SMOLED equipment for Mass-production

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Abstract

It is very important to get a stable and large-capacity organic effusion source for achievement of OLED mass-production equipment. We present an organic effusion source with film uniformity less than ± 5%, the material charge volume, 300cc for 400× 400 ㎟ substrate. The fine metal shadow mask alignment technology, one of the color forming technique, also have to support more accurate and fast operating in mass-production. In this paper, we will describe the OLED mass-production equipment with the large volume effusion source and the precision shadow mask alignment technique.

1. Introduction

As OLED is applicable to many other fields, it is more interested in mass-production equipment. Mass-production equipment has to support high efficiency, shorter tact time, excellent film uniformity, easy maintenance, precision mask alignment technique.

Organic evaporation source is one of the most important factors in mass production system design. It must be provided with large capacity, stability of deposition rate for a long-time process and excellent film uniformity correspond to large substrate.

Organic materials are so sensitive to heat that they might be degraded or lose stability of rate control in case of long-term process. Therefore organic evaporation source needs accurate control of heat. We intended to control heat capacity of top plate, which composed of patterned molybdenum or tungsten plate and ceramic or quartz cover.

Shadow mask alignment technique, one of the color forming methods, is another important factor in system design. Generally, it provides with ± 5㎛ tolerance. But it is more difficult to align due to mask sag and deformation as shadow mask is larger in proportion to substrate size.

In order to overcome these problems, we suggest a new system concept for precision shadow mask alignment technique.

2. Evaporation source for mass production

Figure 1 shows schematic of chamber equipped with organic evaporation source, which can cover more large substrate size, 400x400㎟. Evaporation source is fixed with suitable deposition height and offset distance.

With this system, we deposited Alq3 on 400× 400㎟ substrate and then measured film uniformity. Also we calculated and measured efficiency and deposition rate controllability of our evaporation source for mass-production after we deposited film.

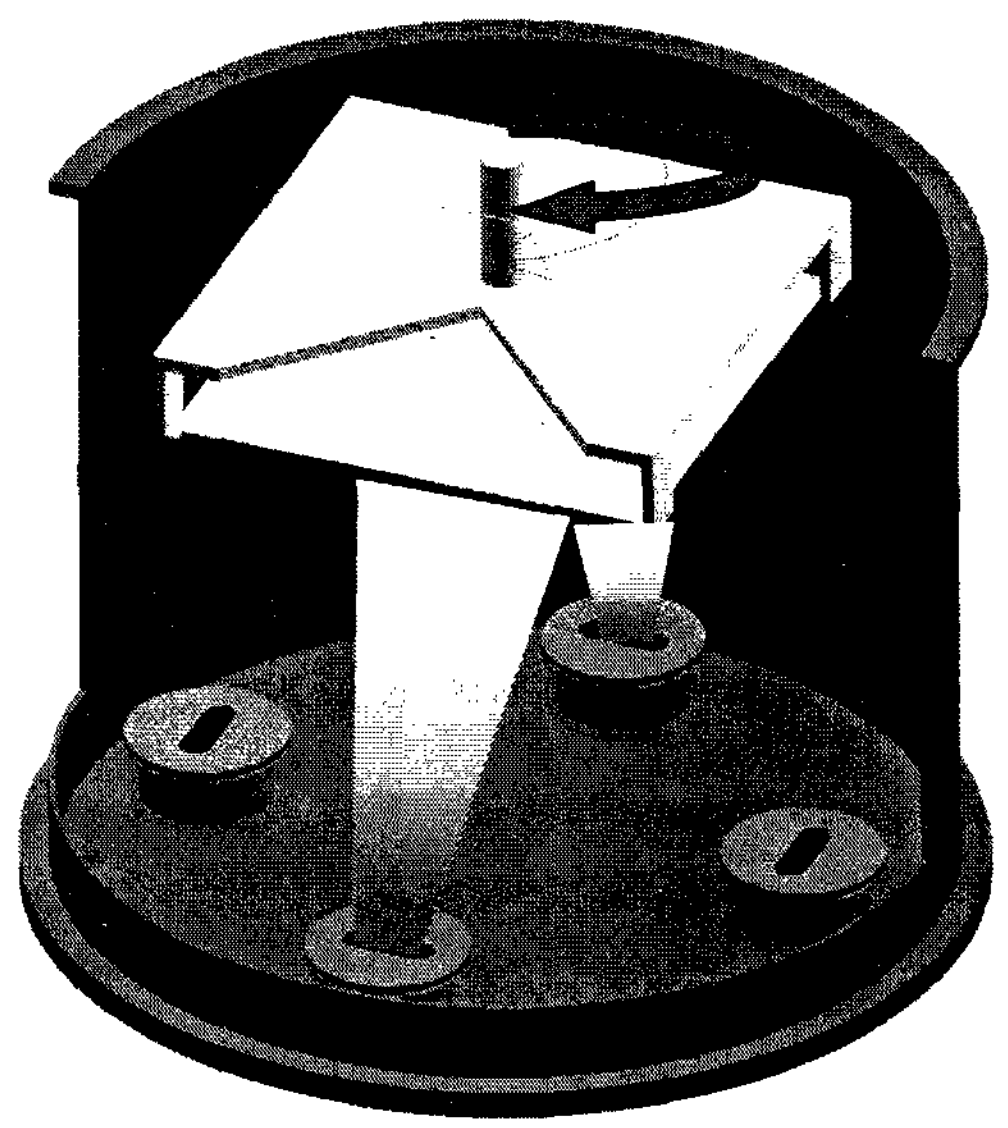

Figure 1 Schematic of chamber equipped organic evaporation source

Figure 2 is a schematic of mass-production organic evaporation source. It composed of ceramic or quartz top plate heater, side heater, and quartz crucible. We can control heat capacity using patterned molybdenum or tungsten plate and side heater. The side heater, which can be made from Al or inconel, prevent contamination of the crucible and add heat to the crucible.

