Preparation of Transparent conductive oxide cathode for Top-Emission Organic Light-Emitting Device by FTS system and RF system

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ABSTRACT

We prepared Al doped ZnO thin film as a top electrode on a glass substrate with a deposited Alq_3 for the top emission organic Light emitting device (TEOLED) with facing target sputtering (FTS) method and radio-frequency (RF) sputtering method, respectively. Before the deposition of AZO thin film, we evaporated the Alq_3 on glass substrate by thermal evaporation. And we evaluated the damage of organic layer. As a result, PL intensity of Alq_3 on grown by FTS method showed higher than that of grown by RF sputtering method, so we found that the FTS showed the lower damage sputtering than RF sputtering. Therefore, we can expect the FTS method is promising the low-damage sputtering system that can be used as a direct sputtering on the organic layer.

Key Words : FTS, RF, AZO, OLED

1. Introduction

Recently, the range of display application is expanding due to the development of display and increase of demand. In the past, from CRT (cathode Ray Tube) to FPD (Flat panel Display), LCD (Liquid crystal display), and PDP (Plasma Display Panel) was main stream of display and studies are being done to improve efficiency of those.

Especially, among the several types of display, the Organic Light Emitting Device (OLED) is receiving attention as a next-generation display because it has emissive bright colors, wide viewing angle and fast response time and doesn't need back-light.[1-2] The OLED can be divided into two types depending on emission method - top emission and bottom emission. The bottom emission OLED use transparent electrode as anode and the light is emitted to anode. However, the bottom emission OLED has a weak point of decreasing its life as power consumption increases. Accordingly, the study of the top emission OLED is being done [2]. The cathode of top emission OLED must be prepared transparent and damage-free to under organic layer. So that, the various sputtering method of associated with the cathode preparing are being studied.

Usually, top transparent cathode is prepared by low-power deposition using RF sputtering [3]. The process of radio-frequency (RF) sputtering method, high-energy particle collides to the target and particles of the target are released. As a result, released particles are deposited on the substrate. Also, organic layer is damaged due to the structure of the substrate facing the target. However, the FTS system is designed to array two sheets of targets facing each other and the substrate is located in a plasma-free area apart from the center of plasma [4]. For this reason, the FTS system reduce the damage of the organic layer more than general sputtering method.

In this study, we carried out experiment about comparing the damage of organic layer by FTS system and RF sputter and observed the performance by changing sputtering condition.

2. Experimental

Before the deposition, the substrate was ultrasonically

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Table 1. Sputtering condition

Deposition Parameter	Sputtering Condition
Targets	AZO
Substrate	Glass
Base pressure	3.4×10^{-6} Torr
Working pressure	2 mTorr, 3mTorr
Alq_3 thickness	700 Å
Thickness	1000 Å
Temperature	Room temperature
Input Power [W]	40, 60, 80
Gas flow	Ar = 15sccm

cleaned with de-ionized water (D.I. Water) for 20 minutes and the isopropyl alcohol (IPA) for 10 minutes and it was dried with N_2 gas. We prepared the Alq_3 (Tris [8-quinolinolato] aluminum) thin films on glass substrate by using thermal evaporation. The deposition chamber was evacuated to a pressure of 5.8×10^{-6} Torr. The deposition rate of Alq_3 was controlled by input current and was maintain at 0.5 ± 0.3Å/s. The thickness of Alq_3 films fixed 700 Å.

After organic layer were deposited on glass substrate, to compare the damage of organic layer by two different sputtering system, we deposited AZO (98 wt% ZnO - 2 wt% Al_2O_3) thin film on as-deposited Alq_3 glass substrate by using FTS system and RF sputtering system. The deposition chamber was evacuated a pressure of 3.4×10^{-6} Torr. To calculate the deposition rate, we deposited AZO thin films on glass substrate with each condition for 30minustes. After that, we deposited AZO thin film on as-deposited Alq_3 glass substrate as function of the working pressure and input power. The AZO thin film thickness fixed 1000 Å. More details of the sputtering conditions are shown in Table 1.

To evaluate the affects of sputtering, we measured the damage by PL intensities using the fluorescence spectrophotometer (Jasco-FP6200).

3. Result & Discussion

Fig. 1 and Fig. 2 shows the schematic of RF sputter and FTS system. The RF sputtering system was designed to the target facing the substrate. As shown Fig. 3, the deposition rate of the RF sputtering system is higher than the FTS system due to the particles of the target is deposited directly to the substrate. But during the deposition, direct collision of the high-energy particles to the substrate causes release of deposited particles and decrease of characteristic of the thin film.

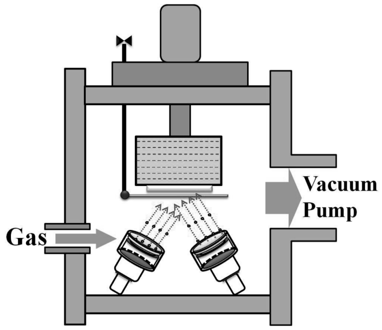


Fig. 1. Schematic of RF sputtering system.

