New SMOLED Deposition System for Mass Production

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Abstract

We will introduce our new concept deposition system for SMOLED manufacturing in this conference. This system is designed to deposit organic and metal material to downward to overcome the limit of substrate size and process tact time hurdle for OLED mass production, and is organized with organic deposition chamber, substrate pre-cleaning chamber, metal deposition chamber and encapsulation system. These entire process chambers are integrated with linear type substrate transfer system. We also compare our new SMOLED manufacturing system with conventional vacuum deposition systems, and show basic organic thin film property data, organic material deposition property data, and basic device property.

1. Introduction

After OLED was optimized with Alq3 and TPD material at 1987 by Tang[1], OLED has been considered one of good display with property of thin thickness, light weight, good brightness, and fast response time. Because of these advantages, many universities and research centers have made efforts to upgrade the quality of OLED, currently many organic materials with good property have been developed. Currently, over 30 companies also have R&D OLED Line and some companies have mass production line. And those systems are mostly cluster systems and deposition tool is K-cell type using upward deposition method.

Generally, those OLED manufacturing systems have very low material using efficiency. Therefore, the deposition system maintenance interval is very short, and those systems have demerits for scaling up substrate size, fine shadow mask alignment issue, and shortening process tact time.

In this paper, we will introduce our new concept SMOLED deposition system. Our SMOLED deposition system can operate over 370 x 470(mm) substrate. Deposition source is located at outside of process chamber and the organic vapor moves through the hot transfer pipe to the scan-head which scanning over the substrate in process chamber. After that, the organic vapor which is ejected from the hole of the scan-head is deposited on substrate linearly. In our deposition system, both organic deposition and metal deposition use scan-heads which are moving over the substrate for all downward processes. The position of fine shadow mask is at upper side to substrate and there is no need for the substrate being rotated to enhance organic film uniformity

At experiment section, we will show our new OLED deposition system scheme, organic material vapor generation source basic data that shows controllability for deposition rate by dilution gas, and downward deposited metal thin film property. And we also propose OLED mass production scheme

2. Experimental

The new OLED manufacturing system realized by ANS Engineering Team is for overcoming the latest OLED manufacturing majority issues and we named this system as DSP(Digital Scanning Process) because the organic and metal vapor deposition scan-heads are digitally controlled.

