CHAPTER 1

INTRODUCTION

Transparent conducting oxide films (TCOs) have been extensively used in optoelectronic devices because of their high visible transmittance and low resistivity. The most important commercial material for transparent conducting films nowadays is Sn–doped In_2O_3 (ITO) owing to its unique characteristics of high visible transmittance (>90%), low resistivity, high infrared reflectance and absorbance in the microwave region [1,2]. The high quality of ITO films deposited by sputtering of oxide targets has already been successfully achieved on a commercialized production scale. Recently zinc oxide (ZnO) has been recognized as a promising alternative material to transparent conducting ITO coatings due to its cheaply abundant raw material, nontoxic nature, cost–effectiveness, easy fabrication and good stability [2].

ZnO has a wide and direct energy gap with wurtzite crystal structure [3,4]. The electrical conductivity of ZnO is controlled by intrinsic defect, i.e. zinc interstitial atoms and oxygen vacancies [5], which act as n–type donors. Hence, low resistivity films can be obtained by controlling these native defects. Nevertheless doping with group III elements such as aluminum, boron, gallium and indium can decrease its electrical resistivity.

ZnO films have attracted many attentions because many different applications are feasible due to its good electrical and optical properties. Additionally, Al–doped zinc oxide (ZnO(Al)) is widely accepted and used as a transparent window layer in thin film solar cells. In combination with $Cu(In,Ga)Se_2$ (CIGS) absorber layer, solar cells with efficiencies up to 18% have been achieved [6].

Many techniques are being used for the fabrication of ZnO(Al) thin films, including chemical vapour deposition [7], sol–gel [8], spray pyrolysis [9], pulsed laser deposition [10] and magnetron sputtering [11–14]. Magnetron sputtering technique is one of the most widely used due to its reproducibility and efficiency. It is a physical technique in which the most important deposition parameters are deposition pressure, power and the distance between the target and the substrate, all of which should be

well determined and controlled in order to obtain thin films with the desired properties. Moreover, some works have been carried out on the enhancement of the electrical and optical properties of ZnO(Al) films and the effects of parameters such as oxygen flow rate [15], substrate temperature [16], Al content [13], etc. has been gradually revealed. In the recent work of K. Ugsornrat [17], the preparation of ZnO(Al) films by alternating single sputtering of ZnO(Al) ceramic target and co–sputtering of ZnO(Al) ceramic target and Zn metallic target has been studied. The films prepared by this method yielded low resistivity and high transparency. However, it consumed a long period of time and consisted of unnecessary repetition of sputtering. The goal of this project is to develop the preparation technique for ZnO(Al) thin films by lessening the amount of time of the sputtering process using single ZnO(Al) with embedded–Zn sputtering target, and to find the suitable parameters that yield low resistivity and high transparency ZnO(Al) thin films. These ZnO(Al) thin films may be used as a window layer in $Cu(In,Ga)Se_2$ thin film solar cells

The procedures in this research are;

- to find the appropriate preparation process of ZnO(Al) target,
- to prepare the embedded–Zn ZnO(Al) target,
- to fabricate ZnO(Al) thin films from these targets by varying the sputtering conditions,
- to investigate the influence of sputtering parameters such as sputtering gas (Ar) pressure, RF power, and Zn content from the measurements of the structural properties, electrical properties and optical properties of the films.

This thesis is divided into three parts. The first part provides theoretical background of ZnO(Al) thin film properties, preparation methods of thin film and theoretical analysis of thin film properties. These are included in Chapters 2 and 3. The second part described in Chapter 4 is the experimental procedures which involve the fabrication techniques and the methods for characterization of the ZnO(Al) thin films. The last part of this thesis presented in Chapters 5 and 6, describes the results

and discussions on the influence of the sputtering parameters on the properties of films. The conclusions are also included in Chapter 6.