Development of Inorganic Alignment Technique with One Drop Filling Processon LCoS Panel

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Abstract

One-Drop-Filling (ODF) process is an advanced vacuum filling process in LCoS manufacture line. The merits not only increase the throughput of liquid crystal filling process but also reduce the number of equipments. Studying application of ODF process in LCoS panel manufacturing is the purpose of is this article. The accuracy of liquid crystal drop size, the stability of seal dispensing and the nozzle size etc. In the tiny panel manufacture are more important than those factors in normal panel manufacture.

1. Introduction

Traditional liquid crystal injection process use capillary phenomenon and pressure difference between panel inside and outside to make liquid crystal into empty panel. All processes include eight steps: seal dispensing, seal curing, assembly, scribing/breaking, liquid crystal injection, end seal, panel cleaning and isotropic. In above processes, we must consider about exhausting speed, vacuum situation, dipping time and leaking start time and so on. For ODF, the first procedure is to drop fixed quantity of liquid crystal on panel's center. Then using vacuum assembling technology to make liquid crystal diffused to all area of panel. Contrary to traditional injection process, ODF process only has five steps, seal dispensing, assembly seal, UV exposure and scribing/breaking. ODF process must consider about the accuracy of LC quantity, suitable seal thatmatch with LC etc. After analyzing advantage and disadvtage, ODF process technology is better than traditional liquid crystal injection process, no matter how process convenience is or what process time is.

2. Experimental

2.1 Material

One of the most important factors in ODF process is to choose the materials. To avoid the sealant polluting the liquid crystal, we must insure that sealant and liquid crystal won't interact with each other. Recently, the alignment method in LCoS has a tendency toward inorganic mothed because of its good performance. After estimation, we use vertical alignment material instead of polyimide. Fig.1 shows the chemical structure of this kind of liquid crystal.

In ODF process, cell gap will be influenced by the quantity of sealant and the spacer size. Besides adding spacer, the uniformity, purity and bubble-free are all concerned in the sealant. Generally speaking, the viscosity of the sealant used in ODF process is more than 200,000 cPs. The sealant may stop in the middle if the dispensing speed is too high or dispensing quantity deficient. Compared with traditional epoxy sealant, the character of improved UV sealant such as adhesion force, durability and moisture-proof is better. At present most of the ODF sealant is consist of epoxy sealant and UV sealant.

In addition, substrates need curing process to solidify the sealant as soon as possible because this sealant is still unstable after assembling procedure. The material and operating condition used in the experiment is as following. Table.1 Materials & Operating parameter.

2.2 Equipment

The optical system for the ODF system consists of seal dispenser, liquid crystal dispenser, vacuum assembly chamber and UV exposure module, Fig.2 shows basic layout of the topic liquid crystal drop and vacuum assembling process. The drop amount of liquid crystal error in the LCoS panel must be accurately controlled within 1.5%.

The vacuum assembly system is the device to align the wafer with dispensed sealant and drop liquid crystal at one side and the ITO glass at the other side in vacuum environment, then assembles them by pressure bonding at atmospheric pressure. The angle of assemble error of wafer and glass is within 0.1 degree, and the assemble position error within 50u.

2.3 Amount of LC

The amount of LC is based on our design of seal pattern and cell gap. We calculate the definition size of seal pattern in central line of seal. Our seal design and the amount of LC are in the followings:

Where L, W and H are the length, width and cell gap of central line of seal, respectively. The seal breadth after assembling is about 1.00mm. We assume that the seal would extend 0.5mm away from the central line in two directions. Then the LC drop area A would become 153.00 mm^2. The LC density is about 1.00g/cm^3. Consequentially, the weight of LC per panel is 0.306 mg.

