FEATURING

Development and Mass Production of the Industry's Highest Performance Organic EL Panel

Full-Color Organic EL Panels Based on Sony's Unique "Super Top Emission" Technology

- **Previously unknown superb picture quality**
- **Panel structure that gets the best performance from the technology**
- **Sony's unique "Super Top Emission" technology**

The Sony CLIE "PEG-VZ90" using Sony's first full-color organic EL panel

On September 25, 2004, Sony released the CLIE "PEG-VZ90" that includes Sony's first full-color organic EL display panel. This organic EL panel is the 3.8-type size and as such is the industry's largest organic EL panel in mass production (see photograph 1) and furthermore achieves by far the most strikingly beautiful images. While organic EL panels, due to being self luminescent and having fast response times, provide superlative moving characteristics, this panel also features excellent color reproducibility and high efficiency. Thus the organic EL technology provides more than adequate performance to support future high picture quality moving picture for mobile application and to also be deployed in larger TV sets.

■ Photograph 1 The Industry's Largest (3.8-type) Active Matrix Organic EL Panel

Previously Unknown Superb Picture Quality

Table 1 presents the specifications of the organic EL panel used in the CLIE. This panel achieves high brightness (150 cd/m^2), high contrast (1000:1), and high resolution (151 ppi). Furthermore, its color reproducibility greatly exceeds that of conventional organic EL panels. (See figure 1.) While the color gamut of conventional panels had an area only approximately 70% of that of standard CRT monitors, this panel achieves a gamut that is 147% of the CRT gamut, roughly twice that of the conventional panels. Taken together, these picture quality characteristics mean that this panel creates strikingly beautiful images.

At the same time, this panel holds the per unit area of screen power consumption to levels lower than those of conventional panels. This was achieved by using unique Sony-developed device structures.

■ Table 1 Organic EL Panel Specifications

Screen size	97 mm (3.8 type)
Number of dots	480 × RGB × 320 (HVGA)
Dot pitch	56 µm × 168 µm
Resolution (ppi)	151
Number of colors	262,144 colors
Brightness	150 cd/m^2
External dimensions (width × height × thickness)	94.7 mm × 77.2 mm × 2.14 mm (The thickness is that of the panel only: boss are not included)
Response time (25°C, on)	0.01 ms (Max.)
Color reproducibility (NTSC gamut area ratio)	Approx. 100%
Viewing angle	Vertical direction: approx. 180° Horizontal direction: approx. 180°
Contrast (in a dark environment)	Approx. 1000:1

Panel Structure that Gets the Best Performance from the Technology

Figure 2 presents a comparison of the panel structures.

■ Light extraction methods

While conventional panels adopted a method called bottom emission, this panel uses top emission. The method in which the light generated by EL is extracted from the TFT substrate side is called bottom emission. Since the EL drive pixel circuits are present on the TFT substrate, the area from which light can be extracted is limited and the efficiency with which the light generated by EL is used is reduced. In contrast, light is extracted from the sealing substrate side in top emission and the light generated by EL can be extracted efficiently.

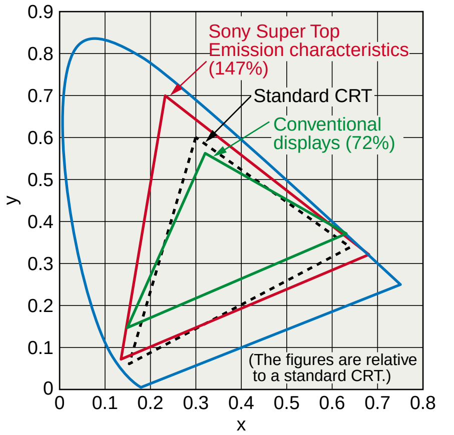
■ No circular polarizer is required

In conventional panels, a circular polarizer (retardation film and polarizer) was installed on the panel surface. While this was provided to prevent the reflection of ambient light, it also reduced the amount of EL light emitted. This panel does not use a circular polarizer, but rather uses the microcavity structure described later in this article and color filters. At the same time as preventing the reflection of ambient light, the microcavity structure and color filters achieve an increase in color purity. The ability to use color filters relatively easily is a feature of top emission. In bottom emission panels, the color filters (OCCF*) are formed on the TFT circuit, and furthermore, the organic film is formed on top of those filters, thus increasing the technical difficulty of manufacturing the panels.
It is the combination of top emission, the microcavity structure, and these color filters that allow this panel to achieve its superb picture quality with low power consumption.

