Journal of the Korean Vacuum Society
Vol. 9, No. 3, September 2000, pp. 233~236

The characteristics of AlW thin film for TFT-LCD bus line

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(Received February 24, 2000)

TFT-LCD bus line을 위한 Al-W 박막 특성에 관한 연구

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(2000년 2월 24일 접수)

Abstact – The structural, electrical and chemical characteristics of Al alloy thin film with low impurity concentrations AlW deposited by using dc magnetron sputtering deposition are investigated for the applications as data bus line in the TFT-LCD panel. The deposited thin films show the decrease of resistivity and the increase of grain size after the RTA at 300°C for 20 min.. Moreover, the resistivity of AlW does not show appreciable grain size dependence after RTA. It is concluded that the decrease of resistivity after RTA is due to the increase of grain size. The annealed AlW is found to be hillock free. And for investigating chemical attack in TFT-LCD etching processing the electric potential of AlW alloy for Ag/AgCl were investigated by cyclic voltammetry. When W wt.% of AlW alloy was higher than about 3%, the electric potential of AlW was more positive than ITO's. Therefore AlW alloy thin film can be propose to use for data bus line.

요 약 – TFT-LCD(thin film transistor-liquid crystal display) 패널의 데이터 배선 재료로 사용하기 위하여 AlW(3 wt%)의 Al합금 박막을 dc 마그네트론 스퍼터링 방법으로 유리 기판에 증착하여 열처리전과 열처리 후의 박막 특성을 조사하였다. 또한 TFT-LCD의 식각 공정상에서 발생할 수 있는 chemical attack에 대한 저항성을 확인하기 위하여 순환전압전류법(cyclic voltammetry)을 사용하여 Ag/AgCl 전극에 대한 ITO와 AlW alloy의 전극 전위를 측정하였다. 증착된 박막을 350°C에서 20분간 열처리하였을 때 AlW 박막은 비저항이 감소하였고 약 11 μΩcm의 다소 높은 비저항 특성을 보였다. 주사전자현미경(SEM)과 원자힘현미경(AFM)으로 표면을 분석한 결과 좋은 힐록방지 특성을 보임을 알 수 있었다. 순환전압전류법을 사용하여 측정한 Ag/AgCl에 대한 ITO의 전극 전위은 약 –1.8V이었고, AlW alloy의 전위 전극은 W의 wt.%가 3% 이상이었을 때 ITO의 전극 전위보다 작게 나타났다. 따라서 측정된 특성값을 볼 때 AlW(over 3 wt.%) 박막은 data bus line으로 사용할 수 있는 것으로 나타났다.

I. Introduction

Longer gate line and smaller pixel size which affect the RC time delay of gate signal are required for high resolution and large screen size TFT-LCD. Because of low resistivity, usually Al is used as gate line and data line material [1]. However pure Al has a serious drawback related to the formation of hillock and is easily attacked by chemical reaction.

Therefore many kinds of Al alloy were used as gate metal [2, 3]. Al-alloy has low hillock density and resistivity of about 10~30 μΩcm and AlW has high resistance of chemical attack.

II. Experiments and Results

Al-W thin films using D.C. magnetron co-sputtering system were deposited on corning class 1737. AlW was sputtered using 1 inch targets of Al and W. This sputtering system can be controled deposition temperature and dc power. The thickness of thin film was controled by deposition time. The rate of deposition is about 100 Å/

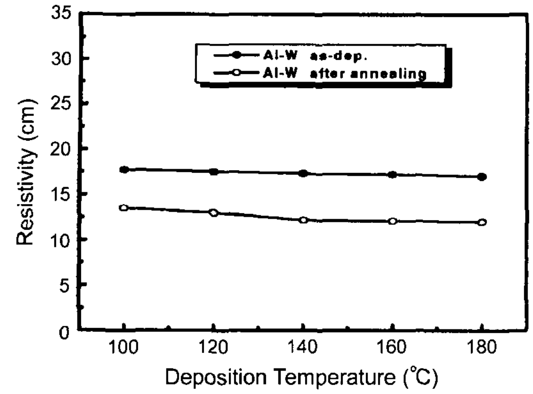


Fig. 1. Deposition Temperature vs. Resistivity (Al-W : 100W, 0.4 Pa, Ar 23 sccm Annealing : 350°C, 20 min).

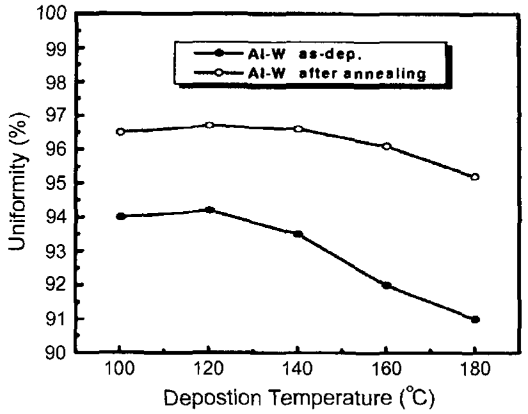


Fig. 3. Deposition Temperature vs. Uniformity (AlW : 100W, 0.4 Pa, Ar 23 sccm Annealing : 350°C, 20 min).

min. (Al-100W, W-40W, 100°C).

To evaluate the characteristics of Al alloy, the resistivity, uniformity of crystallization, grain size and hillock density were investigated by SEM, XRD, AFM and 4-point probe.

The resistivities of Al films deposited at various temperature with constant power are shown in Fig. 1. The resistivity of AlW was reduced when the deposition temperature was increased. This trend is a normal for thin alloy films. After the 350°C annealing, it is almost same trend. The resistivities were reduced after 350°C, 20 min. annealing. It was presumed that after annealing reduction of resistivity was occured by W atom's gathering caused thermal activation in Al matrix. The lowest resistivity was about 11 μΩcm (AlW :3 wt.%). Resistivities of AlW for various thickness are shown in Fig. 2. It can be seen that the resistivity is nearly independent of thickness. For the thickness between 1500~3500 Å, the being was constant.

The average uniformity of AlW resistivity in each sample for various deposition temperature is shown in Fig. 3. As the deposition temperature was higher the reduction of uniformity of as- deposited film is caused by increasing of deposition rate and smoothing of surface by atom having high reactive energy. The uniformity after annealing is about 2% higher than as-deposited film's. This property was caused by increasing of crystallizing of thin film. Fig. 4 is the roughness of AlW for various deposition temperature. When the temperature was increased, the roughness was increased. It is explained by fast nucleation of adatom on surface and increasing of grain size. The average uniformities of AlW resistivity in each sample for various dc power are shown in Fig. 5. According to increasing of dc power (same ratio Al:W = 5:2), the

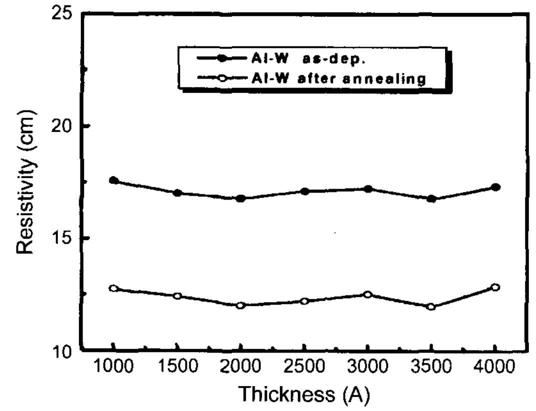


Fig. 2. Thickness vs. Resistivity (Al-W : 100 W, 0.4 Pa, Ar 23 sccm Annealing : 350°C, 20 min).

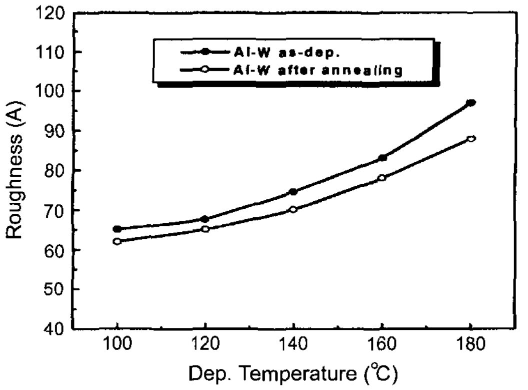


Fig. 4. Deposition Temperature vs. Roughness (AlW : 100 W, 0.4 Pa, Ar 23 sccm Annealing : 350°C, 20 min).

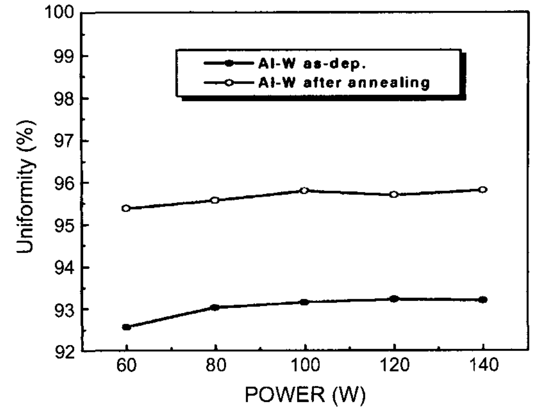


Fig. 5. DC Power vs. Uniformity (AlW : 100W, 0.4 Pa, Ar 23 sccm Annealing : 350°C, 20 min).

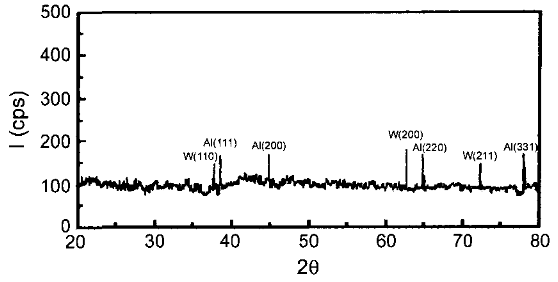
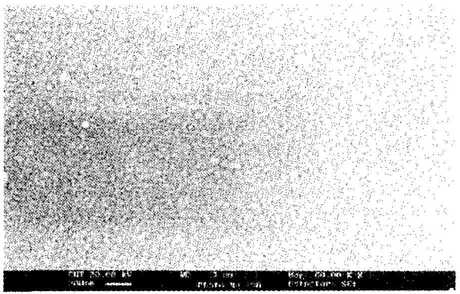


Fig. 6. XRD pattern of Al-W (100 W, 100°C, 0.4 Pa, 23 sccm).

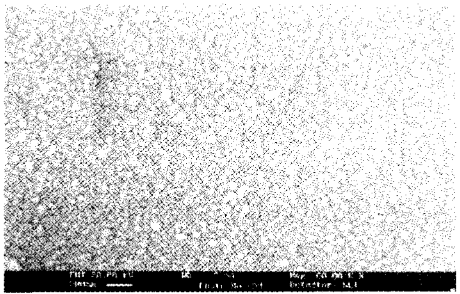
uniformity was increased. It was explained that the atom having high reactive energy was working by medium of surface cleaning. Between 60~140 W there was no change. It is observed that the deposition mechanism is almost same in these power ranges.

The XRD pattern of AlW are shown in Fig. 6. It is observed that the direction of crystallization of Al was (111), (200), (220). Fig. 7. is SEM images of AlW thin film. It is observed that the grain size of after annealing is larger than as-deposition. The hillock density of AlW were investigated by AFM (Fig. 8). The average roughness and maximum size are about 65 Å and 300 Å. They are smaller than 1000 Å, so there is no problem of hillock and there was no spike appearance.

It is difficult to use Al for data line since an electrochemical reaction occurs when Al makes ohmic contact with ITO in an alkaline solution. Positive photoresist developer acts as an electrolyte for the electrochemical reaction between Al and ITO. Al can be covered with a barrier layer when using a positive resist developer or a negative resist process can be substituted. However, both processes result in an increased

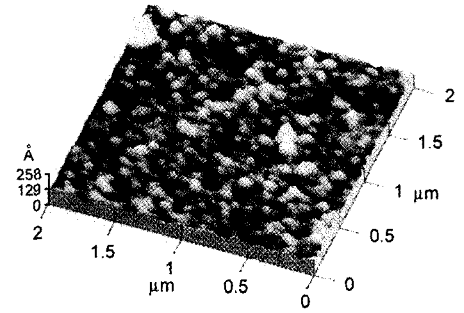


(a) as-deposition

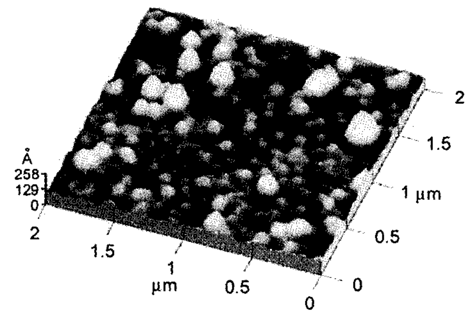


(b) after 350℃-20 min annealing

Fig. 7. SEM image of Al-W.



(a) as-deposition



(b) after 350℃-20 min annealing

Fig. 8. AFM image of Al-W.

fabrication cost. The electro-chemical reaction was prevented by controlling the surface potential of the Al by

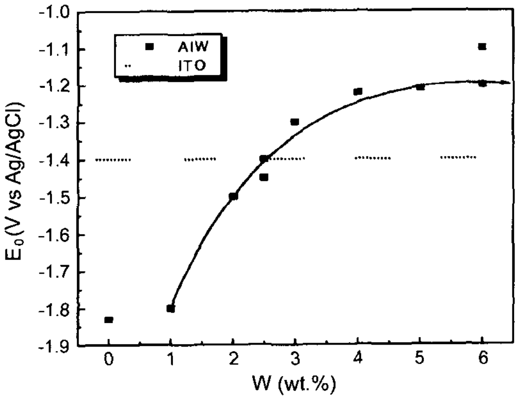


Fig. 9. The electric potentials of AlW alloys.

the introduction of impurities. The electric potentials of ITO and AlW alloy for Ag/AgCl as a function of wt.% are shown in Fig. 9. The electric potentials were measured by cyclic voltammetry. KOH(10%) developer was used as the alkaline solution. The potential of pure Al is more negative than ITO, ITO undergoes reduction, and the Al is oxidized. An effective way to reduce electron transfer is to make the Al potential more positive than ITO. When wt.% of W was higher, the potential was saturated about −1.18 V. The AlW alloy which wt.% was higher than 3% resulted in an electrical potential more positive than ITO. Therefore AlW can be proposed for data bus line.

III. Conclusion

AlW alloy thin film was deposited on corning class (1737) by D.C. magnetron sputtering system.

The resistivity of AlW (3 wt.%) is about 11 $\mu\Omega$cm. Also it is found that AlW can effectively reduced the hillock formation without any surface treatment.

The electric potentials of ITO and AlW for Ag/AgCl were measured by cyclic voltammery. The poteial of ITO was −1.8 V, and AlW alloy which wt.% was higher than 3% resulted in an electrical potential more positive than ITO. As a result AlW alloy (over 3 wt.%) thin film can be used for data bus line.

Acknowledgements

This work has been supported by Ministry of Commerce Industry & Energy and Ministry of Science and Technology through LCD Research Association.

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