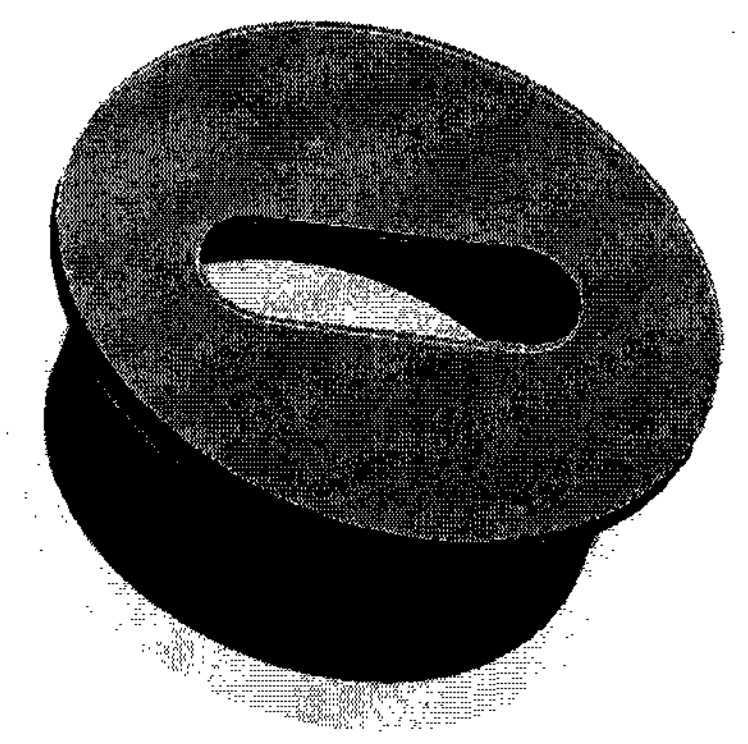

Figure 2 Schematic of evaporation source for mass production

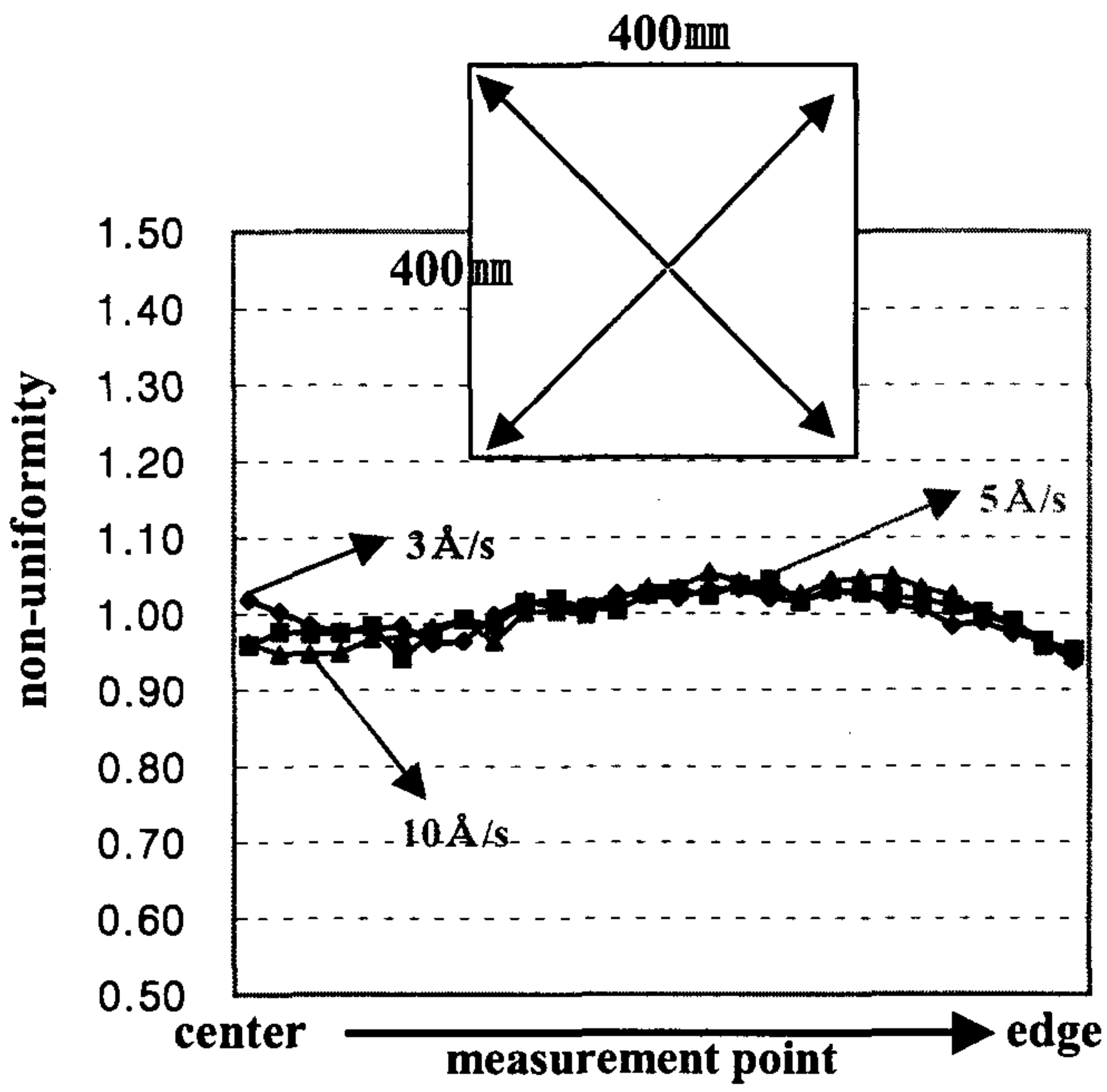

Figure 3 Film thickness distribution of Alq3 on substrate(400× 400㎟)

Figure 3 shows thickness profile after deposit about 1000Å on substrate. The uniformity is about ± 5 % in 400X400㎟ in large substrate. There is almost no difference of uniformity as deposition rate.

We also deposited Alq3 using each two mass production source simultaneously. When we deposited simultaneously we expected that deposition rate was doubled. In process test, after we deposited of 3Å/s by each evaporation source we measured the total thickness of the deposited films. And we could gain the result that real deposition rate was 6Å/s.

This means that if we need to increase deposition rate, we may use several evaporation source. When we design the system, it can be considered in source geometry.

