Chapter 1

Introduction

The group of (In,Ga)(As,N) materials has attracted considerable interest in the past fifteen years due to their unusual electronic properties which make them suitable candidates for GaAs based quantum well (QW) lasers working in the wavelength of 1.3-1.55 μm. These limit wavelengths correspond to the two attenuation minima in silica optical fibers employed in internet network systems.

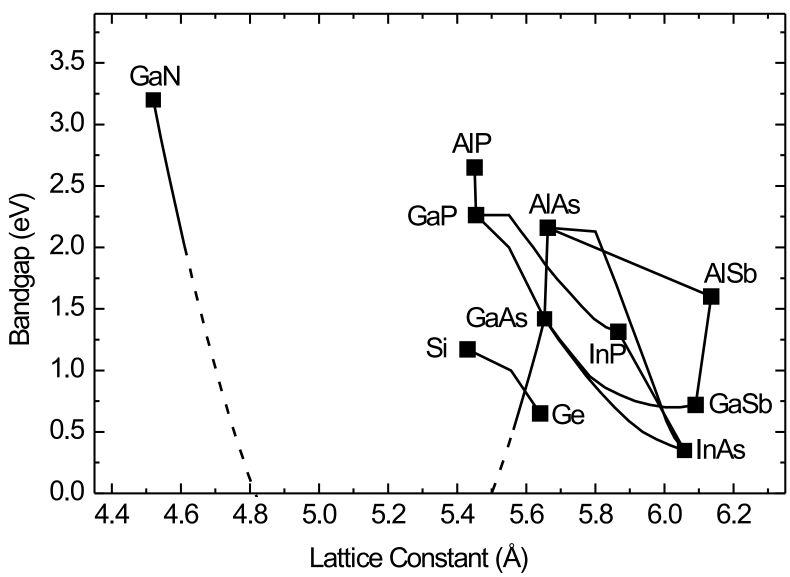

Figure 1.1: Lattice constants and band gaps of several elementary and binary semiconductors with a zinc-blende structure. The lines that connect different semiconductors denote the band gaps and lattice constants of the pertinent semiconductor alloys.

Because of the large difference in atomic sizes and electronegativities of N and As atoms, the introduction of N into GaAs leads to giant bowing of bandgap energy, unlike the conventional III-V alloys (shown in Figure 1.1). This attracts interest both experimentally and theoretically. Technically, the lowering of bandgap energy makes it suitable for fabricating infrared lasers which was dominated by InP QWs, because, first, the use of GaAsN lower the energy barrier height compared to GaAs, leading to lower quantum well (QW) transition energies; second, the group of (In)GaAsN materials is more suitable to be integrated on GaAs or Si substrates, of which the integration techniques are already mature.

However, the materials crystalline quality and optical properties degrade severely with the increasing of N concentration, which largely limits the intended application of it in the optoelectronic devices. This quality degrading is mainly caused by the implantation of ions during growth, phase separation and the low-temperature growth induced III site vacancies. Fortunately, many recent research results showed that the annealing processes could greatly improve the material properties of the (In)GaAsN materials. In the same time, the annealing processes usually induce blue shifts of the optical emission of the materials, which is on the contrary of the purpose on obtaining long wavelength laser emission with this group of materials. Therefore, to investigate the mechanism and consequently seeking optimum annealing conditions is critical for the development of this materials.

At present, dilute nitride based VCSEL emitting at 1.3 μm are already commercialized. InGaAsN/GaAs QWs present good characteristics for good emission at 1.3 μm, but nowadays it is still difficult to obtain the same performance at the second minimum 1.55 μm; the latter wavelength requires the incorporation of a large amount of In, which results in a partial relaxation of the structure due to the high strain and in a degradation of the laser performances. A new dilute nitride alloy, the quinary InGaAsSbN, can overcome the problem. The addition of a few percent of Sb during the growth of InGaAsN results on the improved optical and structural properties of the material. This has been attributed to a surfactant effect of Sb, which allows one to incorporate a higher In % avoiding relaxation. Some of us have managed in this way to build an InGaAsSbN QWs-based laser emitting at 1.48 μm with a peak line width of 35 meV (after RTA). This constitutes the state of art for RT emission near 1.5 μm and it is close to the record value for 1.3 μm emission (27 meV).

In this thesis, we report on the works on the structural and optical investigation of GaAsN/GaS MQWs after RTA processes and EXAFS studies of the InGaAsSbN alloys after RTA processes. The organization of the thesis is as follows: chapter 2 is a brief review of the investigation of the group of (In)GaAsN materials; Chapter 3 reviewed the works on the anneal processes on the dilute nitride group of materials; Chapter 4 is a description of the problems investigated in the thesis; In chapter 5 and chapter 6, we report the characterization of optical and structural evolution of GaAsN/GaAs MQWs (N concentration changes from 0.6 % to 6.1 %) under RTA processes from the temperature of 650°C to 950°C; In chapter 7, we report the EXAFS study of the atomic structural change under the anneal processes of InGaAsSbN alloys; A summary of the main conclusions and possible future works are presented in chapter 8.