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Characteristics of Al-Nd and Al-Zr thin film for TFT-LCD by DC magnetron sputtering system

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DC magnetron sputtering system을 이용한 TFT-LCD를 위한 Al-Nd와 Al-Zr 박막 특성에 관한 연구

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Abstact – Recently low resistance of gate line or data line is required for large screen size TFT-LCD panels. As a result, lower resistance Al-alloy is currently reviewed extensively and the resistivity is required smaller than 10 μΩcm. In this paper, Al-Nd and Al-Zr thin film were deposited on glass substrates by D.C. magnetron sputtering system under various condition. Its properties were characterized by SEM, AFM, XRD and 4-point-probe. The optimal condition was 120°C, 125W, 0.4Pa, 30 sccm (Ar) and 350°C, 20 min. annealing. At that condition the resistivity of Al-Zr (0.9%wt.) is about 4 μΩcm.

요 약 – 최근 TFT-LCD용 대형화면을 위한 저저항 gate line 또는 data line이 요구되고 있다. 이에 따라 저저항 Al-alloy에 대한 연구가 활발히 진행되고 있고, 10 μΩcm 보다 작은 저항값이 요구되고 있다. 본 논문에서는 D.C. mag. sputtering system을 이용하여 다양한 조건하에서 Al-Nd와 Al-Zr의 박막을 성장하였다. 각각의 sample들은 SEM, AFM, XRD와 4-point-probe를 사용하여 그 특성을 조사하였다. 본 실험에서의 최적 조건은 120°C, 125W, 0.4Pa, 30 SCCM(Ar), 350°C-20 min. annealing에서 얻을 수 있었고, 그 때의 Al-Zr(0.9%wt.)의 저항값은 약 4 μΩcm 이다.

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 (thin film transistor-liquid crystal display). Because of low resistivity, usually Al is used as gate line and data line material [1]. But pure Al has several problems such as hillock formation and easy chemical attacks.

There are many reports where Al-alloy is used as gate metal[2, 3]. Al-alloy is hillock free and has resistivity of about 10 μΩcm. In this paper Al-Nd [3] and Al-Zr[5] were selected and deposited for TFT-LCD applications.

II. Experiments and Results

Al-Nd and Al-Zr thin films were deposited on corning class 1737 using D.C. magnetron sputtering system [4]. The 2 inch target materials are Al-Nd (2%wt.) and Al-Zr (0.9%wt.). This sputtering system can be controlled by deposition temperature and D.C. power. The thickness of thin film was controlled by deposition time. The rate of deposition is about 100 Å/min.

To evaluate the characteristics of Al-alloy, the resistivity, uniformity of crystalilzation, grain size

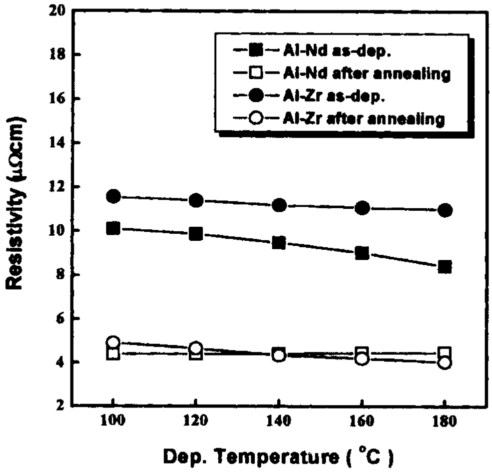


Fig. 1. Deposition Temperature vs. Resistivity (Al-Nd : 500W, 0.4 Pa,Ar 50 sccm Al-Zr : 100 W, 0.4 Pa,Ar 30 sccm Annealing : 350°C, 20 min).

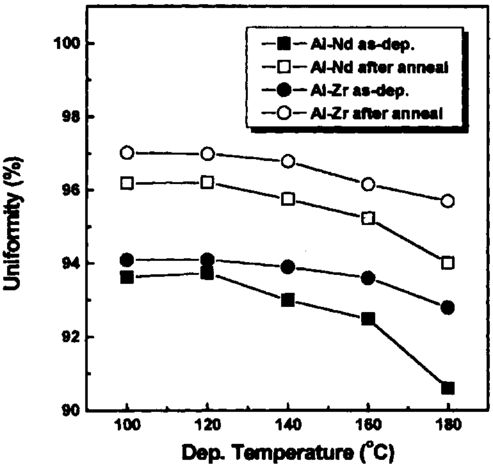


Fig. 3. Uniformity vs. Resistivity (Al-Nd : 500 W, 0.4 Pa,Ar 50 sccm Al-Zr : 100 W, 0.4 Pa,Ar 30 sccm Annealing : 350°C, 20 min) .

and hillock density were investigated by SEM (scanning electron microscopy), XRD (x-ray diffraction), AFM (atomic force microscopy) and 4-point probe.