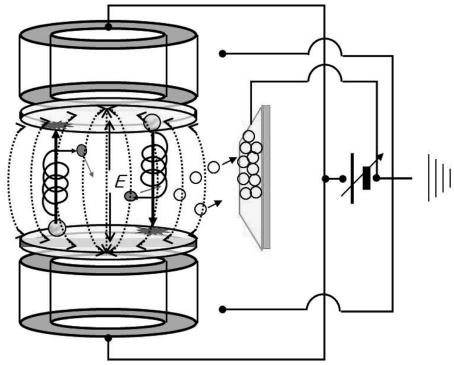
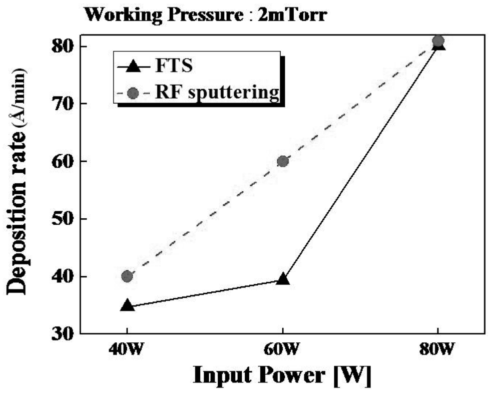
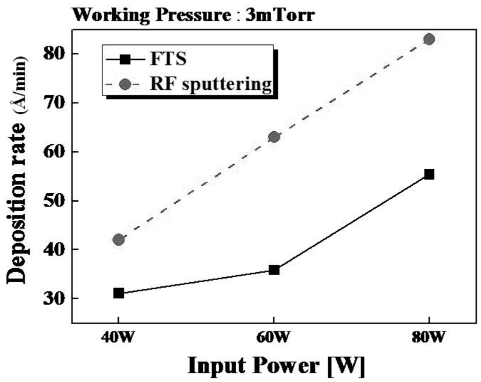


Fig. 2. Schematic of FTS system.

Especially, in the preparing of the top emission OLED, device life time is decreased due to the damage of organic layer because the substrate is located in plasma area. However in the FTS system, substrate is located in a plasma-free area apart from the center of plasma so collision of high-energy particles to the substrate could be suppressed. In other words, the number of Y-electron which arrive at substrate is less than RF sputtering system. For this reason, it is thought that life time of the device could be increased when depositing the transparent top cathode by FTS system due to the greater decrease of



a) Working pressure = 2mTorr

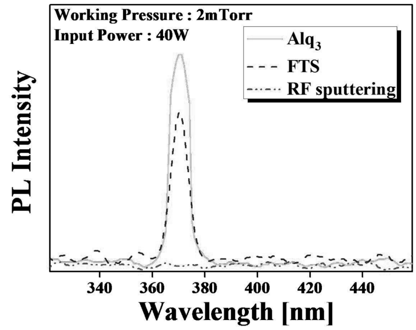


b) Working pressure = 3mTorr

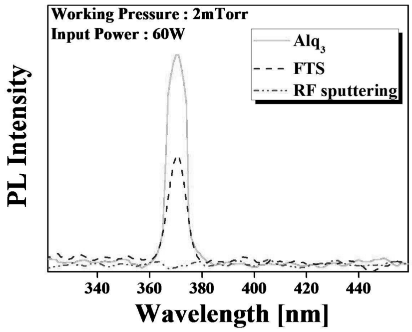
Fig. 3. Deposition rate of FTS system and RF sputtering system.

the damage of organic layer than the RF sputtering system.

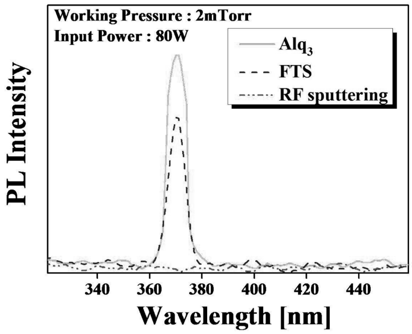
Also, the FTS system is a low-temperature sputtering method because of high ionization rate of working gas. Due to the structure of the targets facing, plasma forms a spiral shape. γ-electron is confined in the magnetic field and it reciprocates between targets to target. As a result, high-quality thin film is prepared due to high-density plasma. Therefore, when high-quality thin film prepared by FTS system is applied to the transparent top cathode, it is expected that the top emission OLED has excellent performance without defects such as crack or pinhole. With comparison to RF sputtering system, the advantage of FTS system is that it can change the form of magnetic field between the targets. The RF sputtering system is difficult to change the form of magnetic field in



