CHAPTER 1
Introduction

1.1 Background

Optical semiconductor devices are widely used, in field ranging from optical fiber communication systems to consumer electronics, and have become indispensable devices in the equipment and system making up the infrastructure of our society. A photodiode is one of the most commonly optoelectronic devices that have been used for nowadays. Photodiodes detect optical signals and convert them into electrical signals. They have been used in a multitude of applications, including medical instrumentation, encoders, position sensing, fiber-optic communication systems, and image processing. The properties of a photodiode are defined by: spectral responsivity or quantum efficiency, response time, noise, dark current and junction capacitance. By modifying these parameters and the device configuration we can design a photodiode that performs optimally in any application requirements.

Many techniques have been used to improve the performance of photodiode and the staircase bandgap is one example that researchers use to develop their photodetector such as $Si_{1-x}Ge_x/Si$ photodetectors [10] and InAlAs APD [13] in order to improve spectral response, sensitivity and reduce noise.

Our research group which is mainly working on GaAlAs/GaAs heterostructure for optical application has the former research on the topic of fabrication and study on spectrum response of GaAlAs/GaAs heterojunction photodiodes by Miss Tosaporn Chavanapranee. This research was concentrated on the photodiode with graded bandgap window layer and found an advantage that the sensitivity of short wavelength was increased due to the buit-in electric field which was generated by the graded bandgap window layer. This particular electric field would reduce the recombination at surface. Therefore, we interest in this electric field and want to apply in active region.

In this research we aim to improve the performance of GaAs/GaAlAs photodiode by the bandgap engineering: (1) employ the window effect of heterojunction on the top $Ga_{0.6}Al_{0.4}As$ (P^+) layer to pass through the photons into the GaAs (n^-) active layer (2) apply the staircase bandgap tailoring especially in active region to produce the quasi electric field.

1.2 Objective

1. To design and fabricate the GaAs/GaAlAs staircase bandgap photodiode
2. To analyze the characteristics of fabricated photodiodes
3. To discuss between the experimental and the theoretical results

1.3 Overview

This thesis is divided into four parts: background and basic principle, structure design, fabrication, experimental result discussion and conclusion.

The first part: covers chapter 1 and 2, describes the background, the basic principle of semicondutor homojunction and heterojunction, PIN photodiode, GaAs-GaAlAs material system, and GaAlAs/GaAs heterojunction and window effect.

The second part: chapter 3, describes the bandgap engineering, spectral respnse simulation, and structure design.

The third part: chapter 4, describes the epitaxial growth technique, material preparation and calculation, growth process, Zn diffusion, and device structure formation.

The fourth part: covers chapter 5 and 6, describes the fabricated structures, current-voltage characteristic, spectral response, discussion and conclusion.