Resistivities of Al-alloys for various deposition temperature are shown in Fig. 1. The resistivity of Al-alloys 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 lowest resistivity was about 4 μΩcm (Al-Zr; 0.9%wt.). Therefore, it has good enough resistance to replace pure Al. Resistivities of Al-alloys 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 resistivity was constant.

Uniformities of Al-alloys for various deposition

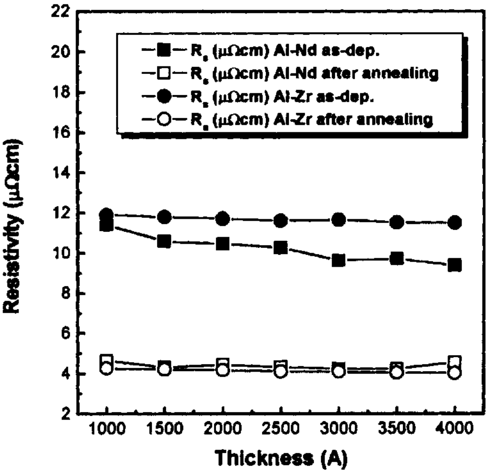


Fig. 2. Thickness vs. Resistivity (Al-Nd : 500 W, 0.4 Pa,Ar 50 sccm Al-Zr : 100 W, 0.4 Pa,Ar 30 sccm Annealing : 350°C, 20 min).

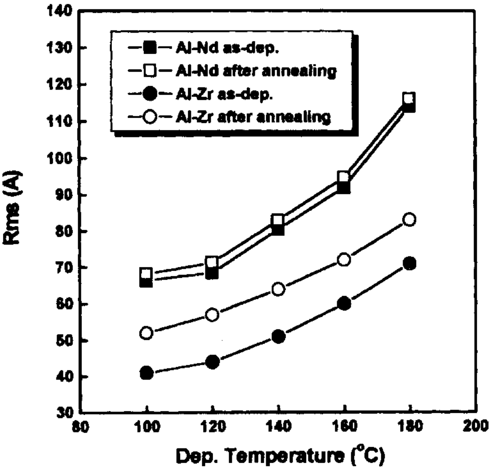


Fig. 4. Roughness vs. Resistivity (Al-Nd : 500 W, 0.4 Pa,Ar 50 sccm Al-Zr : 100 W, 0.4 Pa,Ar 30 sccm Annealing : 350°C, 20 min).

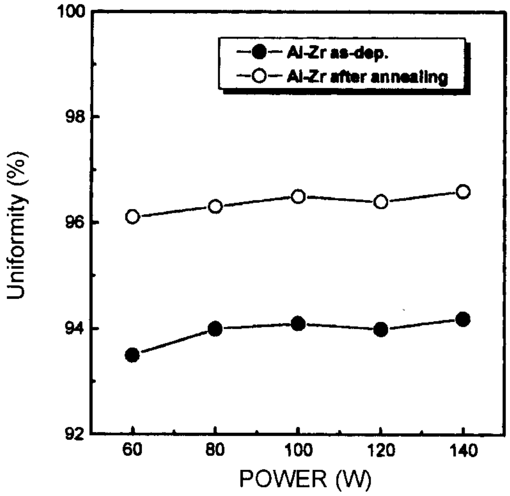


Fig. 5. D.C. Power vs. Resistivity (Al-Zr : 150°C, 0.4 Pa, Ar 30 sccm Annealing : 350°C, 20 min).

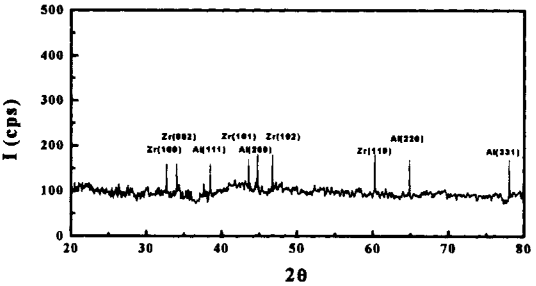


Fig. 6. XRD pattern of Al-Zr alloy (125W, 100°C, 0.4 Pa, 30 sccm).

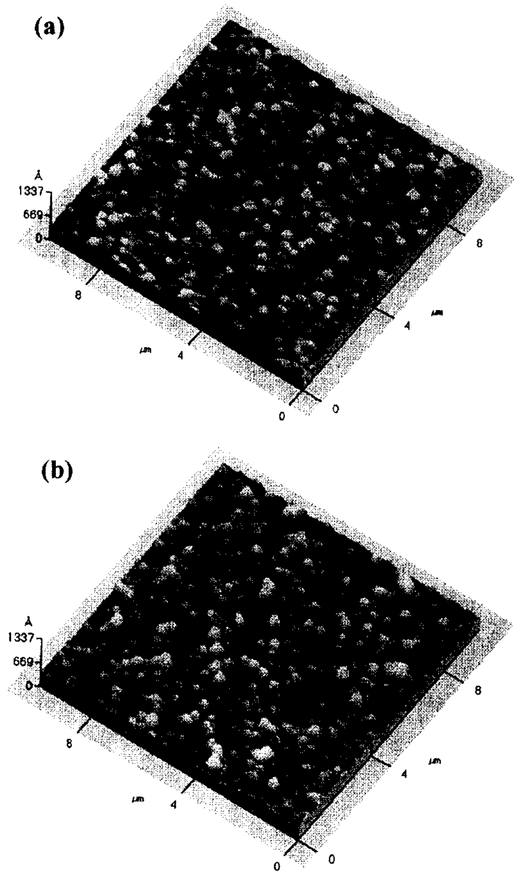
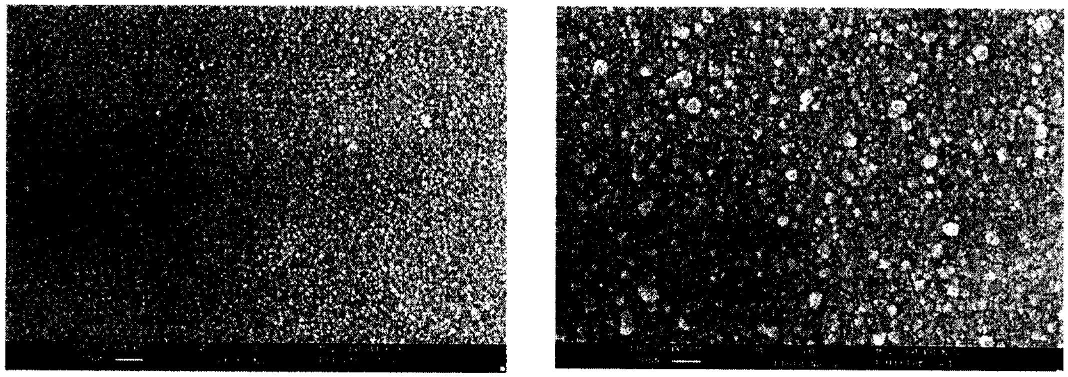


Fig. 8. AFM image of Al-Zr 150 W, 100°C, 0.4 Pa,Ar 30 sccm (a) as-deposition and (b) after 350°C, 20 min annealing.



(a) **(b)**

Fig. 7. SEM image of Al-Zr alloy 125 W, 100°C, 0.4 Pa,Ar 30 sccm (a) as-deposition and (b) after 350°C, 20 min annealing.

temperature are shown in Fig. 3. The uniformity after annealing is about 2% less than that of the as-deposited film. The reduction of uniformity is caused by increasing of deposition rate under various deposition temperature. Fig. 4 is the roughness of Al-alloy 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. Uniformities of Al-Zr for various D.C. power are shown in Fig. 5. Between 60~140W there was no change. It is observed that the deposition mechanism is almost same in these power ranges.

The XRD pattern of Al-Zr is shown in Fig. 6. It is observed that the direction of crystallization of Al was (111), (200), (220). Fig. 7. is SEM images of Al-Zr thin film. It is observed that the grain size of after annealing is larger than that of as-deposited one. The hillock density of Al-Zr was investigated by AFM (Fig. 8). The average roughness and maximum size are about 50 Å and 400 Å. They are smaller than 1000 Å, so there is no problem of hillock.

III. Conclusion

Al-Nd(2%wt.) and Al-Zr(0.9%wt.) thin films were deposited on corning class(1737) by D.C. magnetron sputtering system.

Resistivity of Al-Nd and Al-Zr is good enough to use as the material for metallization (4~5 μΩcm). Also it is found that Al-alloy can effectively reduce the hillock formation without any surface treatment.

Acknowledgements

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