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1997
Commercialization of the world's first Organic LED flat panel display (Pioneer)

~ Discrete Semiconductor/Others ~

In 1987, Eastman Kodak showed the possibility of realizing Organic LED (OLED) with high brightness and high efficiency of over 1,000cd/m² at a low voltage of less than 10V [(1)]. OLED displays are promising as next-generation displays because they are self-emitting, have a wide viewing angle, high contrast, and fast response time, and are structurally thin. Triggered by the announcement of Eastman Kodak, a flurry of development of OLED flat panel displays has been promoted.

As shown in Figure 1, the structure of an OLED element is a sandwich structure consisting of an organic thin film situated between electrodes. At least one of electrodes is transparent made of Indium-Tin-Oxide (ITO) because of the need to extract light. The operating mechanism is a carrier injection type, in which electrons and holes are injected from the cathode and anode into the organic light-emitting layer and recombine to emit light.

Eastman Kodak used electron-transporting Alq3 (Tris (8-Hydrooxyquinolin) Aluminum) as the light-emitting layer, and inserted a diamine derivative (TPD) layer which is called the hole transport layer between the light emitting layer and the anode. Carriers were confined within the organic layer, increasing recombination efficiency, and by making the thickness of the organic layer extremely thin (100 nm), low voltage operation was achieved.

Pioneer developed a four-layer structure of ITO/MTDATA/TPD/quinacridone-doped Alq/Alq/Li:Al from the anode side. The light-emitting layer consisted of Alq doped with 0.2-0.5% quinacridone as the luminescent center. According to the results of joint research with Osaka University, a starburst amine (m-MTDATA), which has a smaller ionization potential than the hole transport layer and is easier to inject holes, was inserted between the ITO and the hole transport layer. This lowers the barrier for holes injection from ITO to the organic layer, thereby lowering the driving voltage [(2)]. A low work function Li:Al electrode was used as the cathode to achieve an even lower driving voltage. The OLED provided a brightness of 300cd/m² at 4V, and the maximum brightness exceeded 100,000cd/m².
(Ref: The required for indoor displays such as home TVs is 350-500cd/m²):

Since organic LED was unable to use organic solvents based ordinary photolithography technology, it is necessary to develop another patterning technologies. Pioneer has developed a technology to automatically pattern the cathode by providing cathode partition with an inverted tapered cross-section on the substrate on which the anode is patterned. Using this partition as a shadow mask, the organic thin film and cathode were formed by vacuum deposition [3].

Pioneer has developed a 256 x 64 pixels passive matrix structure green monochrome flat panel display and launched the GD-F1, an in-car FM teletext multiplex receiver equipped with this display [4],[5]. With a brightness of 100cd/$m^2$and a wide viewing angle, the display has provided excellent visibility of "VICS" and teletext information inside of the car.

