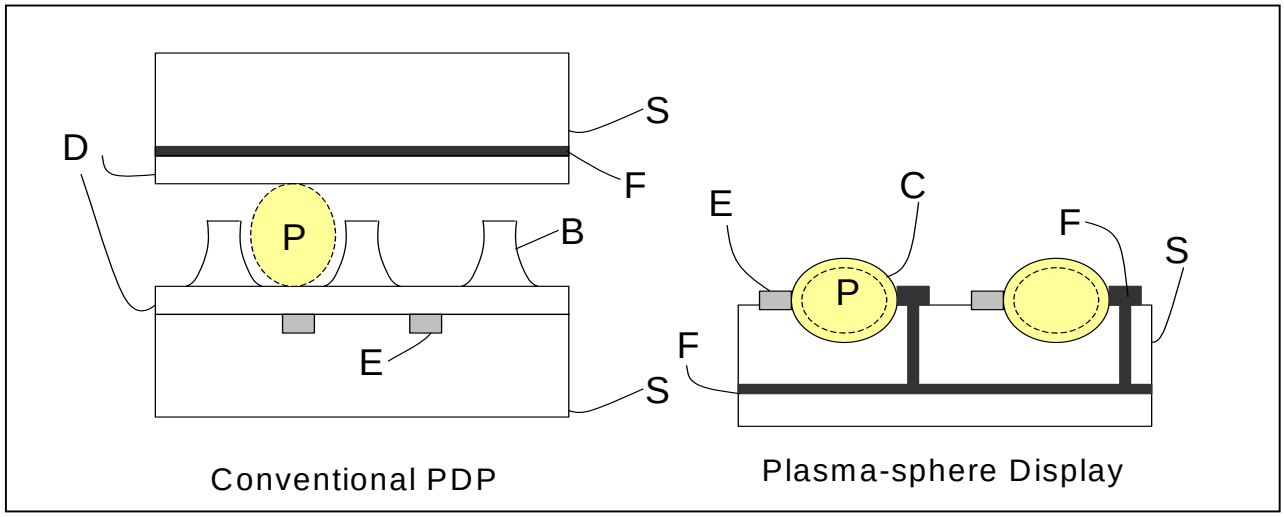
1. Introduction
IST is engaged in a multiyear research and development effort to produce flexible monochrome and color plasma displays using Plasma-spheres. Plasma-spheres are hollow microspheres encapsulating an ionizable gas. This paper includes a comparison of the structure of a Plasma-sphere display with a conventional plasma display panel (PDP); manufacturing advantages of a Plasma-sphere display; and potential applications for the Plasma-sphere display. Results of current research and development are also presented.

2. Background
2.1 Comparison to Conventional PDP
The Plasma-sphere display is a novel closed cell device that uses gas encapsulating spheres to replace the open cell structure of a conventional PDP using Plasma-spheres. **Figure 1** compares the two structures. In a conventional PDP, two substrates (S) form a chamber for an ionizable gas at pressures of 0.3-0.6 atmospheres. The two substrates are flat, rigid, and hermetically sealed. (E) is an address electrode, and (F) is a select electrode. These electrodes define a gas discharge pixel (P). A dielectric layer (D) is applied uniformly to each substrate to insulate the electrodes. Other layers such as MgO and phosphor may also be applied. Barrier ribs (B) may be formed by a number of processes.

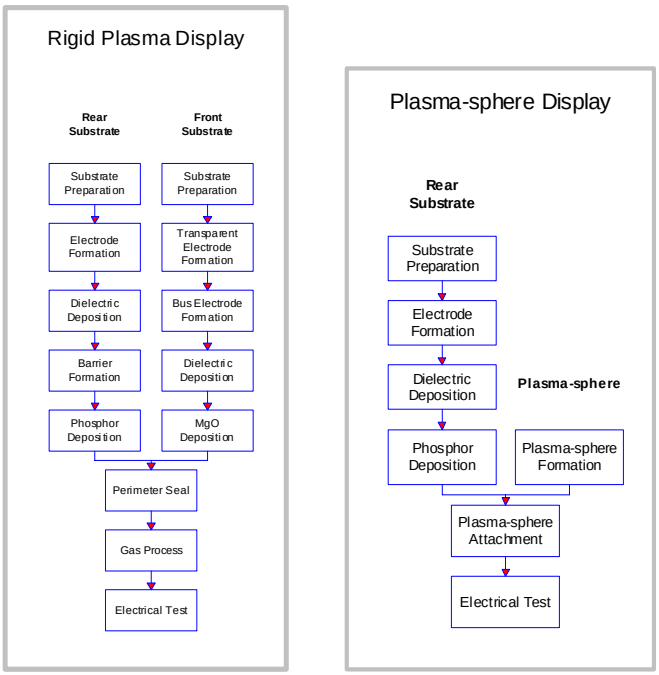
Figure 1 Comparison of Conventional Plasma Display to Plasma-sphere Display In contrast, the Plasma-sphere display is comprised of multiple spheres (C) that contain the ionizable gas. The sphere is composed of a dielectric shell material with highly uniform diameter and thickness due to IST's proprietary processes. Because the pressurized gas is contained in a sphere, the Plasma-sphere substrate is not required to be rigid or impermeable. It can be made flexible and a top substrate is not required. Additionally, because each Plasma-sphere defines the crucial parameters of gap and dielectric thickness, critical tolerances are not needed for the substrate.