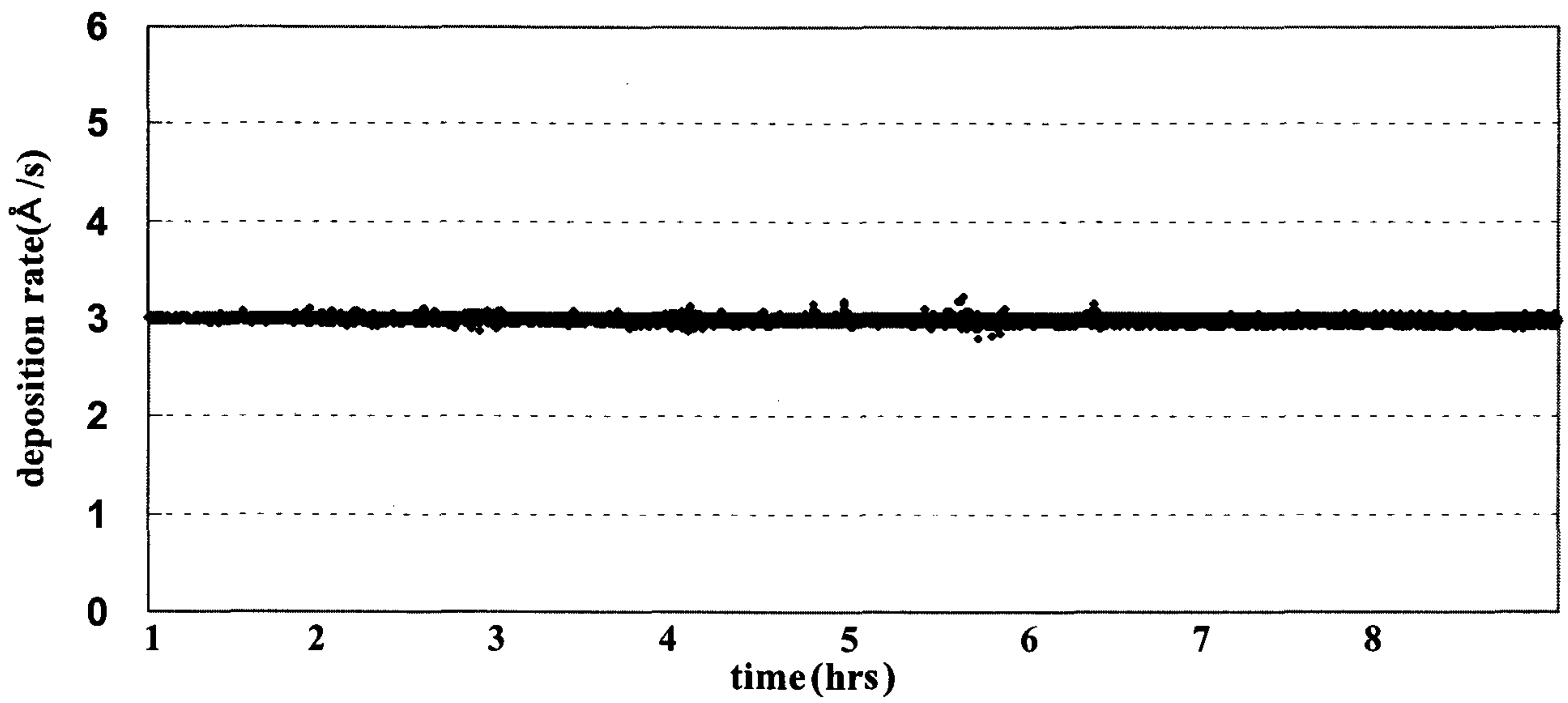

Figure 4 Deposition rate deviation during 8hours deposition process.

Figure 4 is a deviation rate of deposition rate, 3 Å/s during 8hours deposition process. The deviation value is about ±7%. It shows generally stable deviation rate during the process