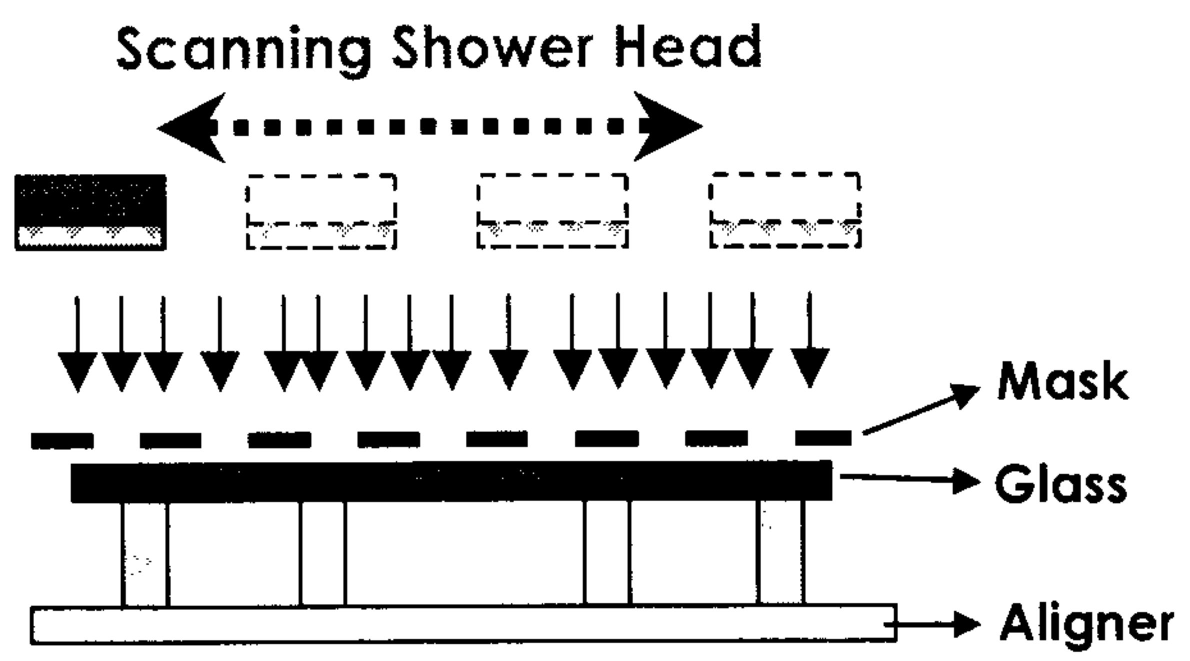

Fig1. The schematic figure of ANS's DSP. Scanning shower head which injects organic vapor linearly moves above substrate and mask.

The organic vapor injected by scanning shower is transferred through the transfer pipe from the organic vaporizing source by inert gas. We thought that this scheme for organic vapor transferring is good for mass production system and will make OLED production line more simple and compatible. We will compare our system with general VTE(Vacuum Thermal Evaporation) system[2]. The summary is Fig 2.

	DSP	VTE
Substrate size	> 370 x 470 (mm)	~ 370 x 470 (mm)
Deposition direction	Top to Down	Down to Top
Material efficiency	~ 50%	~ 5%
Organic source cross contamination	No cross contamination. Sources are separated outside of deposition chamber	Cross contamination. Limited Sources are used.
System flexibility	Easy to add chamber	Difficult for adding system
Process reproducibility	Good reproducibility by using gas control	Not good by using crystal oscillator

Fig 2. The Comparison with DSP and VTE

At the see of Fig 2, the DSP is designed for mass OLED production system. The organic material capacity of DSP is over 100cc, and material efficiency is estimated about 50%. Therefore, the production system down time for organic material refill and system cleaning will be less frequent than VTE system.

Fig 3. shows the dependence of our DSP organic source vs. injected gas flow rate. If the injected flow rate of Ar gas is 50sccm, we can achieve max deposition rate as about 50Å/s. Therefore the deposition process time will be shorter than other deposition system. But this deposition rate is not real deposition rate because our system is using scanning shower head.

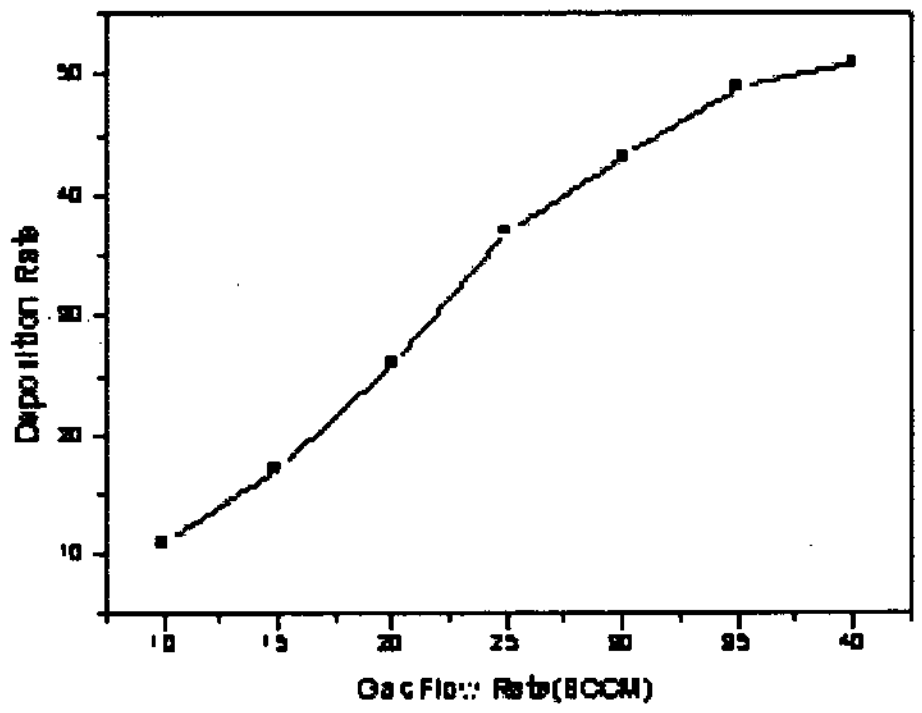

Fig 3 Dependence of deposition rate vs. injected gas. This plot shows the max. deposition rate is about 50Å/s.