2.2 Manufacturing Process
The Plasma-sphere display manufacturing processes are significantly less costly than a conventional PDP processes. The Plasma-sphere technology easily lends itself to a high yield low cost roll-to-roll process. **Figure 2** shows a comparison between the conventional rigid display and the Plasma-sphere display. As can be seen from the diagram, a standard plasma display is produced by joining a front and rear substrate. Each of substrate undergoes numerous process steps including various thin film depositions. The rear substrate is micro-sandblasted to produce the barrier ribs. The sand blasting is a dusty process, not compatible with the clean room environment. After the two substrates are completed, they sealed together and gas processed. Gas processing involves evacuating the air and contaminants from between the two substrates and back filling with the plasma gas. This step takes over 19 hours, and it is one of the last steps in the process. Thus if something goes wrong at this stage an essentially completed display is scrapped.

Plasma-sphere production compares favorably to this time-consuming batch process. First, as mentioned above, the Plasma-sphere display does not require a top substrate. Instead the gas is encapsulated by the Plasma-sphere itself.



The Plasma-sphere is manufactured using a low cost proprietary process developed by IST. With this process, IST has the ability to control shell thickness to within a few microns and gas pressure to within a Torr. Sphere yields are well over 90%.



The substrate may be formed from plastic using a low cost roll-to-roll process. The traditional plasma display processing steps such as sand blasting, vacuum deposition, and gas processing are eliminated. The elimination of these conventional process steps coupled with a roll-to-roll process offers a highly automated, high yield, low cost process.

3. Application

The Plasma-sphere display has advantages over a conventional plasma display including low manufacturing cost, seamless tiling, and longer life. Like the conventional plasma display, it has a full color pallet, wide viewing angle, video update and can scale to large sizes. Plasma-spheres can be mounted on a rigid or flexible substrate. Additionally, the Plasma-sphere display is very rugged in comparison to other display technologies. The Plasma-sphere display can tolerate temperature and pressure extremes and can survive a direct impact to the front surface with little or no damage. In the event that some of the spheres are crushed, the remaining spheres will still function. A comparison of the Plasma-sphere display with other display technologies is provided in **Table 1**.

	Small Size	Large Size	Video Speed	Full Color	Pressure Extreme	Temperature Extreme	Shock and Vibration	Seamless Tiling	May be Flexible	Long Life
Plasma-sphere Display		X	X	X	X	X	X	X	X	X
Conventional PDP		X	X	X		X				
OLED	X		X		X			X	X	
Electrophoretic	X	X		X		X			X	X
LCD	X		X	X				X	X	X

Table 1 Comparison of Display Technologies

Because of their unique characteristics, Plasma-sphere displays will be useful in harsh environments including military, industrial, scientific exploration, and the automotive industry. Because of the large size and seamless tiling, Plasma-sphere displays will also be used in stadiums, entertainment, and advertising applications. The flexible substrate will allow new and emergent applications in flight simulators, large mobile command and control shelters, futuristic video games and entertainment.

4. Research Results

Early in 2004 IST demonstrated a flexible 8 x 32 line addressable monochrome display. This was followed by an 8 x 32 line color display. Voltages and operating margins are similar to standard plasma displays. IST has started work on a flexible 20 in diagonal display. It is scheduled for completion in the next few months.

5. Summary

There are compelling technical and commercial reasons to develop Plasma-sphere displays. Theses displays promise a low cost, high yield manufacturing process with unique characteristics that make them useful for a number of applications especially those requiring large size displays. Current research at our facilities indicates that this is a highly viable display technology. IST continues to focus on developing high quality Plasma-spheres through process optimization, process control, and material selection. Plasma-spheres can be produced ranging in diameter from 0.250 mm to 3 mm using several methods. Shell thickness can be controlled to within several microns.The shell can be made from a variety of materials including glass. Current research has led to methods for adding MgO and other materials to the inside of the Plasma-sphere.

6. Acknowledgement

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References

The following references are recent papers pertaining to flexible displays.

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