Photo-Induced Memory of an OLED in the presence of thio-Michler's ketone

Toshio Enokida and Tae Sun Gwon

Color Materials Business HQ's, Toyo Ink Mfg.Co.,Ltd.
2-3-13 Kyobashi,Chuo-ku,Tokyo,104-8377, Japan, Tel. +81-3-3272-5743,
Fax: +81-3-3272-7308 E-mail: toshio.enokida@toyoink.co.jp

Abstract

Photo-induced memory effect of an organic light-emitting diode(OLED) composed of a hydrazone-derivative(DBAH) dispersed in bis-phenol-A type polycarbonate polymer(PCA) in the presence of thio-Michler's ketone, was investigated by the measuring of the current density and luminance at the various conditions. After the light exposure, the current of the OLED was decreased approximately one order, and the luminance of the OLED also decresed. This memory effct was erasable by heating the OLED to the temperature higher than the glass transition temperature(Tg). As shown in this result, we found the memory effect was erased by heating and returned to its original state in the hole injecting layer(HIL) of the OLED. A series of these phenomena was suggested the possibility of the application to the imaging plate.

1. Objective and Background

Carrier transport mechanism of conductive polymers and molecularly doped polymers has been investigated in the study of organic photoreceptors for electrophotography.[1,2] For the application of the technology, the carrier injection and transport mechanism stuties of the OLEDs have been done for many years. From these stuies, the application of the OLEDs to the imaging plate was presented. The imaging plate is divided into one-way system and rever-sible system. By taking advantage of the OLEDs, we found the photo-induced memory OLED system, only the addition of the memory-inducing organic dye with hydrazone derivative in HIL. This photo-induced memory of this OLED was reversible by the addition of the light-exposure and heat. This system is a proposal to the application of OLEDs to the memory-storage system used organic material.

2. Results

2. 1 Material

Material of chemical structures used in the OLED is shown in Fig.1. Hole injecting material(HIM) is DBAH derivative selected from various hole transporting materials. Memory materials is bis(dimethylamino)thiobenzophenone(thio-Michler's ketone;TMK). Matrix polymer is bis-phenol-A polycarbonate. Electron injecting material(EIM) is Alq3.