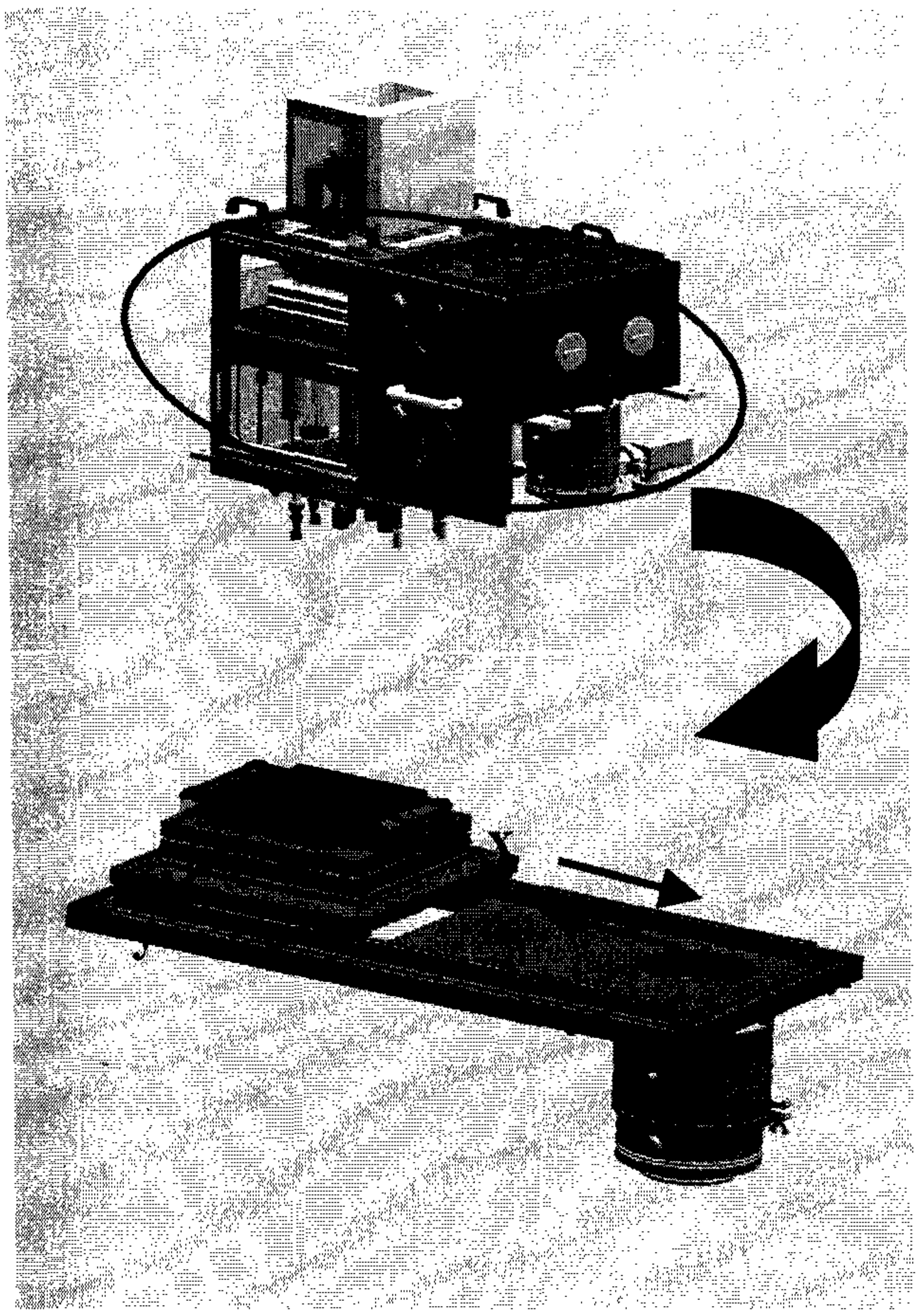

Figure 5 Schematic of Metal shadow mask alignment method

3. Shadow mask alignment technique and equipment

In order to realize full color OLED panel, metal shadow mask alignment technique is used the most. Generally, the alignment between glass and metal shadow mask must not be excess an error,± 5㎛.

But as the substrate size is larger, the shadow mask has to be larger. This may cause a difficulty in precision alignment because of sag and deformation of shadow mask.

Figure 5 is a schematic of mask alignment concept and equipment to resolve above problems. It can align400×400㎟ glass and shadow mask within ±5㎛ tolerance

It consists of x, y,θ align table, which can shift the mask table to x, y, θ direction, and mask table. Because x, y, θ Align table, which can also plays a role as a main shutter, is equipped in chamber, align process is possible at the inside of organic deposition chamber. So we need not prepare another mask align chamber. As you can see figure 5, metal shadow mask can be suppressed its sag or deformation because it is placed on the mask table.

After align process is finished, the glass and shadow mask are attached by attach-detach equipment, which use permanent and electro magnet and was developed by ANS.

In this new alignment process, it takes 15 seconds to align with glass and shadow mask including glass-moving time to align position. And real alignment time with glass and shadow mask is less than 2 seconds.

This method will offer shorter tact time and more precise alignment between glass and metal shadow mask.

4. Mass production system, HELYSIS-XP

HELISYS-XP is an area-color & full color organic light emitting device deposition system for mass production. This system is capable of continuously forming organic thin films comprising a hole-injecting layer, a hole-transporting layer, an emissive layer, an electron-transporting layer and an electrode in vacuum. Applicable substrate size is 400mm × 400mm on this system. Tact time is 5 min. to make a full color OLED device.

This system consists of the followings

1) Loadlock chamber
2) Pre-treatment chamber
3) Organic process chamber A x 3 sets for HIL, HTL, ETL
4) Organic process chamber B x 3 sets for EML (R, G, B)
5) Electrode process chamber x 2 sets
6) Buffer chamber
7) Octagonal substrate transfer chamber x 2 sets
8) Operation and control system

This system is configured as single robot arm based cluster type and enable to get excellent film thickness uniformity and mask alignment between a substrate and a mask with CCD camera for forming precise dot matrix.