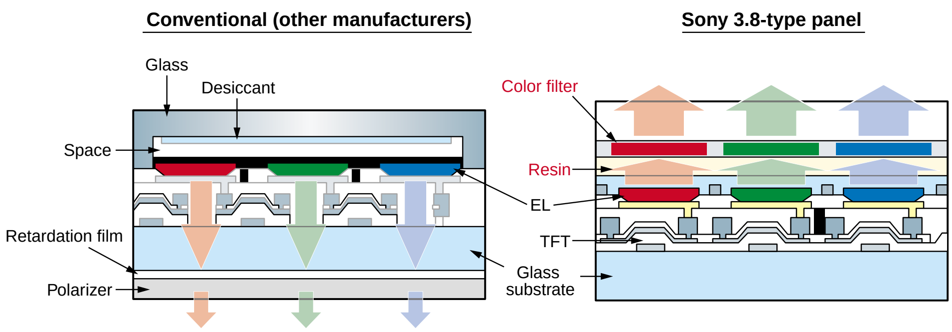
* OCCF: On-chip Color Filter

■ Fully fixed sealing

Previously, CAN sealing, in which an inert gas is enclosed, was used. More recently, glass substrates that have been carved out from the inside and the edge sections retained (see figure 2) have been used for sealing. These are sealing methods that avoid as much as possible damage to the organic films by the sealing process.
In this panel, the problem of damage to the organic films by the sealing process has been resolved and a fully fixed structure that can better withstand external mechanical shocks has been created. This has allowed Sony to reduce the thickness of the sealing glass and make the panel even thinner. Furthermore, it opens the way to creating ultrathin panels using plastic film sealing.



■ **Figure 1 Organic EL Panel Color Reproducibility Comparison**



■ **Figure 2 Conventional (other manufacturers) and Sony Panel Structural Comparison**

Sony's Unique "Super Top Emission" Technology

As we described in the previous section, this panel represents a significant technological leap over conventional panels and shows the way for the future of organic EL technology. It is Sony's unique "Super Top Emission" technology (figure 3 shows its logo) that makes this leap possible.

■ Microcavity structure

Figure 4 shows the device structure. One of the features of this panel is that the thicknesses of the organic films differ for the RGB colors. This is because the film thickness is selected to match the optical path length between the cathode and anode electrodes to the EL spectral peak wavelength for each color (microcavity structure).

Another feature is the point that the cathode electrode is a semitransparent film. The light whose wavelength matches the optical path length between the electrodes repeatedly reflects and interferes (multiple reflectance interference) between the cathode semitransparent film and the (reflective film) anode electrode. As a result the spectrum of the extracted light is sharpened (see figure 5) and the color purity is increased.

■ Microcavity structure and color filters

Figure 6 shows the effect of reducing ambient light reflection provided by the microcavity structure and the color filters. When the organic film optical path length is matched to the wavelength of the green EL light, the green component of the ambient reflected light is cut. At the same time, the ambient reflected light with colors other than green is cut by the green filter. That is, when a color filter is combined with the microcavity structure, essentially all ambient reflected light can be cut. This allows high contrast to be achieved without the use of a circular polarizer.

While this figure shows this effect for green, red and blue operate in the same manner.

