CHAPTER 1

INTRODUCTION

Chalcopyrite semiconductors $CuInSe_2$ (CIS) and its alloy with Ga, namely, $Cu(In,Ga)Se_2$ [CIGS] have been proven to be effective absorbers for thin film solar cells. The high efficiencies of $Cu(In,Ga)Se_2$ thin film solar cells have been achieved when the device structure is soda-lime-glass(SLG)/Mo/$Cu(In,Ga)Se_2$/CdS/ZnO(Al). In addition, each layer of thin film must be fabricated by specific technique. The Mo back contact is normally coated on a soda-lime glass by dc-magnetron sputtering. The CIGS absorber layer is deposited either by physical vapor deposition under high vacuum or deposition of metallic precursor film and followed by selenisation. A thin buffer layer of CdS film deposited by the chemical bath deposition (CBD) technique and aluminum doped ZnO transparent conducting film deposited by rf-magnetron sputtering technique are used for the front layers of the device. The CBD of CdS is commonly used in solar cell fabrication. In this work, the influence of the CBD-CdS buffer layer on the CIGS thin film solar cell performance has been examined via the current-voltage (I-V) characteristics. Development of higher efficiency requires an understanding of the mechanisms which control the photovoltaic performance. Analysis of I-V characteristics is the most important tool to characterize solar cells and has been used here to examine the current transport mechanism in the Mo/CIGS/CdS/ZnO solar cells. The CBD-CdS having different properties i.e., the thickness and the impurity concentration in the CdS layer were used as the buffer layer in a number of CIGS solar cells.

The objective of this thesis was to characterize the I-V characteristics and to investigate the influence of the bulk properties of the CBD-CdS layer on the CIGS solar cell performance. The standard and temperature dependent of I-V characteristics were performed. The I-V characteristics in dark and in illumination were characterized to obtain the standard diode parameters; ideality factor, series resistance and the reverse saturation current which is related to the current transport mechanism. By increasing the impurity concentration or the thickness of the CBD-CdS layer, the effect dominant was the appearance of a crossover effect in the I-V characteristics. The degree of crossover effect was found to increase with the impurities-introduced defects. When a high enough number of impurities are found in the CdS layer by increased thickness the crossover appears at room temperature. The most of high efficiency CIGS solar cells always exhibit a near superposition of the I-V characteristics, i.e., a slight crossover. Hence, these seem to exist an optimal number of defects or impurities in the CdS layer to achieve the high solar cell performance.

However, the complexity of SLG/Mo/CIGS/CdS/ZnO(Al)/Ni-Al heterojunction thin film solar cell requires further analysis in order to provide an exact physical interpretation of the junction mechanism. The compositional and doping variations in the Cu(In,Ga)Se_2, trapping states at the interface and in the bulk, localized growth defects, stress induced defects, the number of the thin CdS interfacial layer, the ZnO transparent conductive layer and the Mo/CIGS back contact must be considered.

The processes in this research are:

- to prepare the CBD-CdS buffer layers appropriated to the SLG/Mo/ Cu (In,Ga)Se_2/ZnO thin film solar cell
- to investigate the electrical properties of the CIGS-based solar cells by using different bulk properties of the CBD-CdS buffer layers
- to analyze the I-V characteristics dependent on temperature and light intensity

- to describe the current transport mechanism for obtain the model of the junction formation of the SLG/Mo/CIGS/CdS/ZnO(Al)/Ni-Al heterojunction thin film solar cell.

This thesis is divided into three parts. The first part provides theoretical background of semiconductor properties and the current understanding of the homojunction and heterojunction thin film solar cells. These are included in Chapter 2 and 3. The second part described in Chapter 4 are the experiment procedures which involve the fabrication techniques and the methods for I-V measurement which include dark and illuminated I-V characteristic both at room (fixed) temperature and temperature dependent. The final part of this thesis, Chapter 5 and 6, describes the experimental results and analysis of the I-V characteristics. Discussion and a model of possible band alignment for the device are also included.