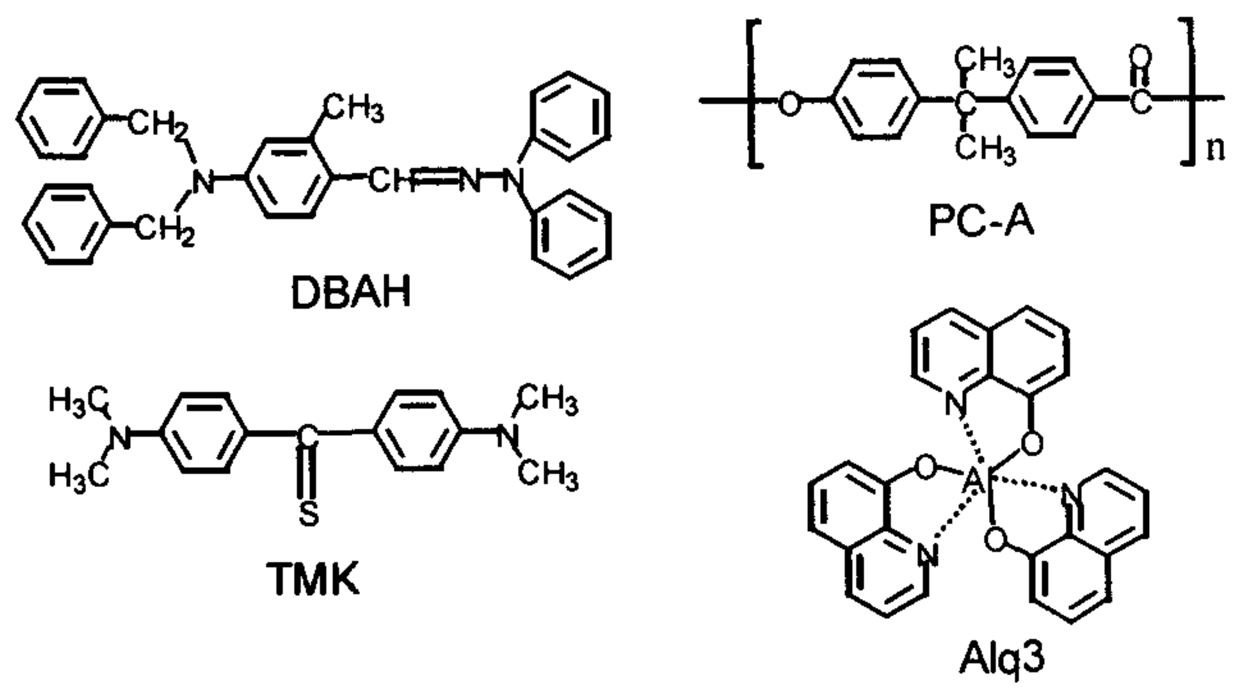


Figure 1. Material used in the photo-induced memory OLED

2-2. OLED Fabrication

Dual-layered photo-induced OLED was made byusing the material as shown in Fig.1. Indium-tin Oxide (ITO) coated glass with a sheet resistance of 10 Ω/□ was cut into 5.0 × 5.0 cm^2, and electrode area was prepared by photo-etching technique. It was cleaned successively with acetone and in an ultrasonic bath. 10 g of DBAH, 1mg-100mgof

TMK, and 10g of PCA were dissolved in tetrahydrofuran(THF). This solution was dipped on the ITO glass, and dried in dry nitrogenatmosphere at the room temperature. Thicknessof the HIL was 50 nm. Electron injecting
layer(EIL) was made on the HIL by vacuum deposition of Alq3. Deposition rate was3 Å/sec in 10^{-4} Pa, and the thickness was 50nm.Alq3 in the EIL was effected as an emitting layer (EL). The Mg and Ag was deposited at 15 Å/sec and 3 Å/sec in 10^{-4} Pa on the top of the EIL as cathode, and the thickness was 300 nm.

2-3. Memory measurement

The current density was measured using a Keithley 617 electrometer. To measure the photo-induced memory with the OLED, the light was irradiated from the ITO electrode side.Wavelength of the light was adjusted through
the UV light irradiation filter(Toshiba Glass) from the Xe-lamp. Fig.2 shows the applied voltage dependence of the current density of the OLEDs. The OLED including TMK in HIL, suggested the higher current density. The current density of the light irradiated OLED, however, was exceedingly decreased. As the result of the light exposure, hydrazone derivative and TMK constituted the rresistant state.