We also checked deposition rate, and the test is made in situation of crystal oscillator being located at scan-head moving start point. The fig 4. shows the deposition rate and thickness for DSP.

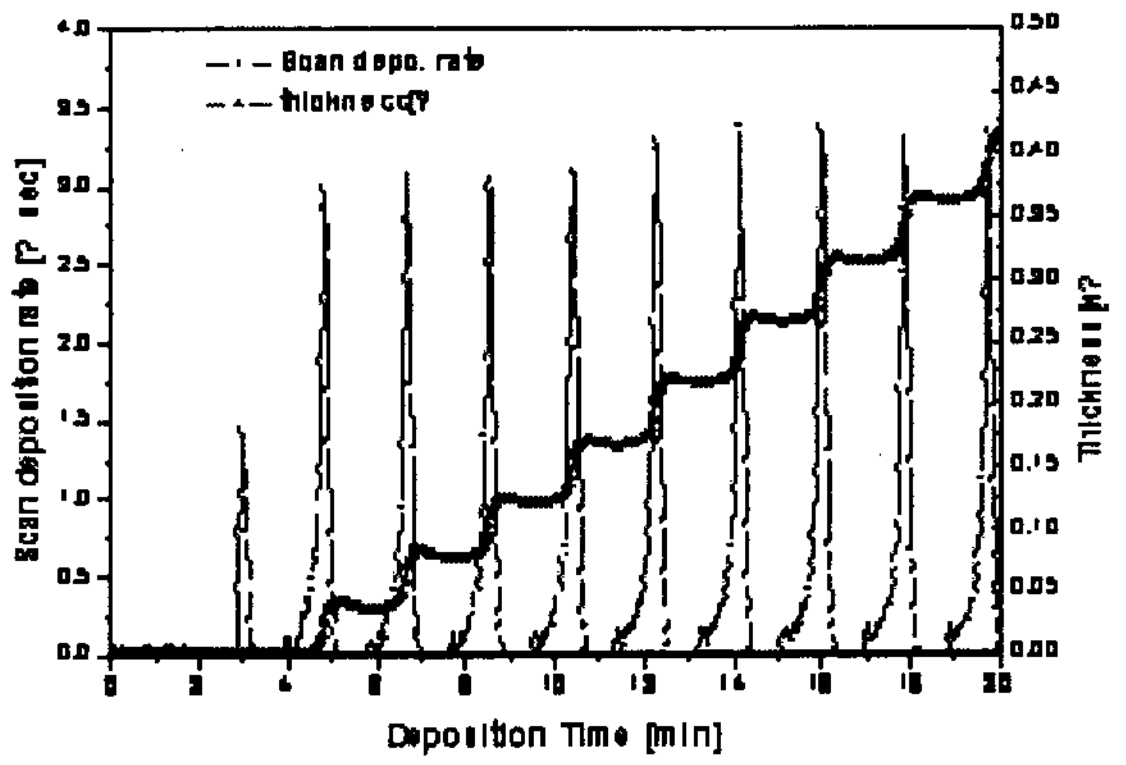

Fig 4. The process condition is as like: The injected gas flow rate is 7 SCCM, the max deposition rate at scanning head is 3.0Å/s ~ 3.25 Å/s

Fig 4 shows that the scan-head moving interval is 2 minutes 20 seconds . If the scan-head moves to crystal oscillator sensor position, the rate increases and when the head moves to the opposite position, the rate decreases. When the deposition head moves repeatedly, we measured the thickness, and the change of thickness. The amount of thickness increase is constant, when measured scan by scan. Therefore, we can assume that the deposition process is being done in stable condition, and is controlled by controlling the injected gas.

