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Graded AlGaAs barriers for near-infrared emission enhancement in InGaAs and GaAsBi quantum wells

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III-V semiconductor quantum well (QW) heterostructures are widely employed in near-infrared photonic devices, yet radiative efficiency is often limited by non-radiative losses, which graded-barrier design directly addresses. InGaAs and GaAsBi occupy complementary roles in this study: the former serves as a mature, well-studied reference system, while GaAsBi offers a temperature-insensitive bandgap and spin-orbit splitting sufficient to suppress Auger recombination [1], though its adoption is constrained by challenging growth conditions. Graded barrier profiles enhance carrier trapping in both systems [2,3], improving radiative efficiency and thermal stability.

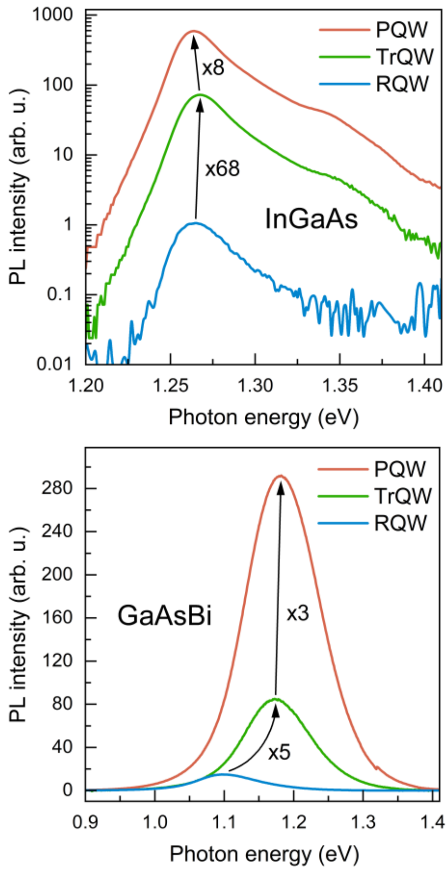

Fig. 1 Room-temperature PL spectra of InGaAs (top) and GaAsBi (bottom) QW heterostructures.

Three barrier profiles were investigated: parabolic (PQW) and linear (TrQW) AlGaAs barriers with Al content varying from 30% to 0% at the QW interface, and references with rectangular GaAs barriers (RQW). Structures were grown by molecular beam epitaxy on semi-insulating GaAs(100) substrates. Characterisation techniques employed temperature-dependent photoluminescence (PL), photoreflectance, time-resolved PL, transmission electron microscopy, and *nextnano* simulations. In InGaAs QWs, PQW sample sustains the highest PL intensity up to 300 K. Similarly, in GaAsBi QWs, the sample with parabolic grading yields more than three times the room-temperature PL intensity of the linear barrier sample, while both graded profiles achieve greatly enhanced carrier localization relative to RQWs.

While the underlying mechanisms differ (suppressed thermal escape in InGaAs versus enhanced localization across a blurred well-barrier interface in GaAsBi), parabolic grading consistently improves QW emission performance. Low-temperature PL excitation confirms more efficient trapping in GaAsBi PQW structures, establishing parabolic barrier grading as a broadly applicable strategy for near-infrared QW emitters and laser diode structures.

REFERENCES

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