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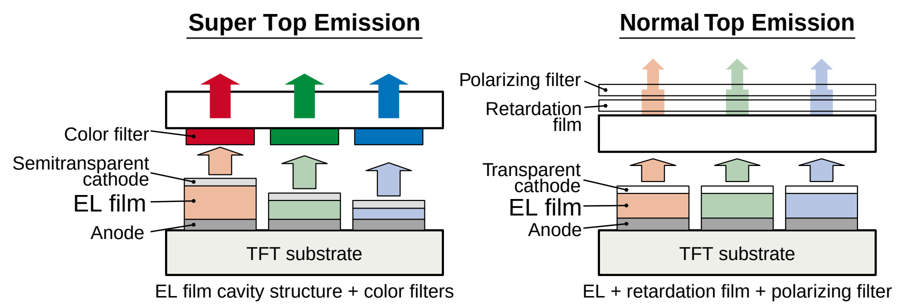
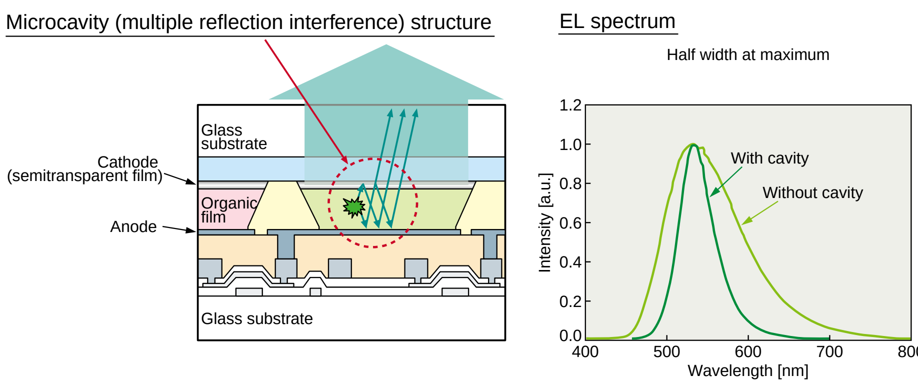
SUPER TOP EMISSION

*: The "Super Top Emission" logo is a Sony trademark.

■ Figure 3 "Super Top Emission" Logo



■ Figure 4 EL Organic Film Structure



■ Figure 5 Microcavity Structure and Spectrum Sharpening

■ Color filter color selection white EL technique

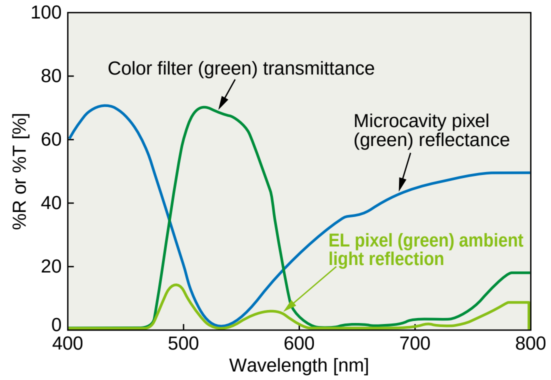
In addition to the technique used in the panel included in the CLIE and described previously in this article, Sony has also developed a microcavity structure color filter color selection white EL technique. In this technique, the whole panel is manufactured using an EL film that generates white light emission and color filters are used for RGB color selection. Figure 7 shows the cross section of a panel using this technique. Sony exhibited a 12.5-type prototype panel using this technique at SID 2004*. (See photograph 2.)

*: SID 2004: Display technology related to conference and exhibition held on May 25 to 27, 2004 in Seattle, Washington.

Future Developments

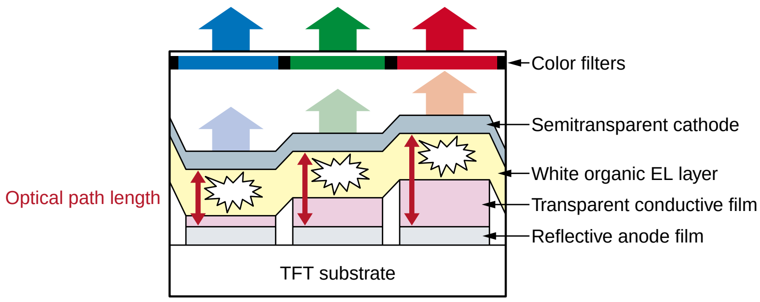
Sony has developed the unique "Super Top Emission" technology that takes maximum advantage of the features of organic EL technology and supports mass production. Sony is committed to providing the highest performance organic EL panels and maintaining their commanding lead over those of other manufacturers in this area.

Keep your eye on Sony for the best in organic EL panels.



■ Figure 6 Reduced Ambient Light Reflection Due to the Microcavity Structure and Color Filters

■ Photograph 2 Sony Color Filter Color Selection White EL Panel (12.5 type) Displayed at SID 2004



■ Figure 7 Microcavity Structure Color Filter Color Selection White EL Technique