A potentially useful technique to extend the emission wavelength of quantum well (QW) lasers on GaAs substrates is to fabricate the laser structures metamorphically on compositionally graded InGaAs buffers. In such buffers, the indium fraction is increased gradually as growth proceeds. This results in steady elongation of the existing dislocations along the growth surface, releasing the additional strain, and the density of threading dislocations can be minimized. Mismatched metamorphic materials have been grown with the use of graded buffers for over 30 years and the most notable successes are mainly in electronic applications, such as InGaAs HEMTs on GaAs, and strained Si or SiGe high mobility MOSFETs on Si. The adaptation of graded buffers to optoelectronic devices, on the contrary, has been much slower, and we have been working to change this situation.

We have recently demonstrated that the use of ex-situ thermal annealing can yield a 30-fold improvement in the photoluminescence (PL) of aluminum-containing single QW structures grown on top of compositionally graded InGaAs buffers [1]. By analyzing the variations of low temperature PL from both the barriers and from the QW as functions of the annealing temperatures, as shown in Figure 1, we have concluded that two processes are involved in the annealing process: a faster one in the barriers and a much slower one in the QW region. By annealing diode structures on the graded buffers, we also observed a large increase in the reverse-biased breakdown voltage from ≈ 0V, due to tunneling through the mid-gap states, to 23V: the avalanche breakdown voltage of the diodes, as Figure 2 shows. Additional QW PL enhancement is found by annealing the samples at a much lower temperature, 700°C, for an extended duration of 20 minutes. With enough carrier confinement in the QWs and with the proper annealing scheme, we obtain emission from metamorphically grown QWs as strong as, and sometimes even stronger than, that from similar single QW structures pseudomorphically grown on GaAs.

REFERENCES: