B-5-5 Influence of Oxygen in Ambient Gas on LPE GaAs Layers

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1. Introduction

Recently, it has been found that the operating lives of GaAs-GaAlAs double heterostructure lasers are much improved by using wafers obtained in liquid phase epitaxial growth under the extremely low oxygen concentration in the ambient hydrogen gas.[1] It is indispensable to clarify the influence of oxygen in the ambient gas and Ga solutions on grown layers in epitaxial processes.

In this paper, we present the influence of oxygen in the ambient gas on the defects, and on the electrical and optical characteristics in the liquid phase epitaxial layers of GaAs.

2. Experimental

Special attention was paid to construct the growth system in which oxygen concentration became less than 0.03 ppm. Oxygen concenration was controlled to maintain at 0.03, 0.4 and 6 ppm during heat treatment of Ga solutions and crystal growth. Before the liquid phase epitaxial growth, Ga solutions were heated at 900°C for three hours. Undoped GaAs layers were grown on <100> oriented GaAs substrates. In order to examine the defect formation, the surfaces of grown layers were preferentially etched in molten KOH at 350°C for 2 minutes, and observed by optical microscopy.[2] Hall coefficients and photoluminescence spectra of grown layers were measured.

3. Results and Discussions

Etch pit patterns of GaAs layers grown in the oxygen concentration of 0.03, 0.4 and 6 ppm are shown in Figs. 1(a), (b) and (c), respectively. Etch pits with black contrast attached to arrows in Fig. 1 correspond to dislocations in the GaAs layers.[2] The other pits, which are called saucer pits, appear in high density in Figs. 1(b) and (c). In contrast to them, saucer pits are rarely found in the layers grown in the oxygen concentration below 0.03 ppm as shown in Fig. 1(a). These results indicate that the formation of defects in GaAs layers is associated with the oxygen which is incorporated into GaAs layers through Ga solutions from the ambient gas.

N-type grown layers were obtained in this study. Figure 2 shows the carrier concentration and the mobility of GaAs layers as the function of the oxygen concentration in the ambient gas during crystal growth. The carrier concentration increases in proportion to the oxygen concentration. The mobility of grown layers increases with decreasing the oxygen concentration.

Figure 3 shows the photoluminescence of grown layers at 77 K. The two peaks are seen at the positions indicated by arrows A and B. The peak A corresponds to the emission from near-band-to-band transitions. The emission intensities of B increase with increasing the oxygen concentration in the ambient gas. The band B seems to be due to the deep levels associated with oxygen.

4. Summary

The oxygen concentration in ambient gas during liquid phase epitaxial growth was quantitatively measured. It is found that the influence of oxygen on the crystal is very important as follows:

(1) saucer pit density in the grown layers decreases drastically when the oxygen concentration in the ambient gas reduces to less than 0.03 ppm

(2) the carrier concentration in the grown layers decreases in proportion to the oxygen concentration in the ambient gas

(3) the emission intensity of photoluminescence spectra due to deep levels associated with oxygen much reduces.

The results show that it is unavoidable to investigate the oxygen behavior in the grown layers and the solutions in order to grow homogeneous layers by liquid phase epitaxy and to improve the characteristics of devices such as lives of lasers.

References

1) H. Kan, H. Namizaki, M. Ishii and A. Ito: Appl. Phys. Letters 27 (1975) 138.

2) M. Ishii, R. Hirano, H. Kan and A. Ito: Japan. J. appl. Phys. 15 (1976) 946.

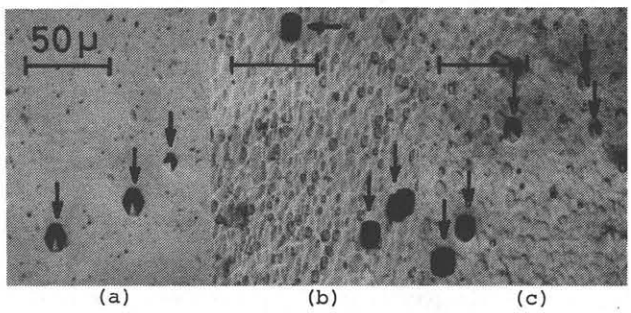

Fig. 1. Photographs of etch pit patterns corresponding to the oxygen concentration a) 0.03 ppm, b) 0.4 ppm and c) 6 ppm.

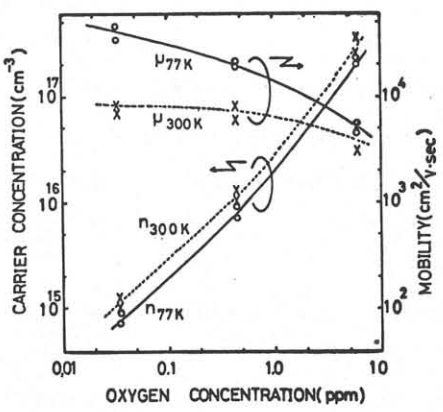

Fig. 2. Carrier concentration and mobility as the function of the oxygen concentration.

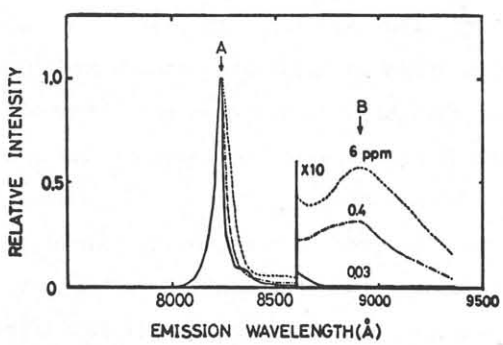

Fig. 3. Photoluminescence spectra at 77 K.