3. Results and Discussion

3.1 Experiment process

The flow chart of our experiment is shown in fig.4. We use two substrates, which the upper substrate is ITO glass, and the bottom is silicon wafer. First, the two substrates are cleaned by D.I. water. The pre-cleaning process has important relations with the next processes. For example, if there were particles on substrates, then these particles would cause the non-uniform cell gap of assembled panel, and reducing the quality of projecting image. Second, the process is the deposition of inorganic alignment layer. Third, we use the dry cleaning technology to remove the dust on substrates coming from deposition chamber. Fourth, UV seal dispensing and LC ODF process on wafer, which is shown in Fig.5. We align the head to drop the LC in the center of seal pattern. In this process, we will use dummy glass to measure the cross-section area of UV seal after dispensing, and we measure the weight of LC drops. In our panel design, the panel size is so small that we need to measure the weight of 20 drops LC for the limitation of the precision of the electronic weighting scale. Fifth, we assemble two substrates together in the vacuum chamber. It is very important to optimize the venting parameters with regarding to the panel performance. Sixth, we put the assembled substrates with UV seal and LC into the UV curing machine. Since the LC in panel would be damaged by UV light, we need a mask with the specific pattern to avoid the LC from injury. Finally the assembled substrates are put into oven to do the post bake of seal and isotropic of LC as well.

3.2 Newton Ring

In this experiment, Newton ring can apparently decrease by controlling the vacuum condition and the amount of liquid crystal. Because no spacer supports cell active area, the cell will decline in center region. The surface of the cell are showed wavelet (Newton ring) if cell gap is not uniform everyplace. Acceptable criterion is under 1.5 fringes. Exceeding the number, (1.5) would causes serious influence on contrast ratio and gray level of cell display. Fig.6 is the motion of Newton ring.

In this test we control the change of vacuum situation to reduce the produce of Newton ring, so in the section of assembly process the yield can up to 70% for conservative calculation. Fig.7 is the Newton rings properly controlled fewer than 1.5 fringes.

3.2 Result

In the experimental process, we have to take care of liquid crystal without permeating into seal at the beginning of ODF process. Expanding process time between assembly and UV exposure, contamination is showed on interface of liquid crystal and seal. If we do not instantly expose cell to UV exposure right after assembly, the pollution phenomenon will occur easily. According to contamination and injection insufficiency situation happening to our experiment, liquid crystal drop point and amount need to be curbed carefully. We ever encountered the drop spread on active area when we started ODF process. Because nozzle choked, this can improve immediately after wiping off clog.

We observe this panel in on-state and off-state to see the projected image without Mura, so we find that ODF liquid crystal filling process technology can be applied to LCoS panel manufacture. Fig.8 is the projected image used ODF technology. In the future, one of our most important works is to match liquid crystal material with seal property, so we must accompany the assurance test to verify about liquid crystal contamination.

Conclusions

In this paper, we apply the ODF liquid crystal filling process technology in the LCoS panel manufacturing. We had optimized the effects of seal and liquid crystal dispensing, and the conditions of assembling chamber. We also succeeded in switching on the panel, and get good projected image. In the future if the materials problem could be verified properly, the tact time and yield of LCoS manufacturing can be promoted by ODF technology.

Acknowledgement

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Table 1. Materials & Operating parameter

Materials	Type
Sealant	Type A
Sealant viscosity	> 200,000cps
Curing illumination	100 Mw/cm2 (10sec)
Curing energy	1,000Mj
Curing condition	120℃,1hr
Interval between nozzle and substrate	20(um)

