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Sharp Photoluminescence of the GaAs/AlGaAs SQWs Grown on Si Substrate by MEE at 300° C

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Recently, device quality GaAs epitaxial layers grown on Si substrate have been much attracted. For the most part of the studies are concentrated on suppression of both generation of anti-phase domain and propagation of the misfit dislocations into epitaxial layer. However, when the epitaxial growth is done at high temperatures the problems on the internal stress and resultant bending of epitaxial wafer still remain, which are caused by difference in thermal expansion coefficient between Si and GaAs. Migration Enhanced Epitaxy (MEE) is a recently developed epitaxial method which enable us to grow epitaxial layers at fairly low temperatures. In this paper, the photoluminescence properties of GaAs single quantum wells (SQWs) grown on Si substrate by MEE method are reported.

The substrates used are Si (100) misoriented by 2°toward <011> direction. After flashing the substrate at 950℃, the substrate temperature was lowered to 300℃ under As_4 irradiation. Then a 0.5-1.0μm-thick GaAs buffer layer, and three SQWs with Lz=10,5, and 2nm separated by 50nm $Al_{0.3}Ga_{0.7}As$ barrier layers were successively grown by MEE at 300℃ (Type A). The samples with the same structure were also prepared by applying high temperature annealing process. After depositing 30nm-thick GaAs buffer layer, the temperature was raised to 450℃ and kept at this temperature for 15min. Then the substrate temperature was reduced to 300℃ again, and the MEE growth discribed above was continued (Type B).

The typical photoluminescence (PL) spectrum is shown in Fig.1. The values of the full width at half maximum (FWHM) of PL peaks are relatively small. In the outermost SQW (Lz=2nm), FWHM is as little as 10.5 meV that is the narrowest linewidth measured on SQW grown directly on Si substrate ever reported. This SQW showed the highest PL intensity. For inner SQWs, PL peak intensity drops much faster than those for SQWs grown on GaAs substrate. In addition, FWHM values of these inner SQWs are not smaller than that of the outermost SQW, although these SQWs have larger Lz's. These facts suggest that SQW layers closer to the substrate surface work as a superlattice buffer layer and therefore, the crystalline quality of the inner SQWs are inferior to that of the outermost SQW.

In Fig.2, FWHM values are plotted as a function of Lz for different samples (○;Type A, △;Type B). As shown in the figure, FWHM values do not seem to be affected by the growth procedure. The measured values of 10-13meV in FWHM reveal a high crystalline quality of MEE grown SQWs on Si substrate if the 4% lattice mismatch and the buffer layer thickness of only 1 μm are taken into account, although these values are still larger than those observed in SQWs grown on GaAs substrate by MEE (see ◇).

These results proved that MEE is a promissing growth technique for lattice mismatched hetero-systems as well as for lattice matched systems.

