Introduction

1.1 The need of photovoltaic among renewable energy sources

The demand for new sources of energy is increasing as the world population grows continually. The worldwide total electricity demand was 12 trillion kWh in 1997, and is projected to reach 19 trillion in 2015. This constitutes an worldwide average annual growth of 2.6 percent, whereas the growth rate in developing countries, which are becoming industrialized, is projected to be almost twice the world average, namely approximately 5 percent. Most of the present demand of the energy used worldwide is currently generated by nuclear and fossil power. Of course, these sources of energy have allowed the industrialization of the world, but not without a heavy price. They are obviously available now, but are finite and are going to run out one day; in addition the burning of fossil fuels is responsible for the emissions of many pollutants, including a large amount of greenhouse gases responsible for global warming. Surprisingly, humanity has relied almost exclusively on renewable energy sources such as wood and other natural fuels. Only in the latter half of the 19^{th} century have fossil fuels become the dominant source of energy. Finding access to means of energy with little or no emissions and environmentally friendly (renewable energy) becomes imperative, since global warming is predicted to increase the average temperature of the earth's atmosphere from about 1.4 to 5.8° C [1]. Renewable energy sources are expected to be economically competitive with conventional energy sources in the medium to long term, because increasing the share of renewable energy in the energy balance enhances sustainability and also helps to improve the security of energy supplies by reducing the community's growing dependence on imported energy sources. Renewable energy encompasses technologies such as solar, wind generation, ocean, biomass geothermal and hydroelectricity. Several of these technologies, especially wind energy, but also small- scale hydro power, energy from biomass, and solar thermal applications can become economically viable and competitive. Solar and wind energy are the most important sources among renewable energies and have many advantages since they are pollution free and also sources of abundant power. Additionally, solar energy generates power near load centers, eliminating the need for running high voltage transmission lines through urban and rural landscapes, and has a role to play in reducing carbon dioxide (CO_2) emissions. Thus, although photovoltaic technologies are still in their infancy, they are expected to play a leading role in meeting electric power needs, provided that they can be made competitive with other renewable energy technologies and above all conventional power generation. The conversion of sunlight directly to electricity using photovoltaics could also be one of the major means to bridge the technological gap between developed, threshold and developing countries, because the developing countries have a plentiful supply of sunlight during the year as is shown in figure i.1.

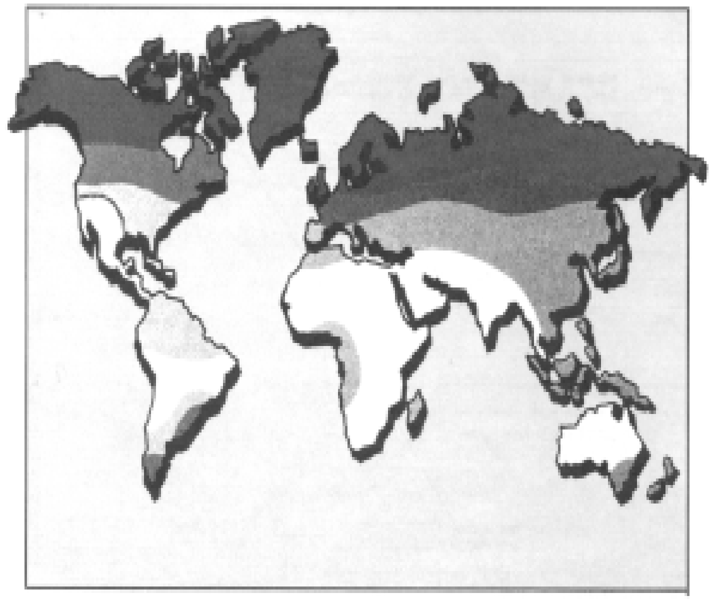

Figure i.1. *Solar radiation by regions of the world with higher energy potential in the whites areas (From ref* [2]*)*

1.2 Leading role of solar cell based $Cu(In_{1-x}Ga_x)(Se_{1-y}S_y)_2$ material.

The major strategy to make photovoltaic energy more economical is based on cheaper materials and manufacturing techniques. The major contributors to solar cells thus far are amorphous silicon (a-Si), thin film crystalline silicon (f-Si), crystalline gallium-arsenide, polycrystalline cadmium telluride (CdTe), organic solar cells, dye sensitized, and polycrystalline coper-indium-gallium-selenide or sulfide [$Cu(In_{1-x}Ga_x)(Se_{1-y}S_y)_2$] (CIGS). The most widely used material in terms of commercial sales up to now, are solar cells based on crystalline silicon with long-term stability and high power yield. However, crystalline technologies are very expensive, the preparation process requires high temperatures and finally the silicon material yield is very costly. The best alternative to the crystalline technologies are the amorphous and polycrystalline technologies provided by inexpensive deposition techniques on cheap substrates, that have the potential to become an economically competitive energy source and are easy to produce on a large scale.

(CIGS) based solar cells have yielded the highest power conversion efficiencies among all thin- film photovoltaic technologies in large-area modules (19.5 %) and small area devices (12.1%) in the laboratory scale [3]. Test modules and arrays based on this material have evidenced over years little degradation, and the overall performance of devices and modules has been steadily improved. Despite the fact, that CIGS materials have many benefits, they still have many disadvantages before achieving their optimal performance and lowest cost manufacturing. Among the limitations of CIGS we can cite the lack of control of the manufacturing process and the basic sciences underlying CIGS materials properties.

1.3 Purpose

The purpose of this thesis is try to elucidate some of these hurdles. The first step is to develop a quantitative deposition process and high quality level semiconducting thin films relationship. Chemical closed space vapor transport (CCSVT) technique is used to deposit polycrystalline $CuGaSe_2$ films onto glass or Mo coated substrates. Indeed, the CCSVT process was chosen for the deposition of the $CuGaSe_2$ because due to the use of the halogenides as transport agents it enables lower deposition temperatures compared to the conventional physical vapor deposition technologies, and the consumption of the $CuGaSe_2$ source material (Ga_2Se_3) is low, inexpensive and doesn't use toxic procedures and components. This fulfills well the ecological and economical requirements. One of the major tasks is the study of the growth mechanism of the deposited thin films to enhance the film quality and the correlation between material properties and stoichiometry deviation. The second step is the development of effective strategies for doping of $CuGaSe_2$ by extrinsic impurities and the understanding of the effect of the extrinsic defects on the $CuGaSe_2$ materials.

1.4 Organization

The organization of this thesis follows its goals, and is divided into seven chapters:

Chapter one gives a short introduction necessary for the understanding of the main issues about $CuGaSe_2$ compounds. Special attention is paid to the well known optical, and structural properties of the $CuGaSe_2$ compounds

Chapter two is a detailed description of the measurements carried out in the course of this thesis

Chapter three focusses on the preparation technique of the $CuGaSe_2$ films used in this thesis, the reduction of deposition temperature and the monitoring of the deposition parameters being the main goal.

Chapter four investigates the correlation between the elemental depth profile, the structural and optical peculiarities of the films deposited by CCSVT process with the stoichiometry deviation.

Chapter five is devoted to the investigation of the radiative transition in the CCSVT as prepared $CuGaSe_2$ films. Additionally, we have implanted the $CuGaSe_2$ films to investigate the effect of extrinsic doping using Ge and understand the doping mechanism

Chapters six deals with the investigation of the paramagnetic centers induced by Ge implantation into the $CuGaSe_2$ by means of electron spin resonance.

Chapters seven summarizes the major contributions of this thesis and finally gives some suggestions for future research.