Chapter 6

Conclusions

A series of experimental study on the liquid phase epitaxy (LPE) growth for GaAs-GaAlAs laser diodes fabrication has been conducted. The reseach work began with the most simple structure, i.e. double heterostructure (DH). In this DH structure, Zn was used as the impurity in p-cladding and diffused into the active layer. This diffusion problem caused high threshold current density and nonlasing conditions. Then, the four-layer structure was developed to solve the above-mentioned problem to some extents. To improve the external quantum efficiency, the separate-confinement heterostructure (SCH) was finally chosen. In order to have a guideline in the fabrication of different structures of laser diodes, the linear gain theory was used to compute various parameters, i.e. the active layer thickness, the waveguide layers thickness and its Al content, and the Al content in cladding layers, etc. Then, a series of experiments was performed to realize the actual devices. The characteristics of GaAs-GaAlAs laser diodes with different structures were examined. The results are summarized as follows :

1) The optimal and proper structures of laser diodes with low threshold current density could be realized by the LPE-growth using combined techniques of two-phase solution and supercooling. Very thin or thin layers could be grown from the two-phase solution technique. Meanwhile, a few micron thick layers could be grown from the supercooling technique. These combined techniques could be achieved by the novel design of the graphite boat with lateral sliding. Supersaturation in the solutions would be ensured by our

novel graphite boat.

2) The threshold current density of DH LD's with 0.1 μm active layer thickness was 4-8 KA/cm^2 for the cavity length of 300-700 μm. This value was improved to be 2.6-4 KA/cm^2 and 1.8-3.2 KA/cm^2 for the four-layer heterostructure (the active layer less than 500 Å), SCH (the active layer 700 Å), respectively.

3) The spectra of most LD's were multimode and the lasing wavelengths were in the range of 865-892 nm.

4) The LPE growth with combined techniques was feasible to form a GaAs-GaAlAs single quantum well structure. The very thin active layer as thin as 300 Å was obtained from our experiment.

5) The quantum size effects were confirmed by the broadening of emission spectra of the photoluminescence measurements as well as those of the electroluminescence measurement.

6) The LPE-growth SQW-SCH lasers, with broad-area structure having the cavity length of 600 μm, could provide threshold current density as low as 500 A/cm^2. The optical power output of SQW-SCH laser, having 25 μm-wide SiO_2 stripe-geometry and the cavity length of 450 μm, is found to be higher than 400 mW/facet. The lasing of SQW-SCH lasers became longer wavelength when the cavity length was increased to some limit. This change could be explained by the bandgap shrinkage effect of the quantized states in the quantum well.

This conclusion indicates that LPE-Growth technique is still a powerful method in laser diode fabrication. The novel design of graphite boat and the proposal of using a combined techniques in our research were emphasized. Finally, we have demonstrated the potential of LPE-Growth technique in SQW-SCH lasers fabrication.