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1.5-1.6μm Wavelength (100) GaInAsP/InP DH Lasers

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There have been several reports of GaInAsP/InP DH lasers(LD) in the range of 1.1-1.5μm by LPE technique,[1,2,3,10] and the normalized threshold current density J_{th}/d was 4-5kA/cm²/μm in the range of 1.2-1.5μm.[10] Concerning the lasers emitting at long wavelength of about 1.7μm, J_{th}/d of LD prepared by LPE was 8-15 kA/cm²/μm,[7,8] and it was higher compared with J_{th}/d of 5-6kA/cm²/μm obtained by VPE[5] and MBE[6]. For LPE growth it is difficult to grow GaInAsP/InP DH wafer of long wavelength lasers due to dissolution of active layer during the growth of InP, and this difficulty prevented making longer wavelength lasers. Then, we made new structure DH wafer using two-phase solution technique and obtained low threshold lasers at the wavelength of 1.5-1.6μm. This wavelength range is very important to low loss optical fiber communication.[4]

In this conference we want to report GaInAsP/InP longer wavelength lasers with low threshold value J_{th}/d prepared by two-phase solution technique. The threshold value J_{th}/d was comparable to that of shorter wavelength GaInAsP/InP lasers.

It is very difficult to grow a longer wavelength(λ>1.5μm) GaInAsP/InP DH wafer by LPE technique because the quaternary layer tends to meltback into the In-P melt which is used for InP layer growth. For this reason, the active layer was cladded by a quaternary layer of GaInAsP in order to prevent this melting back of the active layer.[9] As a result, however, a higher threshold current density was produced since the carrier confinement was insufficient. So we proposed to use InP crystal as a cladding layer and use GaInAsP crystal as only "anti-meltback" layer.[8]

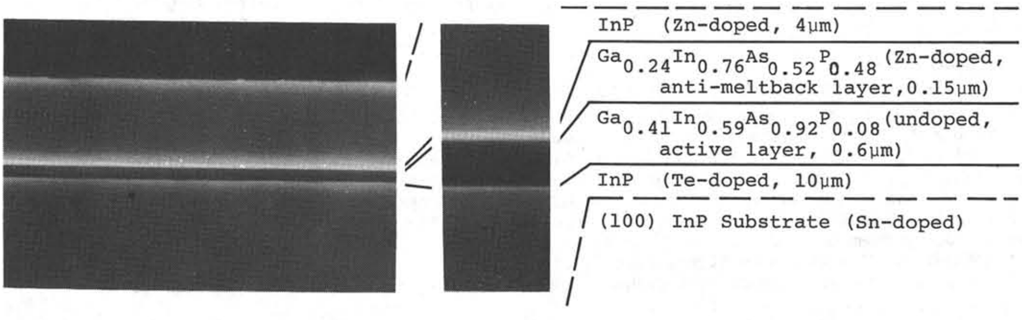

Fig.1 SEM photograph of DH wafer

DH wafers were grown on (100) InP substrate. These wafers consisted of four layers, (i) n-type InP (Te-doped, 10μm thick), (ii) $Ga_yIn_{1-y}As_xP_{1-x}$ (undoped, active layer), (iii) p-type $Ga_{0.24}In_{0.76}As_{0.52}P_{0.48}$ (Zn-doped, anti-meltback layer, 0.15μm thick), and (iv) p-type InP (Zn-doped, 4μm thick). The quaternary layers were grown using two-phase solution, and InP layers were grown using saturated solution. For LPE growth we used a conventional type of graphite sliding boat. After maintaining a temperature of 670°C(T_s:soak temperature) for 40min, we lowered the temperature at a rate of 0.81°C/min. And the growth temperature of active layer was 631°C. An example of SEM photograph of the cross section of a DH wafer for the lasers of 1.65μm wavelength is shown in Fig.1. In this case the thickness of active layer was 0.6μm. Lattice mismatch between GaInAsP and InP was less than 0.05%.

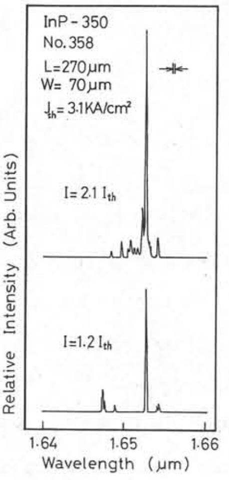

Fig.2
Lasing spectrum

After polishing the wafer and making ohmic contacts, we fabricated broad contact type laser diodes by cleavage. Figure 2 shows the lasing spectrum of broad contact type laser under pulsed operation. Threshold current density J_{th} was 3.1kA/cm², and the active layer thickness d was 0.6μm. With same configuration of DH wafer, we fabricated other wavelength lasers of 1.45 μm and 1.55μm, and measured J_{th}/d. Figure 3 shows the J_{th}/d as a function of lasing wavelength λ. J_{th}/d was 5-6kA/cm²/μm in longer wavelength region and is almost as same as the value obtained for the lasers of 1.2-1.5μm region.[10]

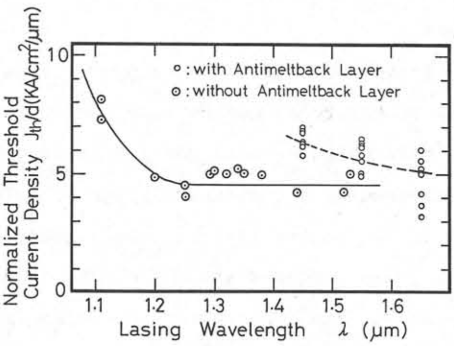

Fig.3 Normalized threshold current density J_{th}/d as a function of lasing wavelength

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