Fabrication of GaAlAs Multi-Quantum-Well Buried Heterostructure Lasers Using Diffusion-Induced Disordering

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As Multi-Quantum-Well (MQW) has a step like density of electronic states, MQW lasers have low threshould current density and its weak temperature dependence.[1,2] These features are favourable for integration of the laser diodes and electronic devices.[3,4]

Since MBE or MO-CVD, which can not be used to make CSP or BH structure, is applied for the fabrication of MQW, transverse mode control of MQW lasers has been difficult. Diffusion-induced disordering (DID) of GaAlAs MQW structures grown by MO-CVD has been reported by W. D. Laidig et al.[5] GaAlAs MQW structures with barrier layer thicker than 40 Å have the refractive index larger than that of GaAlAs alloy with averaged AlAs mole fraction[6]. Accordingly DID can be used to make MQW BH lasers.

In this paper, we demonstrate an application of DID to the fabrication of MQW BH lasers. The fabrication processes of MQW BH lasers are shown in Fig. 1. First, the following layers were grown on p-type (100) GaAs substrates by MBE. The layers grown are a 3 μm $Ga_{0.65}Al_{0.35}As$ (Be: 1.3 x $10^{18}cm^{-3}$) cladding layer, a 1 μm $Ga_{0.7}Al_{0.3}As$ (Be: 1.3 x $10^{18}cm^{-3}$) optical guide layer, an undoped MQW active layer consisting of 10 periods of GaAs quantum well (80 Å) and $Ga_{0.65}Al_{0.35}As$ (60 Å), a 1 μm $Ga_{0.65}Al_{0.35}As$ (Si: 1.2 x $10^{18}cm^{-3}$) cladding layer and a 0.5 μm GaAs (Si: 2 x $10^{18}cm^{-3}$) cap layer. Next, the n-GaAs cap layer was removed by dry etching leaving 4 μm wide stripe region using Si_3N_4 mask. Then zinc was selectively diffused at 666°C for 48 minutes from $ZnAs_2$ in an evacuated silica ampoule. The MQW structure became compositionally disordered by this Zn diffusion. The DID was confirmed by Rutherford backscattering and photoluminescence measurements (Fig. 2). These measurements show that the DID region has averaged AlAs mole fraction of MQW structures. Zinc diffused regions of the cap layer were selectively etched by peroxide/alkaline solution in order to electrically isolate the n-GaAs and Zn-diffused $Ga_{0.65}Al_{0.35}As$ cladding layer. The top p-GaAlAs surface was anodically oxidized in oxygen plasma and subsequently the Si_3N_4 film was removed by dry etching to make ohmic contact to the n GaAs layer. Figure 3 schematically shows the MQW BH laser structure fabricated by these processes.

Typical light-output versus current (I-L) curve of MQW BH laser with 300 μm cavity length is shown in Fig. 4. The threshould current I_{th} is 50 mA. No kink is observed in this I-L characteristics. Details of characteristics will be given at the conference.

In conclusion, it has been confirmed that the DID is a simple and reliable process for fabricating MQW BH lasers, and is useful for making optical waveguide and other devices. Low threshould current is expected by optimization of MQW structure and refinement of fabrication processes.

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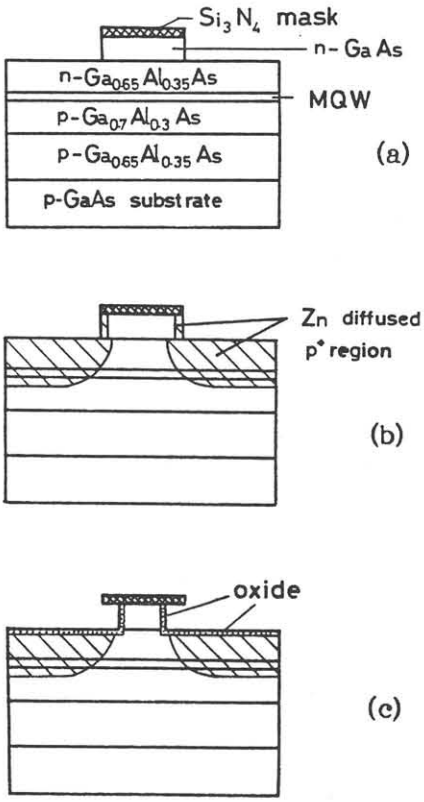

Fig. 1 Fabrication processes of MQW BH laser
(a) Epitaxy and dry etching
(b) Zn diffusion
(c) side etching and anodic oxidation

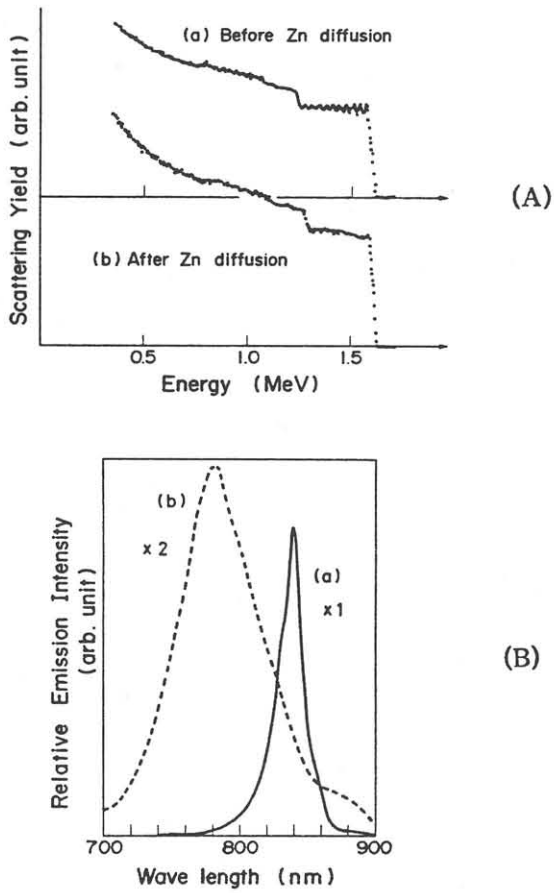

Fig. 2 RBS (A) and PL spectra (B) of GaAlAs-GaAs superlattice (a) and a disordered superlattice (b) by Zn diffusion

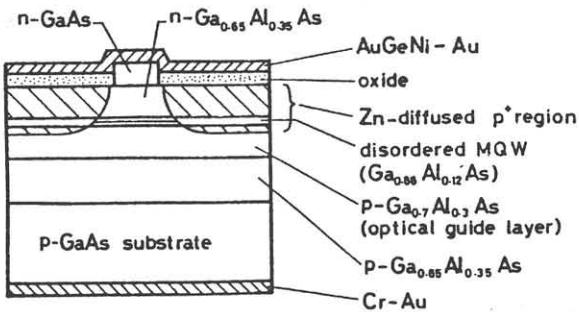

Fig. 3 MQW BH laser structure

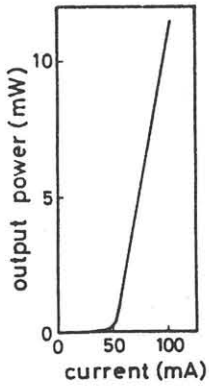

Fig. 4 I-L characteristic of MQW BH laser