2003년도 대한전기학회 하계학술대회 논문집 2003.7.21-23

PDP용 MgO 박막의 스퍼터 연구

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Sputtering of Magnesium Oxide this film for Plasma Display Panel Application

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Abstract - An MgO thin film sputtering system for the PDP (Plasma Display Panel) applications has been developed. This system was manufactured with a vertical In-Line type of 42 inch, which has the length of 520 mm and the width of 900 mm. A reactive magnetron discharge for this sputtering was generated using an unipolar pulsed power supply which has functions of constant voltage (Max. 500 V) and current (Max. 15 A) control, frequency of 10~100 kHz and duty ratio of 10~60 %. The experiment was conducted under various conditions : 3~10 mTorr of pressure, the ratio of O_2/Ar = 0.1~0.5, 50 % of duty and power of 0.5~1.7 kW. From the experiment, the deposition rate of a static state and a moving state were measured to be about 45 nm/min and 6 nm m/min at the distance of 50 mm between the target and the substrate, respectively.

1. 서 론

A plasma display panel (PDP) is one of the most promising flat panel devices for large-size wall-hanging displays because of simple structure, high definition, and wide viewing angle. Although the PDP are now entering into the world wide markets, further improvement is still needed from the points of picture quality, long lifetime and low cost. Magnesium Oxide (MgO) thin films is one of the hot issues of many researchers. MgO thin films have been used as a protective layer for dielectrics in the AC-PDP to improve discharge characteristics and the panel lifetime because of its hard physical stability, high transmittance and secondary electron emission coefficient [1-3].

In this paper, reactive sputtering results of MgO thin film for PDP application are described. The experiment was conducted using a developed reactive sputtering system of 42 inch. This system adopts unipolar power supply of rectangular waveform with varying frequency and duty. With this power supply, a hysteresis characteristic was observed in proportion to the oxygen flow rate. On the basis of the hysteresis curve, all experiments were performed with oxide mode in this study. Then, we show the analysis results about the manufactured MgO thin film.

2. 본 론

2.1 Experimental setup

Figure 1 shows the photograph of the reactive sputtering system, respectively. The total width of this system is about 5 m. The purity of the used MgO target is 99.95 %. The target size is width of 3.5", length of 25" and thickness of 1/4". This system is designed to extend the number of the magnetron cathode targets up to 5. In this experiment, one Mg target was used. The size of the substrate is length of 520 mm and width of 900 mm. The distance between the target and the substrate can be varied from 3 cm to 15 cm. The heater temperature was set at 200 °C. The moving speed of the carrier is 1~30 cm/min.

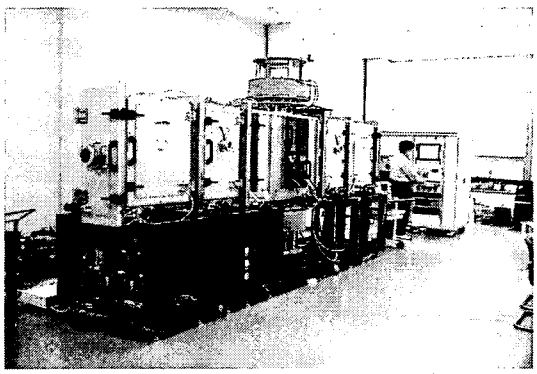

Fig. 1 Photograph of the reactive sputtering system. (Dimension : 5000 (length) x 1000 (heigth) x 300 (width), mm)

The operation pressure was 3~10 mTorr with the O_2/Ar mixture gas flow. The mixture ratio of O_2 to Ar gas was 0.1~0.5. The capability of the power supply is 7.5 kW having a pulsed rectangular unipolar waveform. The power supply has functions of constant voltage (Max. 500 V) and constant current (Max. 15 A) control. The frequency and the duty can be changed 10~100 kHz and 10~60 %, respectively. The voltage of negative polarity was applied to the magnetron cathode target. When the magnetron discharge happened at the surface of the target, the voltage and the current of the target were directly measured using voltage probe (Tek. P5100) and

pulse current transformer (Pearson 410), respectively. And then, the incident power of the target was calculated using the measured waveforms of the voltage and the current. To observe the area of the metallic and oxide mode when the discharge happened at the surface of the Mg target, a hysteresis curve was detected with varying the oxygen flow rate of 0~16 sccm