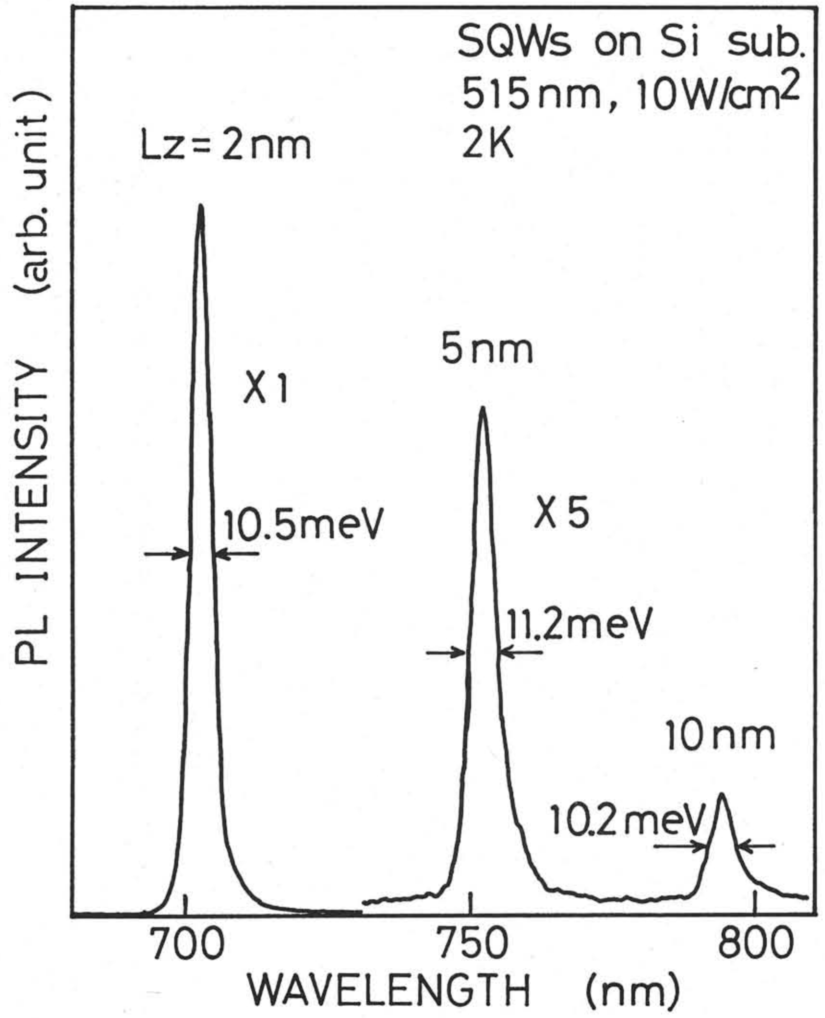

Fig1. PL spectrum of MEE grown SQWs on Si substrate at 300C.

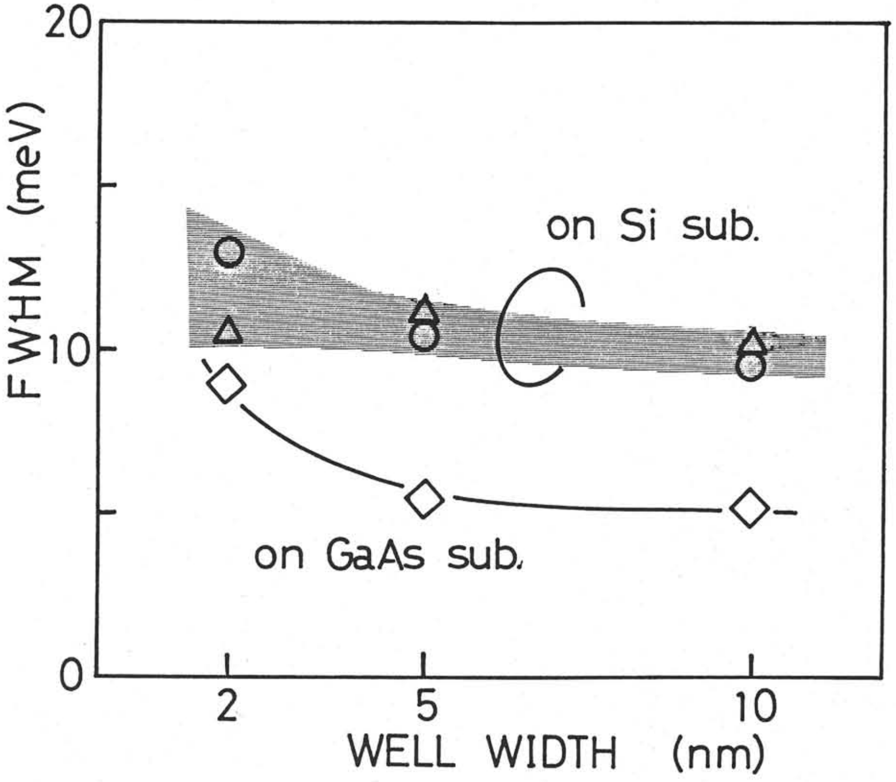

Fig2. FWHMs of PL spectra of MEE grown SQWs on Si and GaAs substrates at 300℃.

○ ; direct growth on Si substrate, △; 450℃ 15min annealing process was inserted after depositing 30nm-thick GaAs layer on Si substrate, ◇ ;direct growth on GaAs substrate.