We also designed metal downward deposition chamber. DSP metal downward deposition chamber is integrated with DSP organic downward deposition chamber so that to prevent flip of substrate during the organic and metal process. The deposition source is also located over the substrate and this deposition source moves linearly for covering large area substrate. However, the distance between the deposition source and substrate is larger than organic deposition system. The larger distance between substrate and source is required for lessen the thermal damage from metal deposition source.

With this metal and organic deposition system, we designed new concept SMOLED manufacturing system. Fig 5. shows our system outline for mass production and also test system is in our lab. floor. This test system is configured with an organic deposition chamber, a metal deposition chamber, and a glove box. The glove box is located center position and two deposition chambers are located at right and left position each. Our test system is capable of process 370 x 470(mm) substrate and 4 organic deposition sources and 2 metal deposition sources are installed. So by using of this test system, we made single organic layer and basic OLED device.

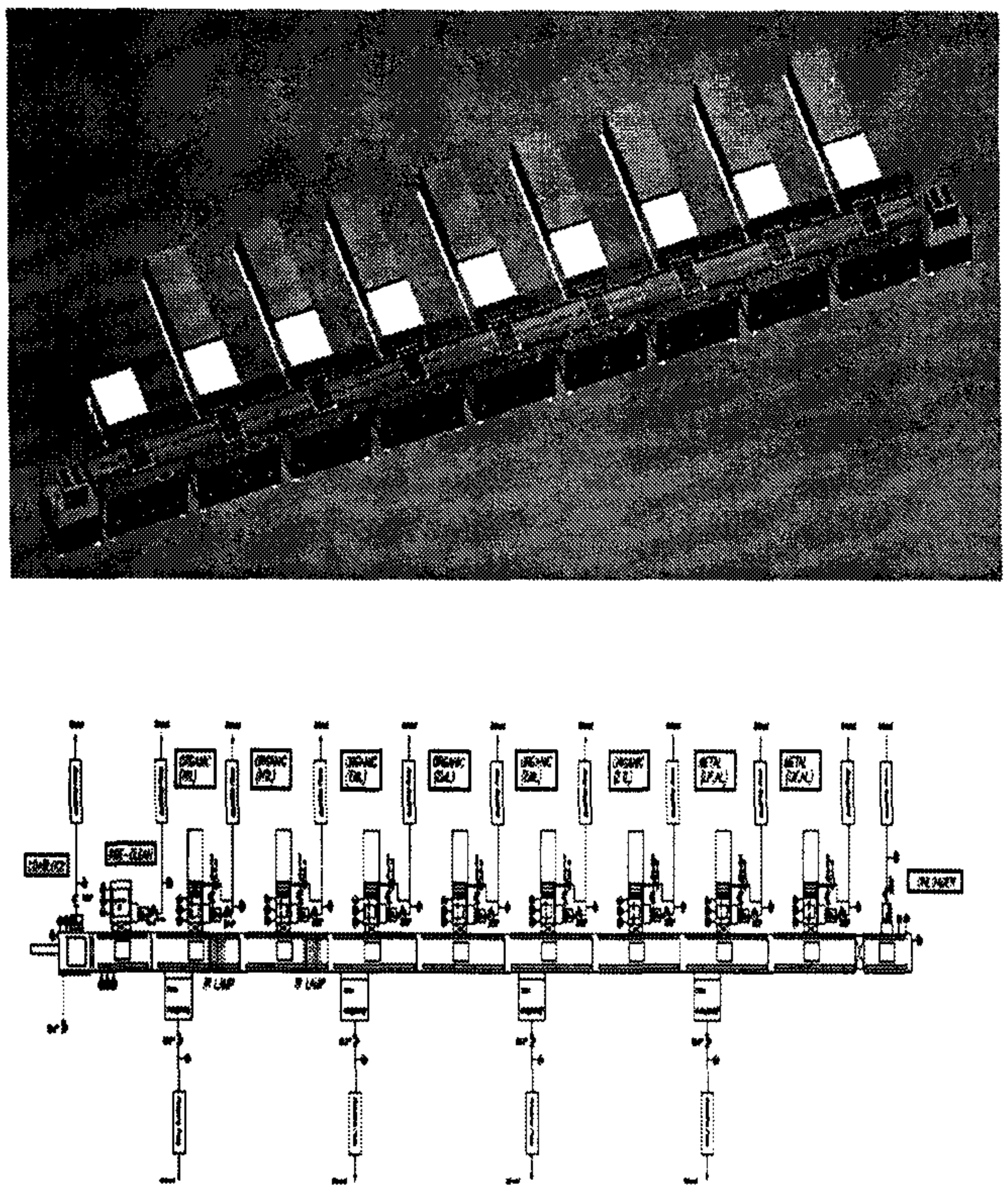

Fig 5. DSP Mass Production System layout.

In above Fig 5 shows our DSP Mass Production System layout and configured as pre-cleaning, organic, metal and Loadlock and Unloadlock chambers.

With using our DSP test system, we checked organic and metal film thickness uniformity, organic film property of AFM, metal film property of SEM, and the PL property of Alq3 and NPB film. Fig 6 is summary of this basic property of our DSP.

a)

Organic Film AFM data (RMS)	13.2 Å
Film thickness Uniformity (organic)	±4.2% (370 x 470mm)
Film thickness Uniformity (metal)	±6.5% (370 x 470 mm)
Organic film PL measurement	Alq3 (512 nm) NPB (451 nm)

b)

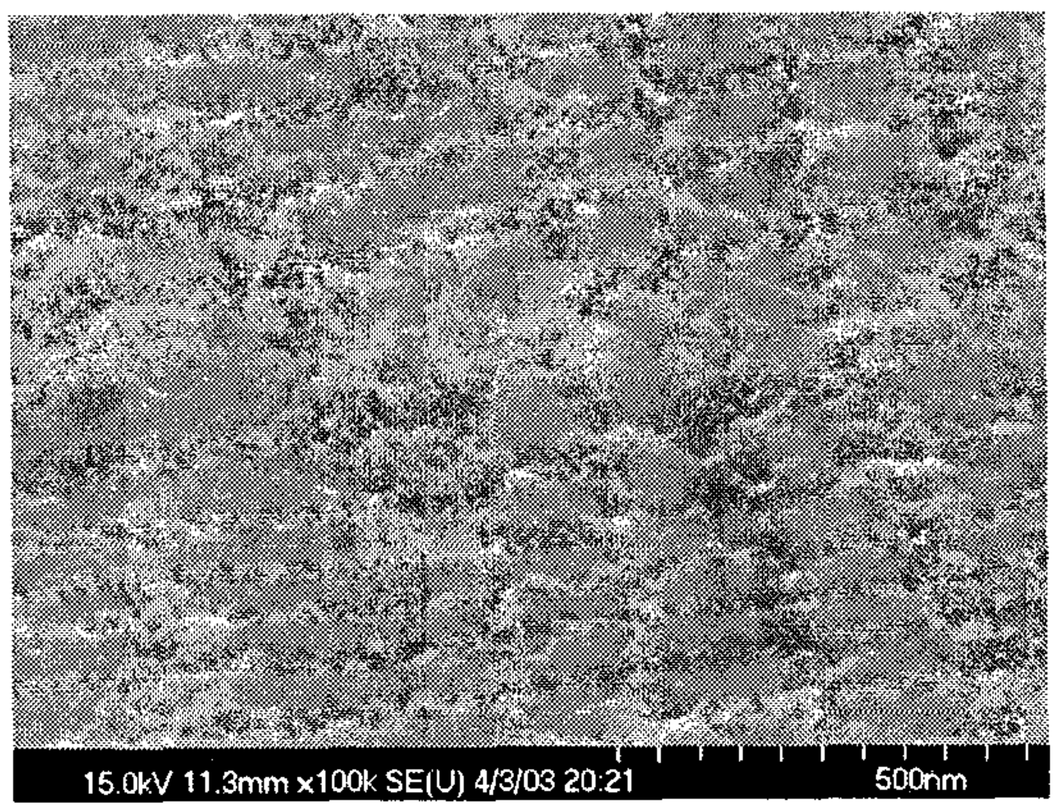

Fig 6. a) Summary of DSP basic process data.
b) SEM image of Al film. deposition rate :7Å/s, film thickness : 2000Å