2.2 Results and discussion

Figure 2 shows the characteristics of hysteresis curve, pressure and incident power when the oxygen flow ratewas varied from 0 sccm to 16 sccm and from 16 sccm to 0 sccm. At this time, the flow rate of argon gas was constant as 110 sccm. From the hysteresis curve, the transition area from the metallic mode to the oxide mode [4,5] could be observed when the oxygen flow rate is 14~15 sccm. At this area, the target voltage dropped rapidly from 147 V to 115 V, whereas the working pressure rose rapidly from 4.67 mTorr to 5.04 mTorr. This is due to the residual partial pressure of oxygen. The incident power of the target increased with the flow rate of oxygen. The maximum power was delivered to the target at the oxide mode. The saturation power of the used target can be measured as 1.7 kW with increasing input current. Deposition rate is in proportion to the incident power.

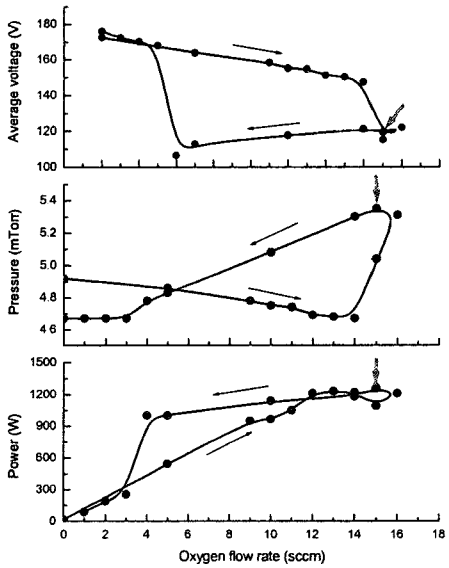

Fig. 2 Characteristics of the average voltage, pressure and power due to the flow rate of oxygen in the reactive magnetron sputtering system for MgO thin film. (Ar gas : 110 sccm, O_2 gas : 0→16→0 sccm)

Figure 3 shows the alpha step profile of the deposited MgO thin film during 10 minute at the power of 1.5 kW. The maximum static sputter rate was obtained as 7.5Å/s (45 nm/min). This deposition rate is more than the previous work of 5Å/s (30 nm/min) [5]. Figure 4 shows the measured waveforms of the voltage and the current at the Mg target. In case of the moving state, the sputter rate was obtained to be 6 nm m/min.

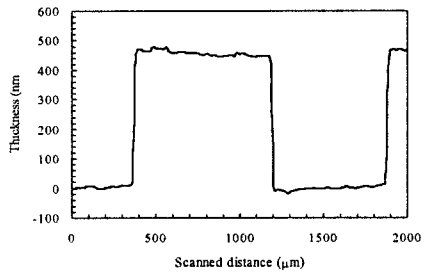

Fig. 3 Alpha step profile of the deposited MgO thin film. (pressure : 5 mTorr, O_2/Ar = 0.4, substrate temperature : 200 C, distance from the target to the substrate : 50 mm, power : 1.5 kW, working time : 10 min.)

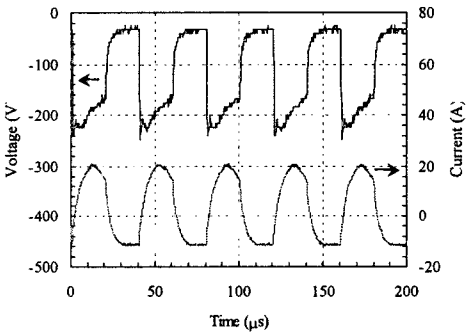

Figure 5 shows the deposition rate at the pressure of 3~10 mTorr when the mixture ratio of O_2/Ar is varied from 15 % to 50 %. From this result, the maximum deposition rate was observed at the pressure of 5 mTorr when the mixture ratio of O_2/Ar is 40 %.

