A Self-Consistent Simulation of the Modulation Response of Quantum-Well Lasers Including the Effect of Strain

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A self-consistent simulation of a InGaAsP quantum-well laser is conducted to study the effect strain has on the modulation response. This study is an extension of the work done in [1] where the effect of carrier capture on the modulation response was studied. There are a number of factors determining the modulation response of a quantum well laser. One must consider the majority carrier drift outside the quantum well which produces the low frequency roll-off in the modulation response. In addition, minority carrier diffusion and ballistic emission into the quantum well need to be included. These transport processes are also affected by the carrier capture in the quantum well which sensitively influences the modulation response. The difficulty in the simulation lies in coupling the transport across the classical portion of the device (i.e. separate confinement and optical confinement regions) with the quantum well region where size quantization is considered. This was done by treating the classical regions with drift-diffusion and thermionic emission theories and coupling them to the quantum well regions by including the relaxation of injected carriers into bound states.

Strain is incorporated into our existing model by approximating the nonparabolic valence bands as being anisotropic but parabolic parallel and perpendicular to the growth plane [2]. By including the corresponding effective masses , $m_\perp$ and $m_{||}$, in the appropriate equations we present the effect strain has on the modulation response. We also study how the low frequency roll-off is affected as the capture and emission rates are varied while including strain.

References

[1] M. Grupen, G. Kosinovsky, and K. Hess,"The Effect of Carrier Capture on the Modulation Bandwidth of Quantum Well Lasers" IEDM Technical Digest, Washington D.C., Dec. 1993, pp 609-612.

[2] Z.-M. Li, M. Davies, M. Dion, and S. P. McAlister, "A versatile two-dimensional model for InGaAsP quantum-well semiconductor lasers," Can. J. of Phys., vol. 70, no. 10, pp. 937-942, 1992.