5. Summary

In this paper, we suggested a mass production SMOLED system. It can achieve non-uniformity of ± 5% for 400× 400㎟ substrate. We also proposed new concept for precision alignment technique and equipment. It can support an error less than ± 5㎛. On the basis of theses technology, we designed n production system, HELYSIS-XP.

6. References

[1] H.K.Pulker, Coatings on Glass, p170-189. (1984)

[2] Russell J.Hill, Physical vapor deposition (1976)

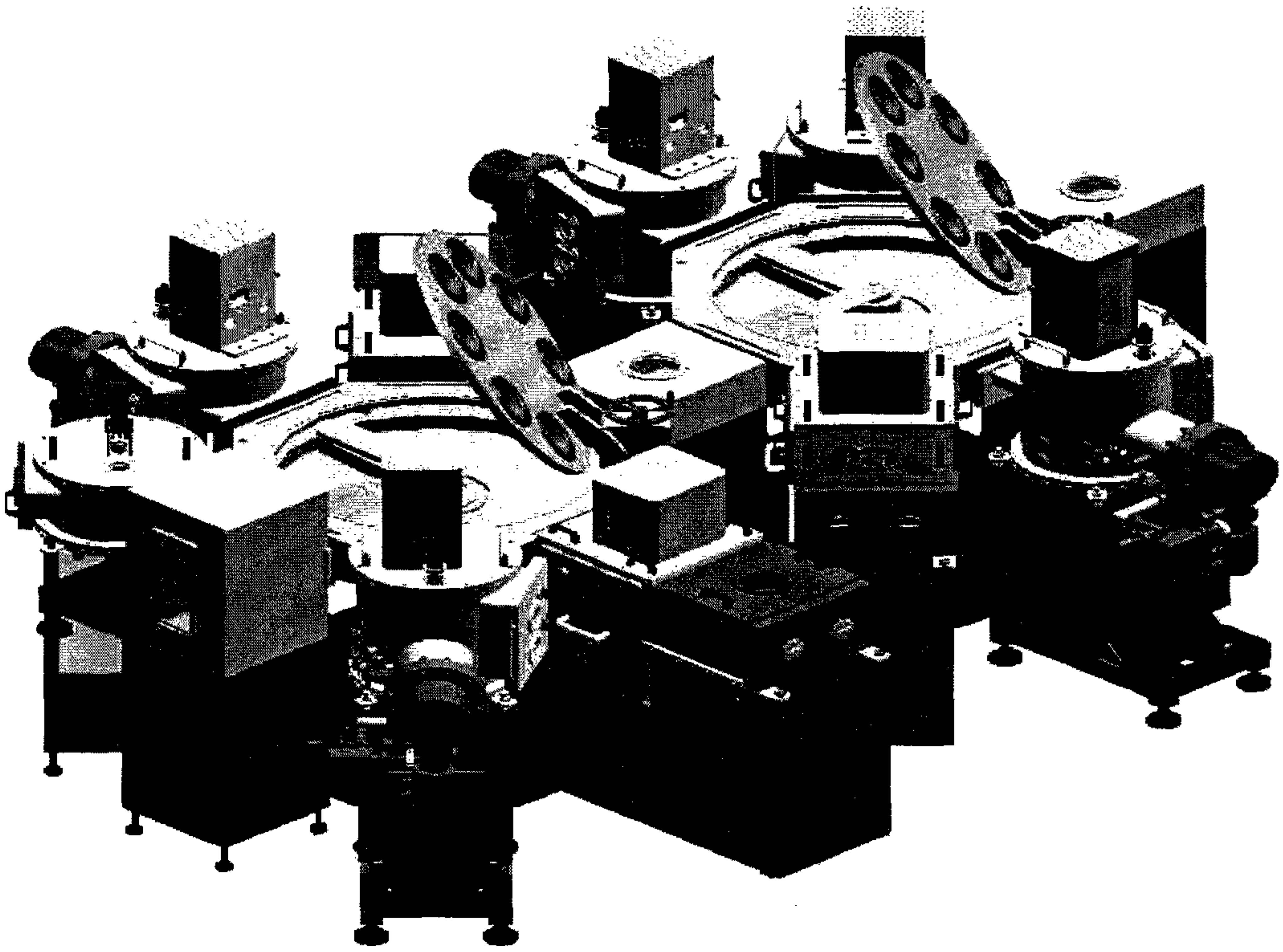

Figure 6 Schematic of HELYSIS–XP