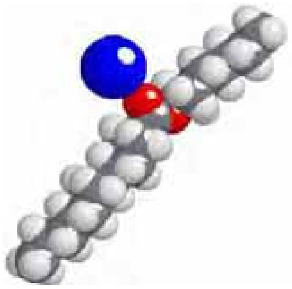

Figure 1 Chemical structure of VA type liquid crystal

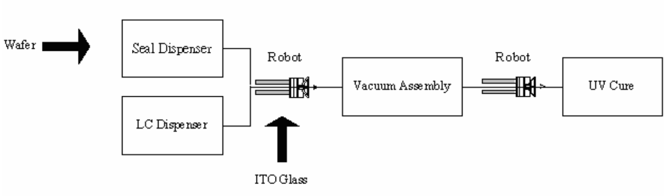

Figure 2 Shows basic layout of ODF system

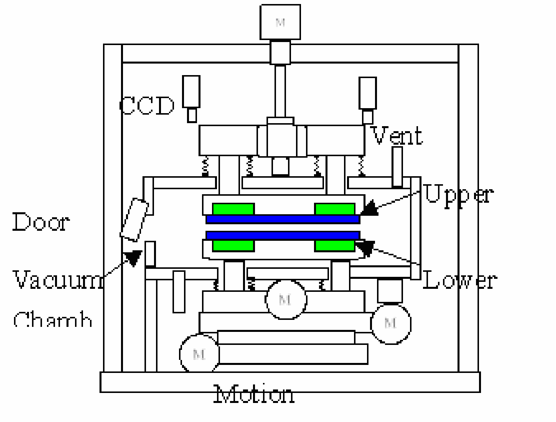

Figure 3 Vacuum assembly system

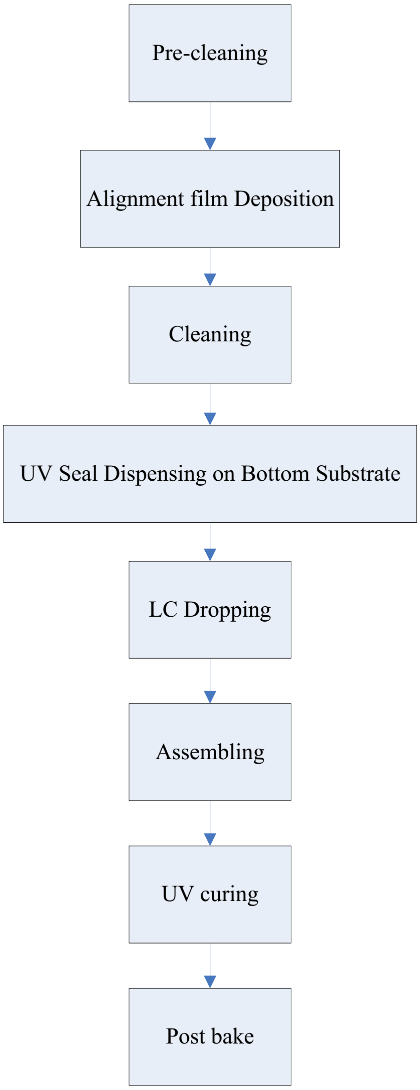

Figure 4 Flow chart of our experiment

Figure 5 LC drop on the center of seal pattern

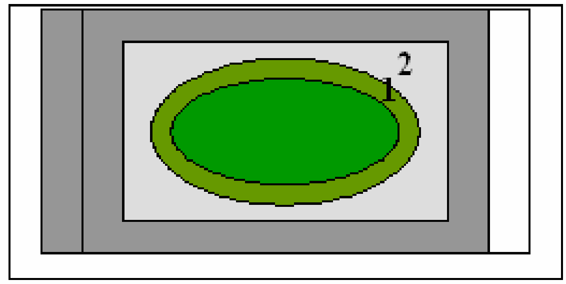

Figure 6 The motion of Newton ring

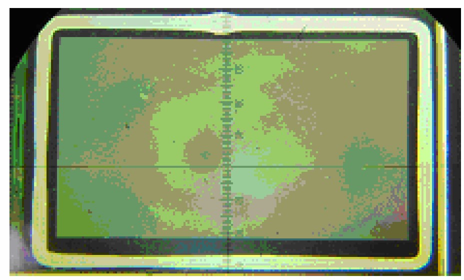

Figure 7 The Newton ring controlled fewer than 1.5 fringes.

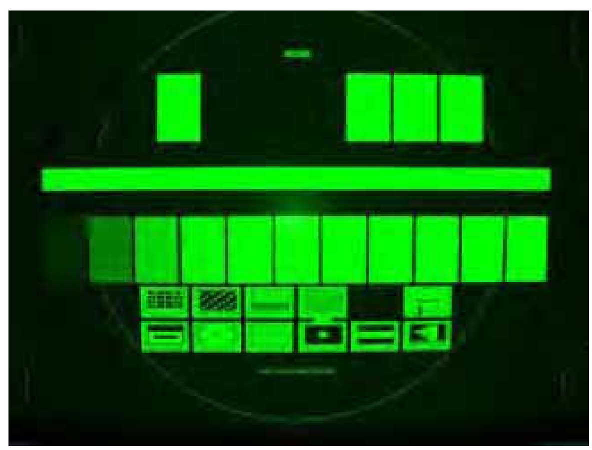

Figure 8 The projected image used ODF technology