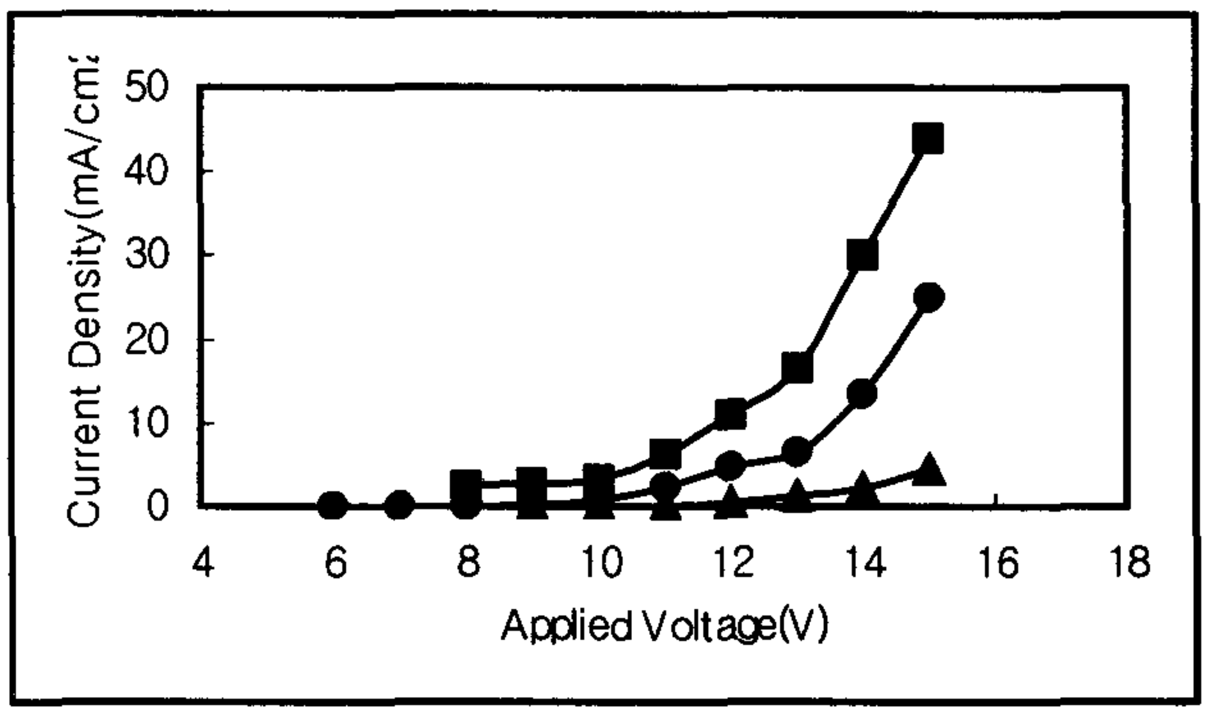


Figure 2. Current density of the OLEDs. 1)circle:original OLED, 2)square:OLED including 2.5wt%TMK in HIL, 3)triangle: OLED including 2.5wt%TMK in HIL, after the light exposure (450nm, 0.3J/cm2). Maximum absorption peak ofTMK is 450nm.