Finally, we made OLED with our test system and checked the device property only with eye. The device structure is NPB/Alq3/Al, and we will check the electrical property of device for comparison with the device made by K-cell system. We made device with test cell substrates which size is 370mm X 400mm and shows in the photograph Fig 7. When we check the device with eye, there was no defect therefore we could know the high possibility of our system. The next schedule of our lab. is that we will make doped emission layer, encapsulate the device with metal or glass can and also make display with fine pattern.

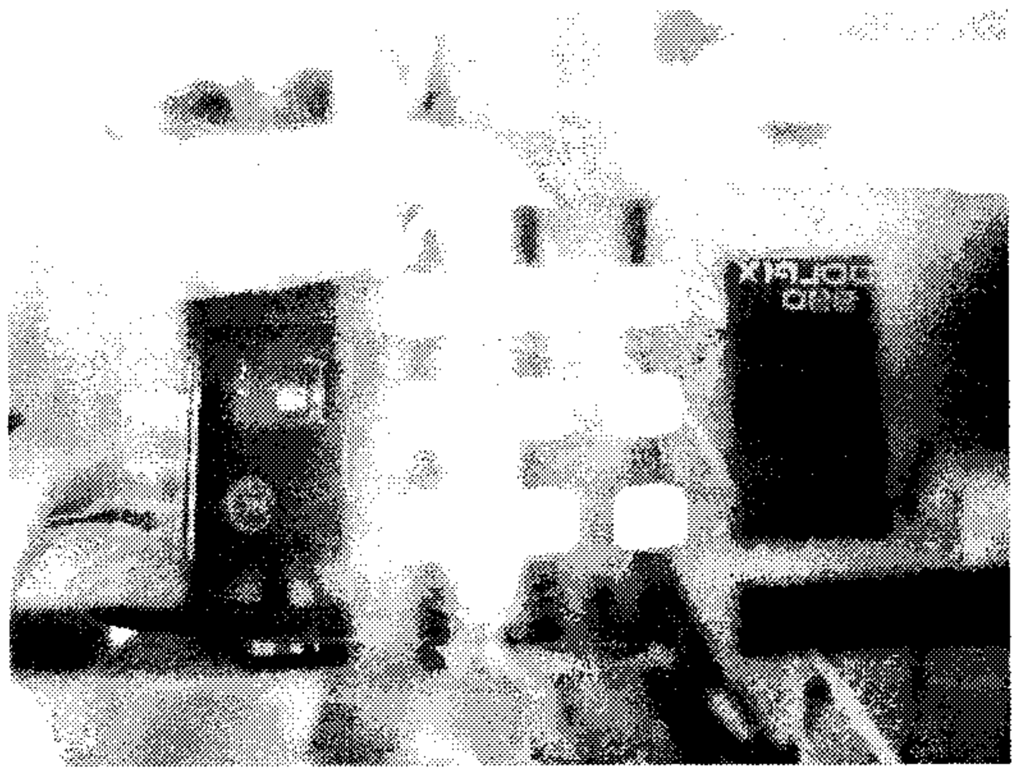

Fig 7. The photograph of device made by DSP. The substrate size is 370 X 400 mm.

4. Conclusion

Until now, the industry of OLED made much development and on this development, many issues for OLED mass production system was found. So, we developed new concept SMOLED downwards deposition system and this system is very good for large size substrate process and fast tact time. We believe this DSP system will be the best solution for OLED mass production soon.

5. Acknowledgement

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6. References

[1] C. Tang and S.Slyke, Appl. Physics. Lett. 51, 913 (1987).

[2] M. Schwambera, N. Meyer, M. Gersdorff and M. Reinhold, SID 03, 52.3 (2003).

[3] M. Shtein, H. F. Gossenberger and S. R. Forrest, JAP. 89, 1470 (2001).