CHAPTER 6

CONCLUSIONS

In this research, the transparent conductive ZnO(Al) thin films using embedded–Zn ZnO(Al) sputtering target have been prepared and the influence of the sputtering parameter such as argon gas pressure, RF power and Zn content on the structural, electrical and optical properties of the films have been investigated. The conclusions based on the finding of the research are as follows:

(1) The deposition rate of the films is inversely proportional to the argon gas pressure and linearly proportional to the RF power. Moreover, the deposition rate has the influence on the structural, electrical and optical properties of films. The high deposition rate can cause an increase in the defects such as oxygen vacancy, Zn interstitial atom and Al on the Zn site, resulting in the decrease of the resistivity of the films. However, the high rate can cause also a decrease in the transparency of the films due to more excess defects during deposition of the films. In this research, the suitable deposition rate is the rate at the RF power of 100 W because the transparency of the films is still high and the resistivity of the films is low enough.

(2) The ZnO(Al) films fabricated by the RF magnetron sputtering were polycrystalline with a hexagonal structure and a preferred orientation with c–axis perpendicular to the substrate. Moreover, the intensity of (002) diffraction peak slightly decreases when decreasing the argon gas pressure but it rapidly decreases with increasing RF power. This indicates that the crystallinity of the films strongly depends on the RF power. The lower RF power or the lower deposition rate yields better crystallinity because it leads to a large grain size. For the ZnO(Al) films deposited from different targets (different Zn contents), the XRD patterns indicate that the Zn content has the influence on the crystallinity of the films. The grain size becomes smaller with the increasing of the Zn content in the target.

(3) The resistivity of films is proportional to the inverse of the product of the carrier concentration and the Hall mobility, and it is strongly affected by the preparation conditions such as the RF power and the Zn content adding in the target.

The results show that the lowest resistivity is obtained at the RF power of 125 W for the target with no Zn content added (0 wt%) and at the RF power of 100 W for the target with Zn content added.

(4) The impact of the RF power on the transmission of the films is very small for the RF power from 50 W to 100 W. The average transmissions of above 90% are obtained in the range of 400 to 1000 nm. For the RF power of 125 W, the average transmissions drop to about 80%, which is not suitable for using as the transparent films.

(5) The influence of the Zn content on the transmission of the films in the range of 400 to 1000 nm is very small. All of the films have the average transparency of over 90%. At the Zn content of 3 wt%, the films exhibit the lowest absorption coefficient which is suitable for using as the transparent films. Moreover, the Zn content added in the target cannot only cause an increase in the transmission but also an increase in the resistivity of the films.

(6) The ZnO(Al) films are degenerate semiconductors with direct optical energy gap. The absorption edge is shifted toward shorter wavelength (blue shift) with increasing RF power. It is mainly attributed to the Burstein–Moss effect. The energy gap increases as the carrier concentration in the ZnO(Al) films increases. The lowest and highest energy gap values correspond to the highest and lowest resistivity of the films, respectively.

(7) In this research, the best combination of electrical and optical properties of the ZnO(Al) films is obtained from the ZnO(Al) with added Zn content of 1 wt% as determining from the figure of merit.

The suggestion for further development of the ZnO(Al) film preparation is to investigate the fine tuning of the sputtering conditions using the ZnO(Al) target with added Zn content of 1 wt%. The sputtering conditions include either location of the substrate or distance between the target and the substrate. Moreover, the substrate temperature may be taken into consideration. These may lead to a better achievement for the preparation of the suitable transparent conductive films for window layer of solar cells.