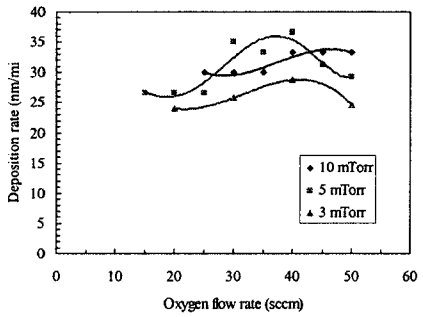

Fig. 5 Deposition rate due to the working pressure and the ratio of O_2/Ar. (pressure : 3~10 mTorr, O_2/Ar = 0.15~0.5, power : 850 W, Ar : 110 sccm)

Figure 6 shows the result of the X-ray diffraction analysis of deposited MgO film. The film was deposited on slide glass at a substrate

temperature of 200 °C and at a pressure of 5 mTorr. Several peaks show the typical MgO X-ray diffraction patterns. The intensity of (111) texture was detected two times as much as the reference intensity. This means that the (111) texture has the relatively much portion in the deposited MgO film. The other peaks show the reference intensity of MgO property. The secondary electron emission coefficient of the deposited MgO was measured by using the focused ion beam (FIB) system [6].

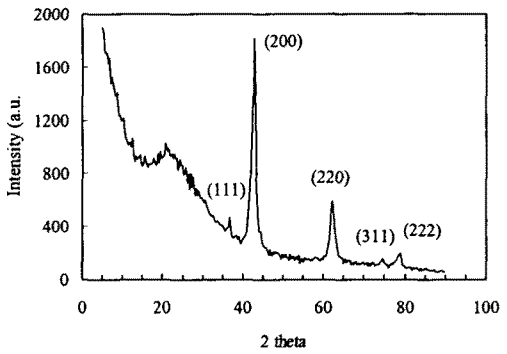

Fig. 6 X-ray diffraction spectra of MgO thin film deposited by reactive sputtering system.

Figure 7 shows the measurement result of gamma . When Ne+ ion was accelerated from 50 V to 150 V, was increased from 0.054 to 0.144. This is compares well with gamma of MgO film which is evaporated by means of the electron beam method. Reference 6 shows as 0.12 at the acceleration voltage of 150 V. This indicates that gamma of the MgO film using sputtering is slightly higher than that using an evaporation method with electron beam.

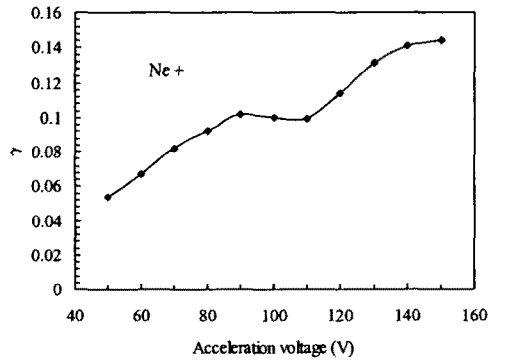

Fig. 7 Secondary electron emission coefficient of the deposited MgO thin film, versus Ne+ ion acceleration voltage from 50 V to 150 V.

3. 결 론

An MgO thin film was deposited by a reactive sputtering system of 42 inch. The properties of the deposited MgO thin film were analyzed to be practically reasonable. Especially, the merits of the deposited MgO thin film such as high density and high secondary electron emission coefficient are of great key point to solve the problem of long lifetime and efficiency.

In a next step, we will try to operate the sputtering system using 3~5 targets for faster deposition of the MgO film. And the deposited MgO film will be analyzed to understand the performance of the deposited MgO film in an assembled PDP of 42 inch under the real operation conditions.

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