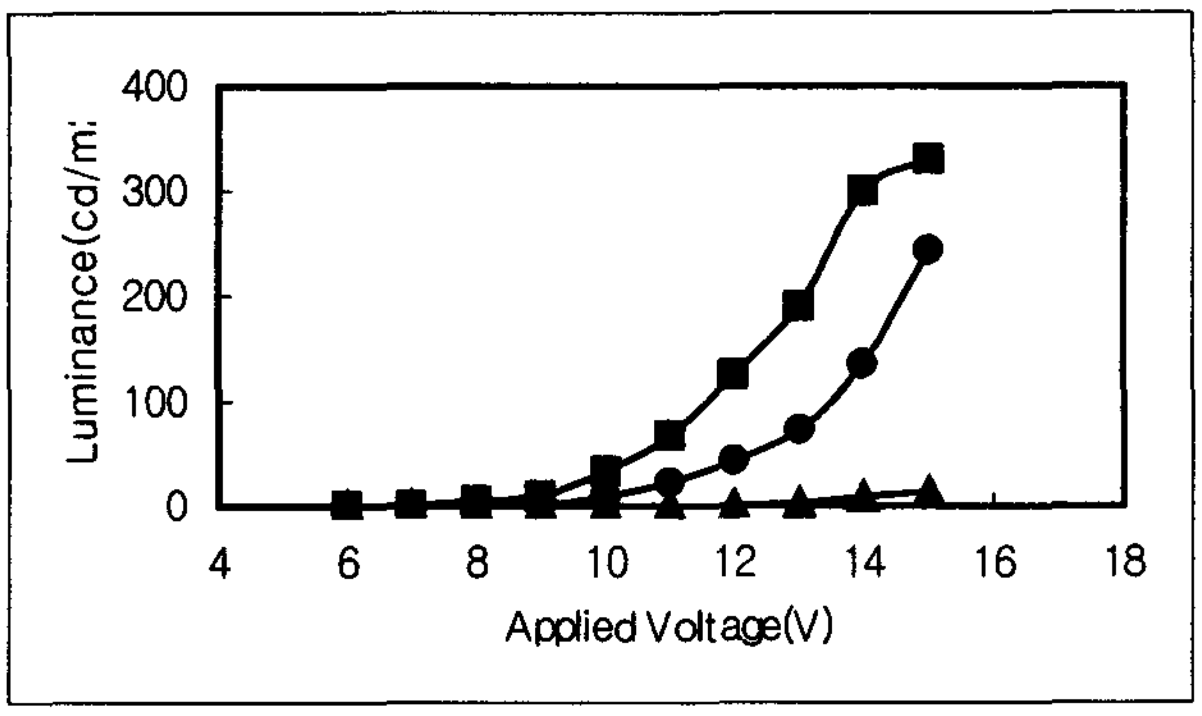


Figure 3. Luminance of the OLEDs. 1)circle:original OLED, 2)square:OLED including 2.5wt%TMK in HIL, 3)triangle: OLED including 2.5wt%TMK in HIL, after the light exposure (450nm,0.3J/cm2).

Fig.3 shows the applied voltage dependence of the luminance of the OLED. This luminanceshows the similar tendency to the current
density. Fig.4 shows the luminance of the OLED depend on the light irradiation time.Maximum absorption peak of the TMK is 450 nm. The luminances of the OLED were measured at 350 nm and 450 nm, individually. As we would expect, the luminance at 350nm exposure showed an almost constant, however, the luminance at 350nm exposure decreased with increasing the light irradiation time. The difference of the resistance of HIL appeared the OLED luminance. Therefore, the wavelength Dependence,difference of the irradiation amounts,was confirmed.

Heating temperature dependence for the erasability of the OLED also investigated in the range of 50℃ to 110℃. When the light was irradiated to the OLED, the luminance was rapidly decreased from 140(cd/m^2) to 10(cd/m^2). The light intensity is 20 mW at 450 nm for 15 min. After the light exposure, we added the thermal energy to the OLED by heating for 3 min. By this treatment, the luminance of the OLED returned to 12, 42, 88 and 130 (cd/m2) at the temperature of 50, 70, 90 and 110℃, respectively. Temperature dependence of the erasability was confirmed by this treatment.

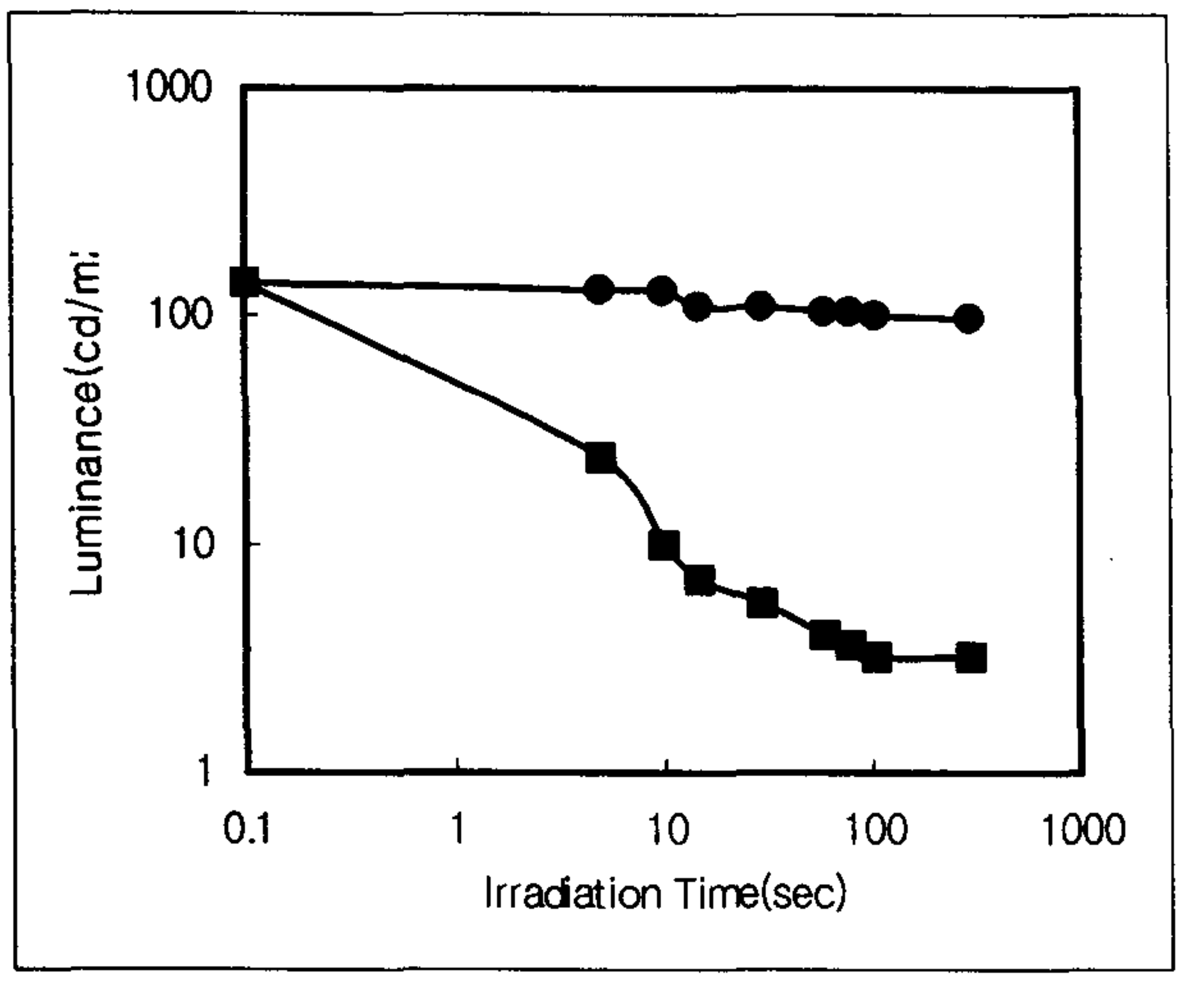


Figure 4. Luminance of the OLED depend on the light irradiation time and the wavelength. 1)circle;350nm,2)square;450nm. The OLED was irradiated
the light at 350 and 450nm, individually. After the light-exposure, the OLED was applied the voltage(AC14V), and measured the luminance.

