Under license of KODAK OLED patents.

High-intensity/Long Operation Organic EL Display

Mono-color(white) Type/Multi-color Type/Full-color Type

UEL series

The latest achievements of TDK organic EL technologies in which serious efforts have been made to satisfy the passionate and rigorous requests of device designers are reported.

Ten years have already passed since the introduction of the world's first 4-inch, QVGA active matrix full-color organic EL display which was developed in cooperation with Semiconductor Energy Laboratory Co., Ltd..

In the past 10 years, TDK has materialized "want-use" and "useful" mass-productive organic EL displays one by one while seeking the design/mass-production processes which maximize the balance of image quality, longevity, cost, and screen size by improving and developing organic EL materials, self-developing luminescent layer structures, and control chips.

Passive Matrix System / Mass-production Specification

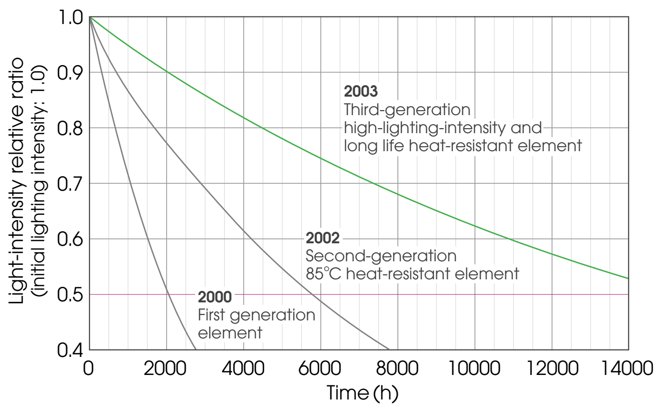
Monocolor (white/4 Gradation sequence)/ Metal-frame 1DIN Type
Dot pitch:0.31x0.31mm / Number of dots:256x64
Display screen size:79.1x20.0 mm/Brightness:120 cd/m²
Lighting-intensity halving life:10000h min.(at 25°C / Lighting rate : 50%)

TDK has been consistently seeking the production of the best white light-emitting organic EL materials. As the key technology for early realization of mass-production compatible with the market needs with the advantages of organic EL display that go beyond existing displays, such as power-saving, lighting intensity, visibility, thinning, and so forth, effort has been invested in technological improvements of white light-emitting organic EL materials which optimize longevity, brightness, and light-emitting quality.

Also, for the color organic EL display, the top priority was the realization of the world's longest operational longevity, allowing long-term maintenance of high-quality image reproducibility and high-definition image display. For early realization of these features, while being compatible with market needs, a color filtering system was selected from among RGB individual coating systems and color conversion systems, because the system allows realization of long-term display capability and color longevity in a stable fashion in a mass-production format, and accelerates image quality improvement and cost saving efforts. Mass-production has been advanced according to market needs while maturing filter formation technologies proceed.

Transition of light-intensity longevity of monocolor (white) organic EL display

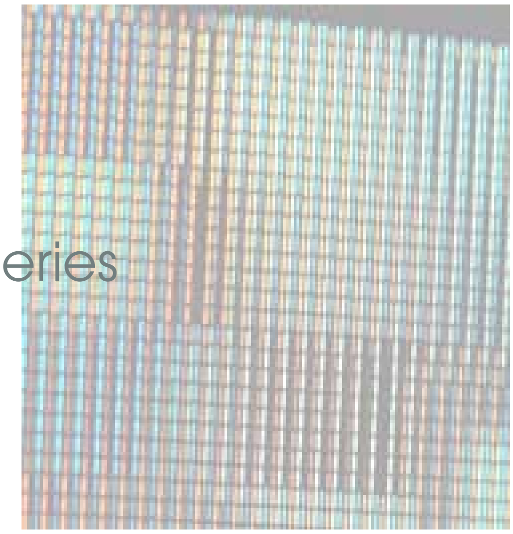
Continuous action test in 85°C ambient (Duty : 1/64, lighting rate 50%)
Initial lighting intensity of the first generation element : 100cd/m²
Initial lighting intensity of the second and third generation elements : 120cd/m²



These efforts based on the "maximized white light-emitting" technologies have already resulted in many device display panels such as car audio devices which are used in severe operational environments, receiving high marks from the application device market for their environmental durability, lighting-intensity longevity, viewing angle, response performance (movie display performance), and so forth.

In this product information file, the basic specifications of four next-generation full-color product types (development sample specifications) as well as those of six mass-produced types (four white monocolor display type / two multi-color product types) will be introduced. It is hoped that these newly developed product types will be useful for planning the future design of next-generation display panels.

