COMPARISON OF QUANTUM WELL INTERMIXING IN GaAs STRUCTURES USING A LOW TEMPERATURE GROWN EPITAXIAL LAYER OR A SiO_2 CAP

D. A. Thompson, A. S. W. Lee, J. H. Huang, and
B. J. Robinson.
Centre for Electrophotonic Materials and Devices,
McMaster University, Hamilton, ON. L8S 4L7,
Canada.

The mechanism of quantum well intermixing (QWI) involves the creation of a non-equilibrium concentration of point defects which diffuse through the quantum well (QW) and adjacent barrier layers during a high temperature anneal treatment. This causes inter-diffusion and consequent change in the QW composition and thickness [1] leading to changes in the effective bandgap of the QWs which shows up as a blue-shift in the room temperature photoluminescence (PL). Then by spatially defining the areas of modified regions across a wafer, this QWI technique has been widely proposed as a method for implementing photonic integration [2]. This work reports on a comparison of the use of a low temperature grown epitaxial InGaP (LT-InGaP) or PECVD deposited SiO_2 with rapid thermal annealing (RTA) for 60s at temperatures up to 900^{O}C to induce QWI. Samples consisted of single QW structures in which the wells and barriers had either changes in the group III (InGaAs/GaAs) or group V (InGaAs/InGaAsP) compositions only. This allows us to separate out the defects migrating as group III or group V species. The results in fig.1 show that the LT-InGaP cap most strongly affects the InGaAs/ InGaAsP sample by inducing a larger bandgap blue-shift, but there is a much reduced photoluminescence (PL) signal. This reduced intensity we ascribe to lateral composition modulation which is greatly increased by the RTA treatment, as shown in fig.2. For the InGaAs/GaAs samples the blue-shift after RTA is similar for both capping layers as seen in fig.3; also, the PL intensities remain strong for anneals up to 900^{O}C. These results will be explained based on previous explanations for the SiO_2 cap behaviour [1] and for the defects hypothesized to be present in LT-InGaP based on our previous work using LT-InP to induce QWI in InP-based QW structures [3].

[1] D. G. Deppe, L. J. Guido, N. Holonyak, Jr., K. C. Hsieh, R. D. Burnham, R. L. Thornton, L. Lindstrom, J. Appl. Phys. 54, 510 (1986).

[2] J. H. Marsh, S. I. Hansen, A. C. Bryce, R. M. De La Rue, Optical and Quantum Electron. 23, S941 (1991).

[3] B. E. Gordon, A. S. W. Lee, D. A. Thompson , B. J. Robinson, Semicond. Sci. Technol. 18, 782 (2003).

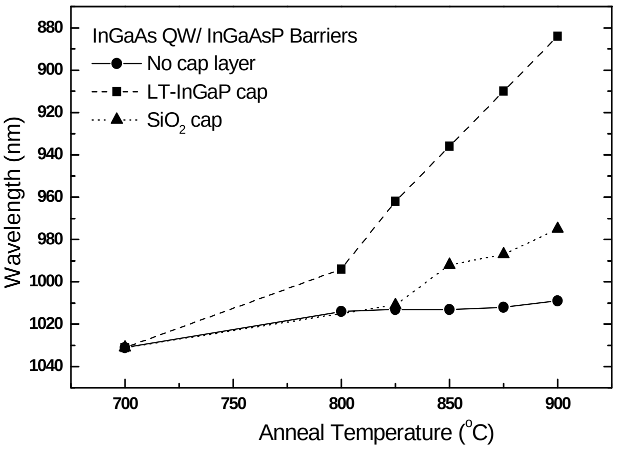
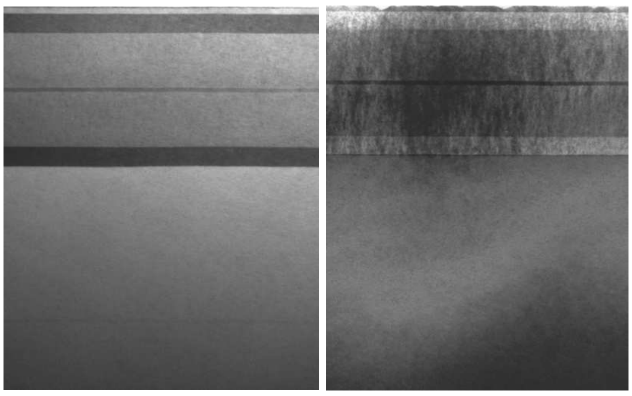


Figure 1. Peak PL wavelength after anneal for the variously capped InGaAs/InGaAsP samples.



(a) (b)

Figure 2. Cross-sectional TEM for samples with InGaAs QW/ InGaAsP Barriers. (a) as-grown, and (b) after anneal at 925^{O}C.

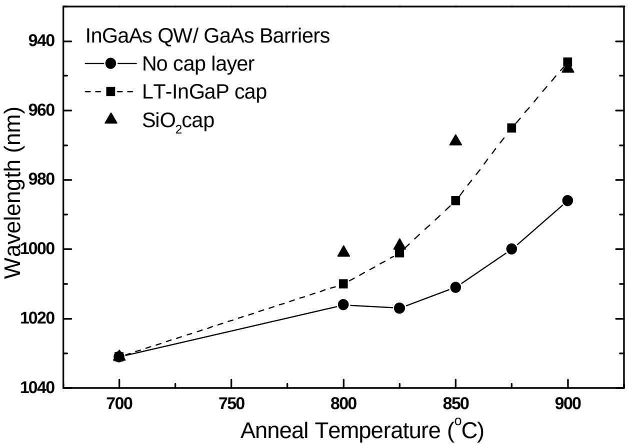


Figure 3. Peak PL wavelength after anneal for the variously capped InGaAs/GaAs samples.