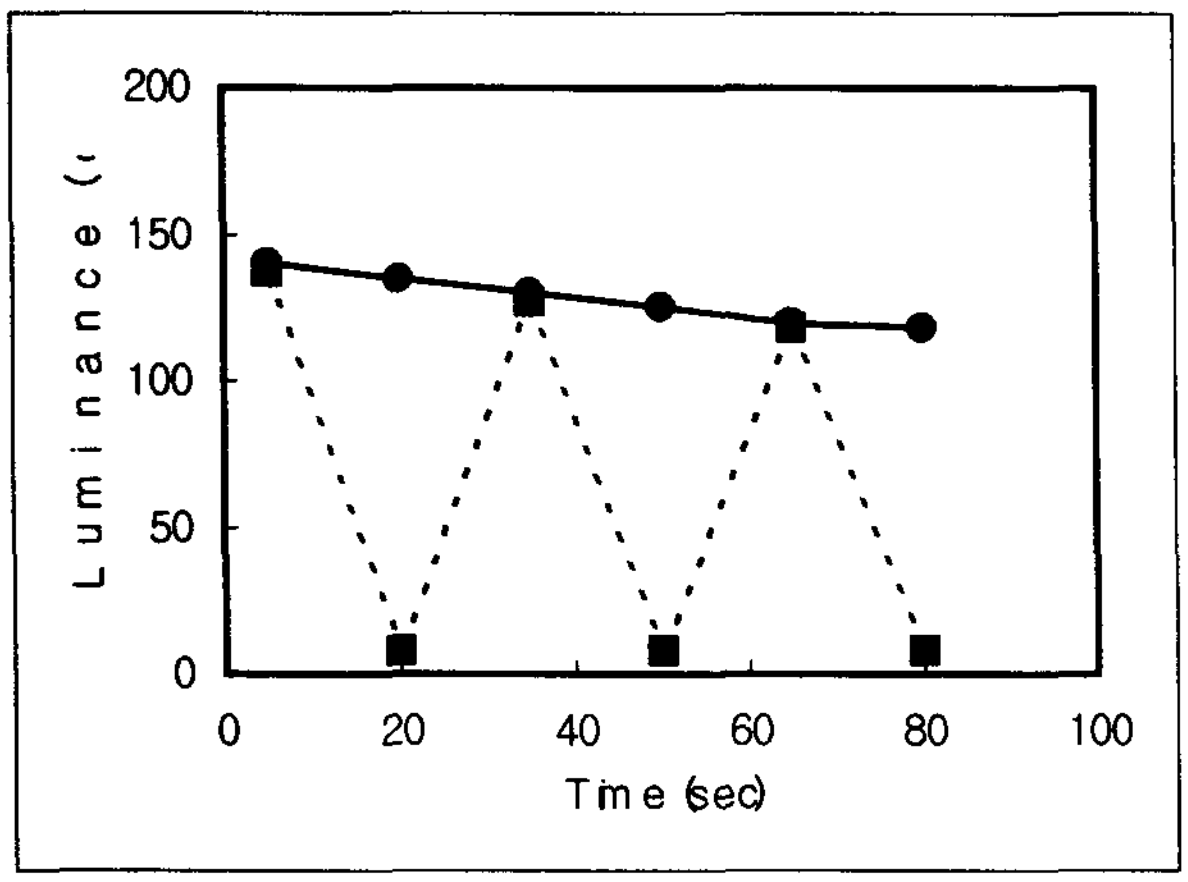


Figure 5. Erasability of the photo-induced memoryOLED. 1)circle;original OLED, 2)square; OLED
including 2.5wt%TMK in HIL.

