Strain-Induced Photoluminescence Degradation in Metamorphically Grown InGaAs Quantum Wells

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We have recently demonstrated that room-temperature PL of both tensilely and compressively strained quantum wells (QWs) grown metamorphically on graded buffers is strongly degraded relative to that of unstrained wells grown metamorphically on the same substrates [1]. For compressively strained QWs, it was found that the strain also brings about a strong temperature dependence of the PL. The integrated room-temperature and low temperature (19K) PL intensities are plotted against the indium compositions in the QWs in Figures 1 and 2, respectively. The degradation can be partially suppressed by reducing the grading rate of the buffer, by using a superlattice after the growth of the buffer, or by inserting a single 5-nm, tensile-strained GaAs layer and a 30-s growth interruption immediately before the growth of the QW. The PL can also be significantly improved if the substrate temperature during the growth of the graded buffers is reduced when the indium content in the graded buffer is high.

Our observations lead us to conclude that the degradation we observe, which has not been observed previously, is unrelated to the Matthews-Blakeslee process. We, instead, believe that the degradation is most likely related to the surface morphology introduced by the graded buffers, and that the surface roughness, which develops during growth of graded buffer layers plays the key role in the reduction. We also propose that one may eliminate the degradation by smoothing the linearly graded buffer layer using chemical-mechanical polishing (CMP) prior to growing a metamorphic QW structure on it. Such a sequence, if successful, offers another pathway to producing long-wavelength opto-electronic devices on GaAs substrates.

Figure 1: The integrated room temperature-PL intensities plotted against the indium compositions in the QWs.

Figure 2: The integrated low temperature (19K) PL intensities of the same set of samples as in Figure 1.

REFERENCES: