Chapter 4

Problems Studied in this Thesis

Due to the large miscibility gap between GaAs and GaN, the GaAsN alloy is usually grown under non-equilibrium conditions, such as growing at lower temperatures, in order to increase the N incorporation. This usually results in nitrogen composition fluctuations and defects in the alloy. Post-growth annealing is generally used to improve the materials quality. It could be seen in Chapter 3 that most of the investigations of annealing effects on (In)GaAsN materials concentrate on obtaining the best optical properties. Although several reports were made of an optimum annealing process in terms of obtaining the strongest PL emission, there have been fewer systematic studies on the detailed mechanism of micro-structural changes during the annealing process from low temperature to high temperature. In fact, these detailed mechanisms during annealing need to be investigated in order to understand the processes more fully and accurately, but also for engineering the device fabrication processes.

On the other hand, the question of lattice properties, including short-range ordering, is also intensively relevant in this group of materials, because of its effect on the sample homogeneity and materials optical properties [69]. In Chapters 5 and 6, we study by Raman spectroscopy the microstructure of GaAsN/GaAs MQWs grown with a N composition of 0,6% to 6.1%, aiming to provide more studies on the structural changes during RTA processes. We demonstrate a new phenomenon observed in the GaAsN materials during the RTA process, which is termed ”negative annealing”, and which has been observed also in more traditional materials, such as Si, during annealing [65]. The possible description of the short range structure is discussed.

In addition, the structural changes on atomic dimensions due to the introduction of N, and the detailed N-atomic neighbor configuration, are important for the interpretation of the unique electronic properties of this group of materials and for the development of the dilute nitride materials for applications [70–72].

This problem is of interest and has been intensively explored by various methods [46, 73]. But due to the the resolution of these characterization methods, it is difficult to obtain quantitatively detailed conclusions for this important problem. Fortunately, EXAFS analysis provided us a way to access the detailed structure on the atomic scale. In Chapter 7, we study structural changes induced by annealing on InGaAsSbN samples by EXAFS and their relation to the optical properties, with the aim to understand if there is short range ordering and/or preferential bonding in the quinary alloy In-

GaAsSbN as a function of different annealing conditions.