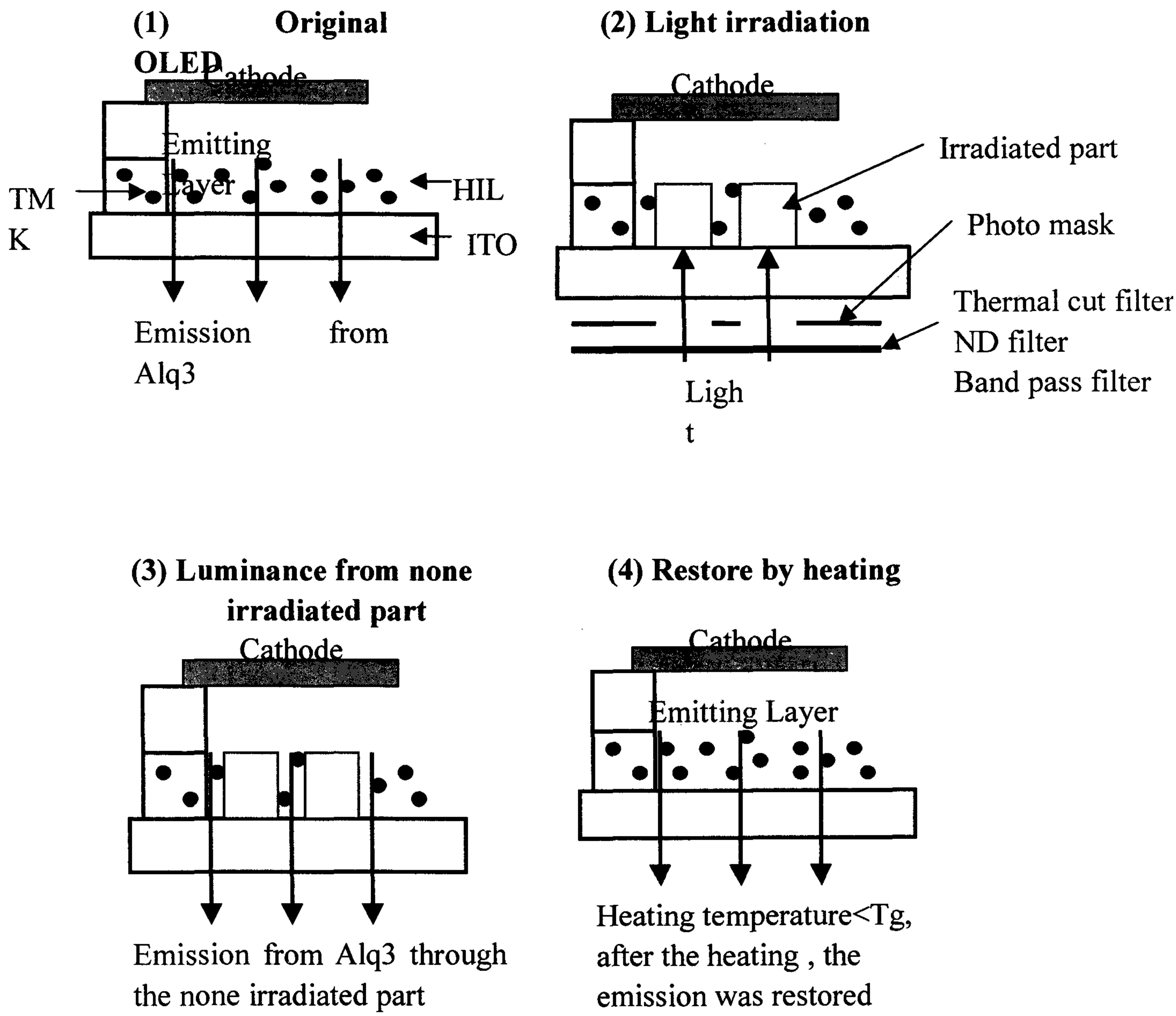
Erasability of the memory OLED was confirmed as shown in Fig.5. Memory effect is erasable by heating the OLED to the temperature higher than the glass transition temperature(Tg) of the HIL(80℃). Exposure(20mW:15sec) and heating(110℃:15min) was repeated. As shown of the luminance, the luminance was decreased by the light exposure, and the memory effect was erased by the appropriate thermal energy and returned to its original state.

3. Impact

For the application of the OLED technology, we focused to the erasable imaging plate by using the simple OLED structure. We found the phenomenon of photo-induced memory effect, and easily return to the original state by adding the thermal energy. This phenomenon was achieved by the addition of a small amount of TMK in HIL. This result is to be expected for the development of the OLED material technology to the other application.

4. References

1 T.Enokida and R.Hirohashi, ; "Morphology and Hole transport of butadiene derivative," J.Appl.Phys., 1991, vol.70(11), pp.6908.
2 A.Fujii, M.Yoneyama, K.Ichihara, S.Maeda and T.Murayama, ; "Memory effect of an organic photoreceptor and its application to a neutron model," Appl.Phys.Lett., 1993, vol.62(6), pp.648.


(1) Original OLED
Cathode
Emitting Layer
TMK
HIL
ITO
Emission from Alq3
(2) Light irradiation
Cathode
Irradiated part
Photo mask
Thermal cut filter
ND filter
Band pass filter
Light
(3) Luminance from none irradiated part
Cathode
Emission from Alq3 through the none irradiated part
(4) Restore by heating
Cathode
Emitting Layer
Heating temperature<Tg, after the heating , the emission was restored