a) Working pressure = 2mTorr, Input power = 40W



b) Working pressure = 2mTorr, Input power = 60W

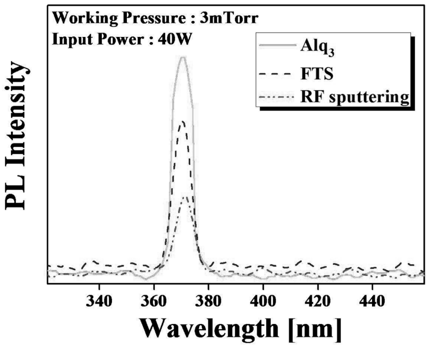


c) Working pressure = 2mTorr, Input power = 80W

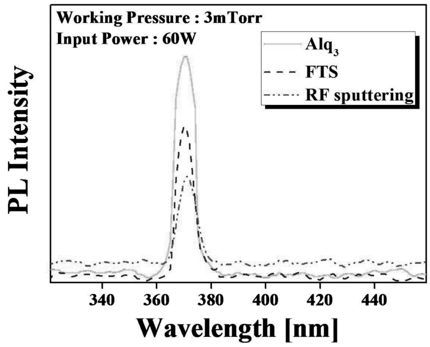
Fig. 4. PL intensity of Alq_3 and after AZO thin films deposition by FTS system and RF sputtering system (Working pressure = 2mTorr).

plasma because it uses one gun. But the FTS system could change the form of magnetic field between the targets by using yoke plate [5-7]. The form of magnetic field can be divided into categories as concentrated magnetic field and distributed magnetic field depending on the use of yoke plate.

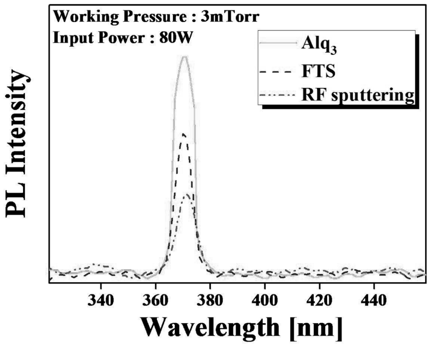
Through change in the form of magnetic field, the damage of organic layer by ã-electron could decrease.



a) Working pressure = 3mTorr, Input power = 40W



b) Working pressure = 3mTorr, Input power = 60W



c) Working pressure = 3mTorr, Input power = 80W

Fig. 5. PL intensity of Alq_3 and after AZO thin films deposition by FTS system and RF sputtering system (Working pressure = 3mTorr).

Also by using the yoke plate, the damage of organic layer could be decreased due to the uniform magnetic field by distributing particles such as neutral Ar atoms and negative oxygen ion between the targets and confining the high energetic particles in the plasma.

Fig. 4 shows the PL intensity of Alq_3 and after AZO deposition by Facing Targets System and Radio Frequency sputtering system.

In working pressure 2mTorr, we observed very low value of PL intensity when the AZO deposited on as-deposited Alq_3 glass substrate by RF sputtering system. On the other hand, we observed over 65% of the value of bare-Alq_3 PL intensity when the AZO deposited on as-deposited Alq_3 glass substrate by FTS system. In working pressure 3mTorr, we observed over 40% of the value of bare-Alq_3 PL intensity when the AZO deposited on as-deposited Alq_3 glass substrate by RF sputtering system. And we observed over 70% of the value of bare-Alq_3 PL intensity when the AZO deposited on as-deposited Alq_3 glass substrate by FTS system.

Through the PL intensity of Alq_3 reduction, the result can be interpreted that the Alq_3 of emission layer was damaged in deposition process. As shown in Fig. 4, we observed that the damage rate of organic layer reduced when the FTS system is used. In the case of RF sputtering system, deposition method of low power has been used to reduce the damage of organic layer. This method uses the principle of controlling the power to reduce particle energy reaching the substrate. As a result, particle collision in the substrate weakens and the damage of organic layer can be reduced a little. But it is considered that this method is unsuitable to solve the root cause. On the other hand, the FTS system can be said that it can solve the root cause of the damage to organic layer. The FTS system can minimize the damage of organic layer because it uses yoke plate and has structural advantage so it can prepare the high-quality transparent top cathode of top emission OLED. Therefore, it thought that the FTS system is suitable for transparent top cathode deposition of top emission OLED.

4. Conclusion

In this study, we prepared AZO thin films on as-deposited Alq_3 glass, compared the damage of organic layer by FTS system and RF sputter and observed the damage of the organic layer by varyng working pressure and input power. As a result, we could observe the damage due to the deposition. The thin film prepared by the RF sputtering system was more damaged than by the FTS system. Although the deposition rate of FTS system is lower than the RF sputtering system, but the FTS system is stability and could reduce damage of organic layer so it is suitable for preparing the transparent top cathode of the top emission OLED.

Acknowledgment

This work was supported by Kyungwon university Research Fund 2010 and the Human Resources Development of the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government Ministry of Knowledge Economy(No. 200914010100060).

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접수일: 2010년 8월 12일, 심사일: 2010년 8월 25일,
게재확정일: 2010년 9월 15일