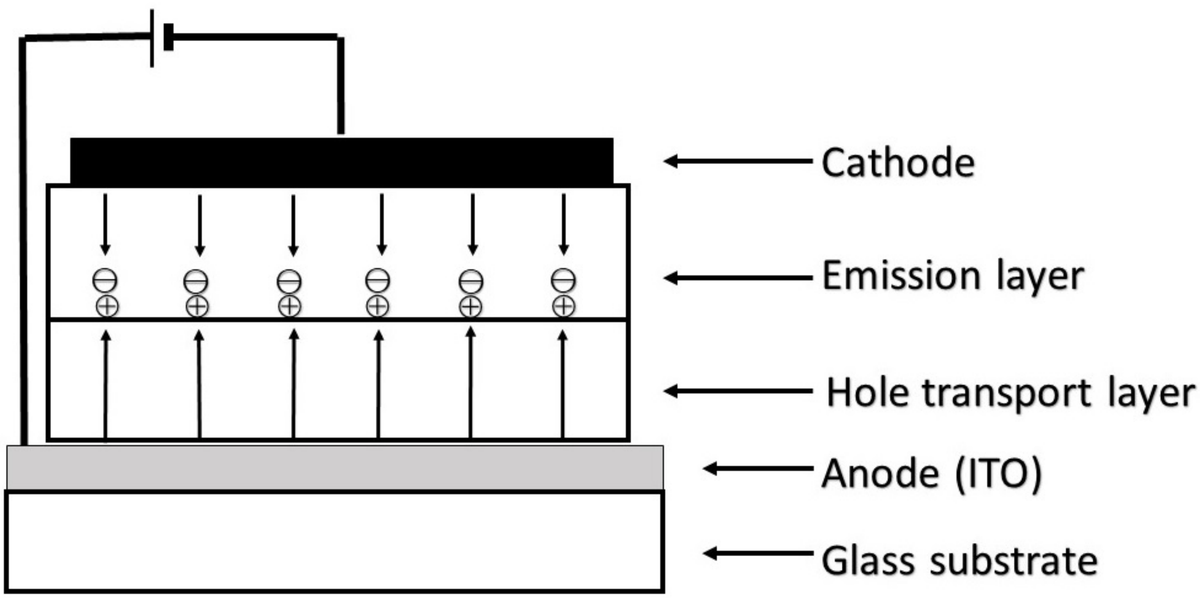

Figure 1　Cross-sectional structure of organic LED

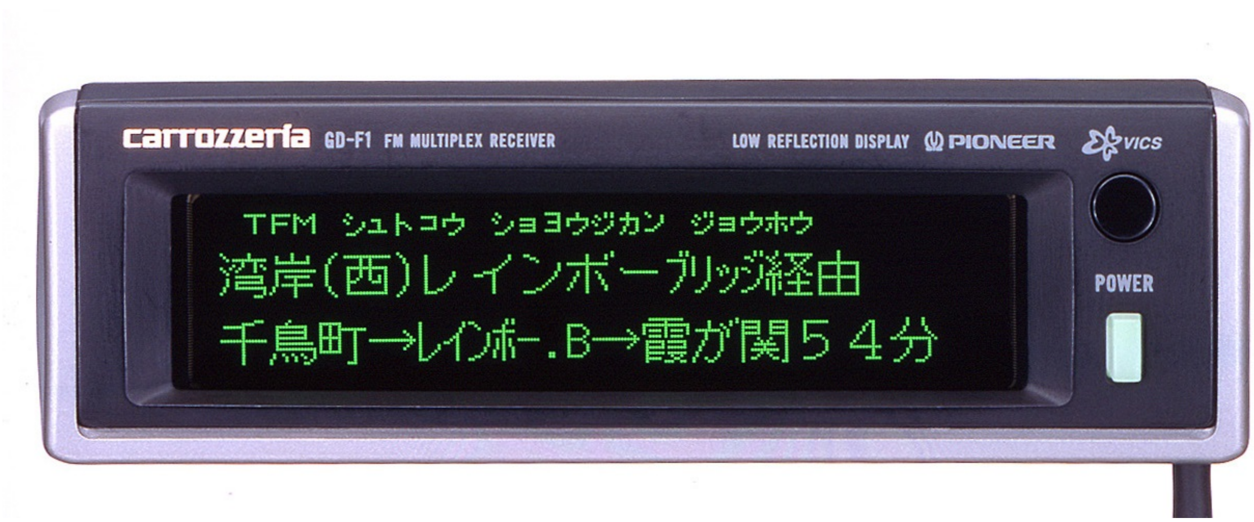

Figure 2　FM teletext multiplex receiver GD-F1（By courtesy of Pioneer Corporation）

References:

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【2】Y. Shirota, Y. Kuwabara. H. Inada, T. Wakimoto, H. Nakada, Y. Yonemoto, S. Kawami, and K. Imai, “Multilayered organic electroluminescent device using a novel starburst molecule, 4, 4’, 4’ – tris (3-methylphenylphenylamino) triphenylamine, as a hole transport material”, Appl. Phys. Lett. , Vol. 65, pp. 807-809, (1994)

【3】Hitoshi Nakada, “How OLED devices became practical”, Oyo Butsuri, vol.69, pp. 1113-1116, (2000) (Japanese)

【4】H. Nakada et.al. “Organic LED dot matrix display”, Digest of Inst of Image Information and Television Engineers Annual Conference, pp. 49-50, (1996) (Japanese)

【5】Pioneer Corporation News Release, “Industry's First Commercialization of Next-Generation OLED Displays Launch of the GD-F1 FM Teletext Multiplex Receiver for Automobiles” (Sept. 30, 1997) (Japanese)

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