UEL series

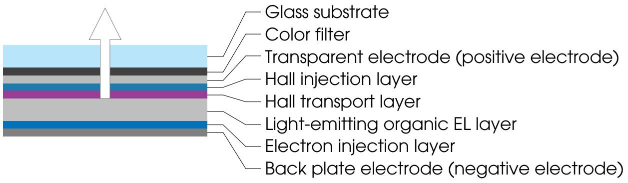


Under license of KODAK OLED patents.

Advantages of organic EL displays and reasons why the color filter system was selected

Basic structure of organic EL display and light-emitting principles

Basic structure model of organic EL display (color-filter system)



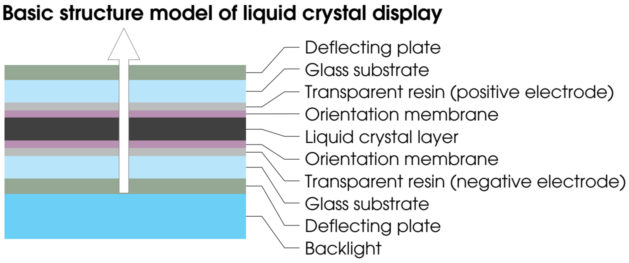
When voltage is impressed on the two electrodes sandwiching organic EL layers, electrons (-) are sent from the negative electrode and the Hall effect (+) occurs at the positive electrode. When these two are re-combined in the organic EL layer, an energy activating the organic EL materials results. When this energy potential decreases (returns to its original level), excessive energy is emitted as light. Organic EL materials have to be formed in a thin membrane of about 0.1 μm because the flow of electric current is weak in general due to their high resistivity and to the necessity of increased permeability. Also, it is quite difficult to realize high-quality white light emission with a single organic EL material. To achieve an ideal white light emission, it is essential that multiple light emission materials are developed and that technologies for the lamination of thin membranes are available.

Advantages of organic EL display

While liquid crystal displays have two glass substrates, an orientation membrane, and electrode layers sandwiching liquid crystal with a backlight, organic EL displays have a simple structure in which a self-luminous organic EL layer is placed between two electrodes (negative and positive electrodes built into the matrix).

From this difference in basic structure, flexible displays can be realized by replacing 0. - something millimeter thick paper panels and glass substrates with transparent resin. Also, because of their self-luminosity, they offer a wide viewing angle and structural advantages in lighting intensity, and response that exceeds that of current liquid crystal displays.

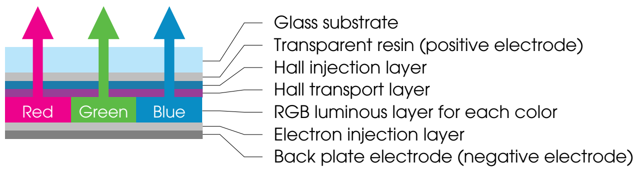
Basic structure model of liquid crystal display



Coloring system of organic EL display

Merits and demerits of each system

RGB individual light emission system



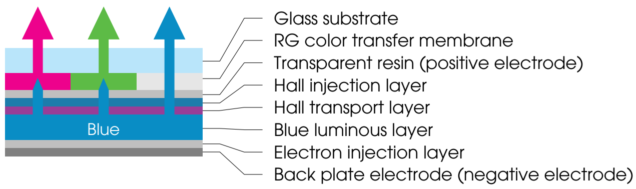
Merits

- Good RGB light emission efficiency
- Minimal energy loss

Demerits

- RGB color's optical and electrical characteristics are different/Each color of RGB differs in its longevity
- Difficulty in high-resolution coloring/ Cost burden

Color light transfer system



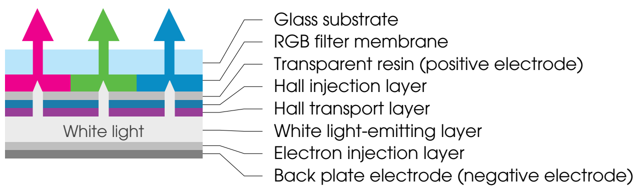
Merits

- Same longevity for each color of RGB
- Low energy loss

Demerits

- Difficulty in developing materials with high color transfer efficiency
- Color filter used in conjunction with for improved color purity

Color filter system (TDK's selection)



Merits

- Same longevity for each color of RGB
- Application of the color filter technology available
- Ease of low-cost production

Demerits

- Significant energy loss
- Increasing the white light-emitting element's life is the most crucial task

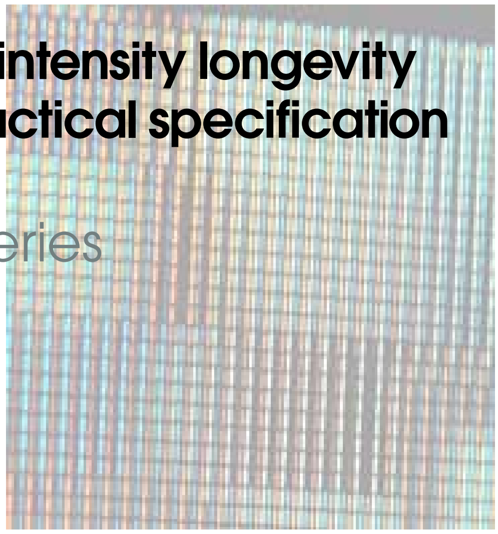
Objective of organic EL display — light intensity longevity
Challenge toward the world's most practical specification

The light intensity longevity characteristic of an organic EL display depends largely on the organic EL material, organic EL thin membrane lamination structure, and organic EL production process. Therefore, there is a need for advanced technical capabilities to optimize material properties.

TDK's development of organic EL materials began in 1991 and an internal system which comprehensively performs consistent research and development from molecular structural design of organic EL materials, to chemosynthesis and device evaluation, has been established, further promoting the development of TDK's long-life materials, thin membrane laminate structure, and low-cost mass-production processes.

Also, TDK's development of white light-emitting organic EL elements began in 1995. In the same year, the active full-color organic EL display (white light-emitting organic EL element + color filter system) developed in cooperation with Semiconductor Energy Laboratory Co., Ltd. was introduced. Since then, TDK's efforts have been directed at making both mono and color type high-resolution, and making the white light-emitting organic EL element one with long life.

UEL series



Under license of KODAK OLED patents.

The first-generation white light-emitting organic EL element (2000) was 1/64 duty passive drive with 100cd/m^2, 85℃ continuous operation (lighting rate 50%), and its light intensity decreased by half after 2000 hours.
The third-generation, whose development was completed three years later, was improved in its light intensity, halving the longevity to 14,000 hours - seven times as long as the first generation under the same conditions.
Comprehensive technical improvements have been accelerated to further increase this value.

Research and development phase

Research and development center

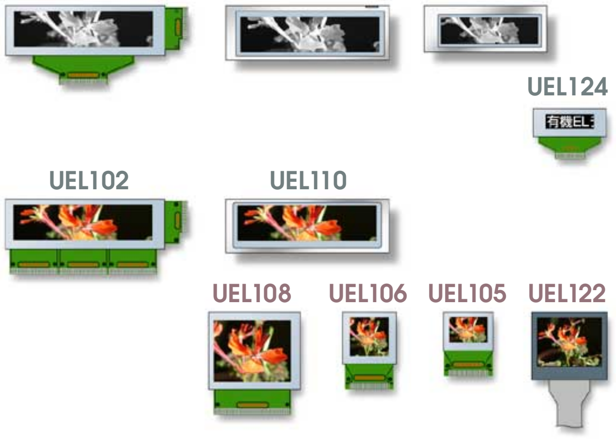
1991 Organic EL material development has begun
1995 White organic EL material development has begun
1995 White light-emitting organic EL material + color filter system full-color display development has begun
1995 Development of active matrix system (white light-emitting element + color filter) QVGA full-color display (first in the world)*
1996 Development of long-life white light-emitting structures
1998 Development of long-life white light-emitting materials and structures

Productization phase

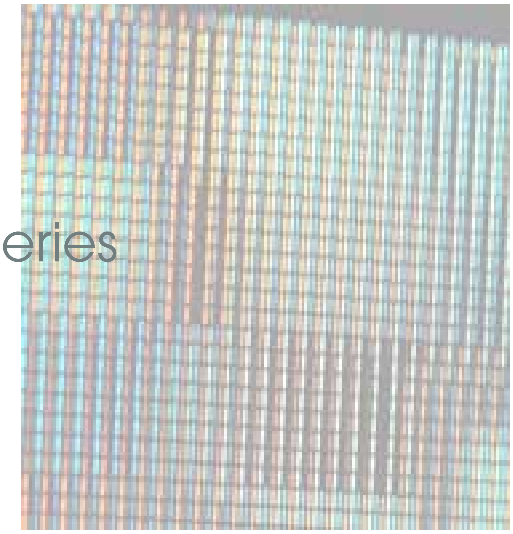
First generation 100cd/m^2, 2000h(85℃ continuous/Lighting rate 50%)
2000 **Productization of passive matrix system white light-emitting display**
2000 Kitaibaraki Factory: pilot line operating manufacturing/shipping
2001 Mass-production technology of long-life white light-emitting display has been established
Second generation 120cd/m^2, 6000h(85℃ continuous/Lighting rate 50%)
2002 **Development of car-mounted type 85℃ heat-resistant white display**
2003 Kitaibaraki Factory: car-mounted type heat-resistant display manufacturing/shipment has begun
Third generation 120cd/m^2, 14000h(85℃ continuous/Lighting rate 50%)
2003 **High heat-resistance/high lighting-intensity, long-life white display development**
2003 Development of passive matrix system 1DIN 4096 colors multi-color display
2003 Development of passive matrix system 6.5-inch high-resolution 4096 colors multi-color display
2004 Kitaibaraki Factory: Multi-color display manufacturing/ Shipment has begun
2004 High heat-resistance of white display/accelerated high lighting-intensity and long-life
2004 Passive matrix system 2.0-inch high-resolution 32768 colors full-color display development
2004 Passive matrix system 1.0-inch high-resolution 65536 colors full-color display development
2004 Active matrix system 1.8-inch QVGA/262144 colors full-color display development*
2005 Kitaibaraki Factory: High lighting intensity, long-life white display manufacturing/ Planned for OEM shipment

* Co-development with Semiconductor Energy Laboratory Co., Ltd..

List of outline specifications



UEL series



Under license of KODAK OLED patents.
QVGA active matrix full-color organic EL display which was developed in cooperation with Semiconductor Energy Laboratory Co., Ltd.

Monocolor(white) Type

System	Passive matrix	Passive matrix	Passive matrix	Passive matrix
Specification	Mass-production	Mass-production	Mass-production	Mass-production
Part No.	**UEL120**	**UEL10042**	**UEL10011**	**UEL124**
Display color	White	White	White	White
Gradation sequence	16	4	4	2
Display screen size (mm)	79.1×20.0	79.1×20.0	55.7×15.0	27.4×8.2
Dot pitch (mm)	0.31×0.31	0.31×0.31	0.44×0.47	0.23×0.23
Number of dots	256×64	256×64	128×32	120×36
Brightness (cd/m^2)	120	120	120	150***
Viewing angle (degree)	160° min.	160° min.	160° min.	160° min.
Response speed* (μs)	10 max.	10 max.	10 max.	10 max.
Panel driving voltage (V)	17 to 18	17 to 18	17 to 18	12 to 16
Logic voltage (V)	2.7 to 5.5	2.7 to 5.5	2.7 to 5.5	2.4 to 3.5
Lighting-intensity halving life(h)**	10000	10000	10000	10000
Operating temperature range (°C)	–30 to +85°C	–30 to +85°C	–30 to +85°C	–10 to +60°C
Storage temperature range (°C)	–40 to +105°C	–40 to +105°C	–40 to +105°C	–20 to +85°C

*at 25°C/ON **at 25°C / Lighting rate : 50% *** Without polarized light film

Multi-color Type/Full-color Type

System	Passive matrix	Passive matrix	Passive matrix	Passive matrix	Passive matrix	Active matrix
Specification	Mass-production	Mass-production	Sample product	Sample product	Sample product	Sample product
Part No.	**UEL102**	**UEL110** Storing UEL102	**UEL108**	**UEL106**	**UEL105**	**UEL122**
Number of display colors	Multi : 4096	Multi : 4096	Full : 32768	Full : 65536	Full : 65536	Full : 262144
Gradation sequence	RGB : 16	RGB : 16	RGB : 32	RB : 32/G : 64	RB : 32/G : 64	RGB : 64
Display screen size (mm)	79.1×20.0	79.1×20.0	43.6×34.9	21.9×21.9	21.9×14.6	36.5×27.4
Pixel pitch (mm)	0.31×0.31(RGB)	0.31×0.31(RGB)	0.20×0.20(RGB)	0.23×0.23(RGB)	0.23×0.23(RGB)	0.11×0.11(RGB)
Number of dots	256×RGB×64	256×RGB×64	220×RGB×176	96×RGB×96	96×RGB×64	320×RGB×240
Brightness (cd/m^2)	80	80	80	80***	80***	150***
Viewing angle (degree)	160° min.	160° min.	160° min.	160° min.	160° min.	160° min.
Response speed* (μs)	10 max.	10 max.	10 max.	10 max.	10 max.	10 max.
Panel driving voltage (V)	17.5 to 18.5	17.5 to 18.5	17.5 to 18.5 (TBD)	17.5 to 18.5 (TBD)	17.5 to 18.5 (TBD)	TBD
Logic voltage (V)	2.7 to 5.5	2.7 to 5.5	2.7 to 5.5 (TBD)	2.7 to 5.5 (TBD)	2.7 to 5.5 (TBD)	TBD
Lighting-intensity halving life(h)**	8500	8500	8500	8500	8500	TBD
Operating temperature range (°C)	–30 to +85°C	–30 to +85°C	–30 to +85°C	–30 to +85°C	–30 to +85°C	–10 to +60°C
Storage temperature range (°C)	–40 to +95°C	–40 to +95°C	–40 to +95°C	–40 to +95°C	–40 to +95°C	–20 to +85°C

*at 25°C/ON **at 25°C / Lighting rate : 50% *** Without polarized light film