CHAPTER I

INTRODUCTION

1.1 Introduction

Any discussion of solar energy and solar (photovoltaic) cells should begin with an examination of the energy source, the sun. Our sun is a dG2 star, classified as a yellow dwarf of the fifth magnitude. The sun has a mass of approximately 10^{24} tons, a diameter of 865,000 miles, and radiates energy at a rate of some 3.8 x 10^{20} megawatts. Present theories predict that this output will continue, essentially unchanged, for several billion years. It is necessary to say essentially, because the sun's energy output may fluctuate by a few percent from time to time **[1]**. The sun supplies energy in the form of radiation, without which life on Earth could not exist. The energy is generated in the sun's core through the fusion of hydrogen atoms into helium. Part of the mass of the hydrogen is converted into energy. In other words, the sun is an enormous nuclear fusion reactor. Because the sun is such a long way from the Earth, only a tiny proportion (around two-millionths) of the sun's radiation reaches the Earth's surface. This works out at an amount of energy of 1 x10^{18} kWh/area. The **figure 1.1** compares this amount of energy to worldwide annual energy consumption and to fossil and nuclear energy resources. The energy sources that we primarily use in our industrial age are exhaustible. A supply shortage (from the technical and economic points of view) in easily extractable oil and natural gas reserves is anticipated in the first third of this century. Even if large new reserves were discovered, fossil fuels would still only last for a few more years. The amount of energy in the sunlight reaching the Earth's surface is equivalent to around 10,000 times the world's energy requirements. Consequently, only 0.01 per cent of the energy in sunlight would need to be harnessed to cover mankind's total energy needs **[2]**.

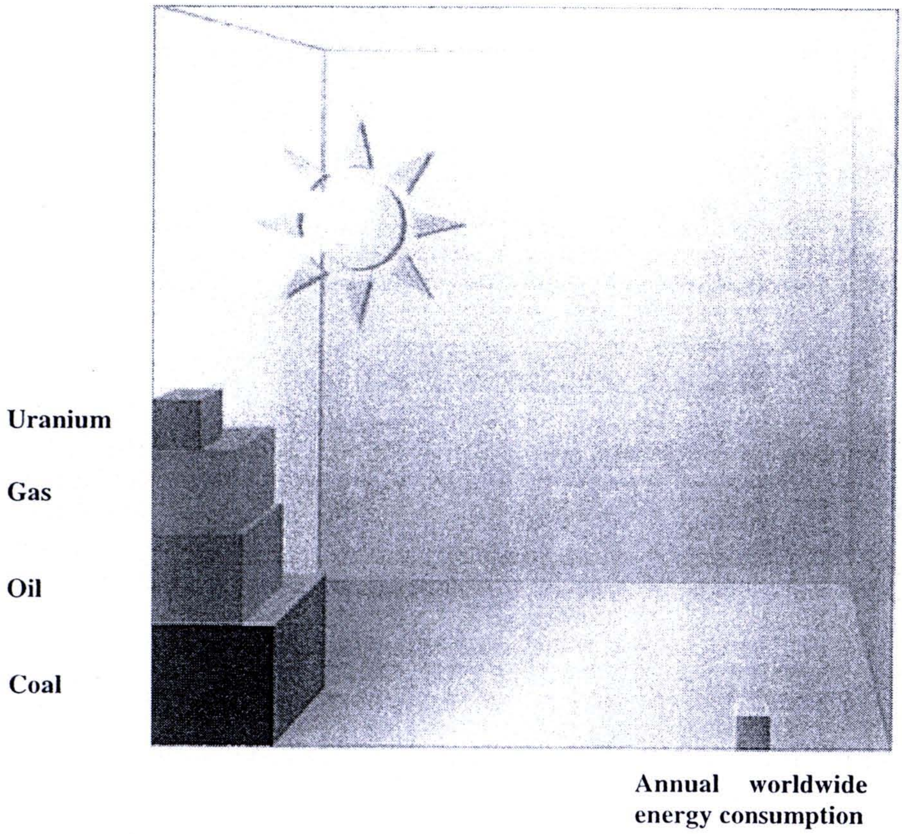

Figure 1.1 Amount of energy in the sunlight reaching the Earth's surface is equivalent to around 10,000 times the world's energy requirements. Consequently, only 0.01 per cent of the energy in sunlight would need to be harnessed to cover mankind's total energy needs **[2]**.

Photovoltaic energy conversion in solar cells consists of two essential steps. First, absorption of light generates an electron-hole pair. The electron and hole are then separated by the structure of the device - electrons to the negative terminal and holes to the positive terminal - thus generating electrical power. The effectiveness of a photovoltaic device depends upon the choice of light absorbing materials and the way in which they are connected to the external circuit **[3]**. The first functional, intentionally made PV device was by Fritts in 1883. He melted Se into a thin sheet on a metal substrate and pressed a Au-leaf film as the top contact. It was nearly 30 cm^2 in area. He noted, "the current, if not wanted immediately, can be either stored where produced, in storage batteries, . . . or transmitted a distance and there used." This man foresaw today's PV technology and applications over a hundred years ago. The modern era of photovoltaics started in 1954 when researchers at Bell Labs in the USA accidentally discovered that *pn* junction diodes generated a voltage when the room lights were on. Within a year, they had produced a 6% efficient Si *p-n* junction solar cell **[4]**. In the same year, the group at Wright Patterson Air Force Base in the US published results of a thin-film heterojunction solar cell based on Cu_2S/CdS also having 6% efficiency **[5]**. A year later, a 6% GaAs *p-n* junction solar cell was reported by RCA Lab in the US **[6]**. By 1960, several key papers by Prince, Loferski, Rappaport and Wysoski , Shockley (a Nobel laureate) and Queisser, developed the fundamentals of *pn* junction solar cell operation including the theoretical relation between band gap, incident spectrum, temperature, thermodynamics, and efficiency. Thin films of CdTe were also producing cells with 6% efficiency. By this time, the US space program was utilizing Si PV cells for powering satellites. Since space was still the primary application for photovoltaics, studies of radiation effects and more radiation-tolerant devices were made using Li-doped Si. In 1970, a group at the Ioffe Institute led by Alferov (a Nobel laureate), in the USSR, developed a heteroface GaAlAs/GaAs solar cell which solved one of the main problems that affected GaAs devices and pointed the way to new device structures. GaAs cells were of interest due to their high efficiency and their resistance to the ionizing radiation in outer space. The year 1973 was pivotal for photovoltaics, in both technical and nontechnical areas. A significant improvement in performance occurring in 1973 was the "violet cell" having an improved short wavelength response leading to a 30% relative increase in efficiency over state-of-the-art Si cells. GaAs heterostructure cells were also developed at IBM in the USA having 13% efficiency **[7]**.

In the 1970s and 1980s, high efficiency and improved radiation hardness of the AlGaAs/GaAs solar cells stimulated the large-scale production of AlGaAs/GaAs space arrays for spacecrafts. An AlGaAs/GaAs solar cell with total area of $70m^2$ was installed in the Russian space station MIR launched in 1986. During 15 years in orbit, the array degradation appeared to be lower than 30% under conditions that included appreciable shadowing, the effects of numerous docking, and a challenging ambient environment. At that time, it was the best large-scale demonstration of AlGaAs/GaAs solar cell advantages for space application. Further improvement of the LPE technology allowed obtaining the efficiency of 24.6% (AM0, 100 suns) on the basis of the heterostructures with an ultra-thin AlGaAs window layer and the back surface flied layer **[8]**.

1.2 Problem Statements

(1) To study fundamental definition of solar cell such as the materials, the structure and optical properties.

(2) To research and to fabricate the solar cell focusing on AlGaAs/GaAs heterostructure solar cell, and then to evaluated the sample by photoluminescence, spectral response, and I-V curve measurement.

(3) To propose and to increase the research of solar cells in developing country such as my country, Laos.

1.3 Objective

The main objectives of this research are:

(1) To study fundamental properties of AlGaAs and GaAs material system.

(2) To fabricate AlGaAs/GaAs heterostructure solar cells.

(3) To characterize AlGaAs/GaAs heterostructure solar cells.

1.4 Scope of Research

(1) To study fundamental of solar cell structure, and how solar cells work.

(2) To study methodology of fabrication.

(3) To fabricate AlGaAs/GaAs heterostructure solar cells.

(4) To characterize by photoluminescence, I-V curve and spectral response.

(5) To calculate fill factor, and efficiency.

1.5 Research Methodology

(1) Literature review on fundamental of solar cells for understanding.

(2) Literature review on AlGaAs/GaAs solar cells.

(3) Design and fabricate AlGaAs/GaAs heterostructure solar cells.

(4) Measure the electrical and optical properties of Heterostructure solar cells.

1.6 Expected Benefits

The future benefit of this study can be:

(1) To give me the basic knowledge of solar cells, and the technical know-how in fabricating AlGaAs/GaAs heterostructure solar cells.

(2) To gain knowledge in characterization of optical, and electrical properties of the solar cell.

(3) To be useful in knowledge transfer to my country especially to National University of Laos, Faculty of Engineering, and Department of Electronic Engineering.