# Threshold current contributions in InGaN MQW laser diodes

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Layer thicknesses for a GaN-based laser structure are optimized using LASTIP and a simple 1-dimensional optical mode calculation program. Laser gain spectra are calculated with LASTIP using the matrix element for the wurtzite crystal symmetry. Several electrical and optical effects are shown to have significant effects on laser threshold.

The biggest effect is electron overflow. Without an electron barrier, the laser threshold is found to increase by greater than 7 times. Other changes have smaller, but still noticeable effects. Defect recombination is also shown to be significant. Non-uniform current injection into the quantum wells and lateral current flow in the device structure are both shown to have a non-negligible effects on lasing threshold. Back-contacted structures are shown to have an advantage in comparison with side-contacted structures.

Optimization of laser design is highly sensitive to parameter data. For example, optimization of the number of quantum wells is presented and is shown to depend on the relative lifetime of the quantum wells. Two cases are presented that describe different relative quantum well (QW) carrier lifetimes for different numbers of quantum wells.

Thicker cladding layers are shown to be beneficial. However, there are tradeoffs with making thicker cladding layers. Making the cladding layers thicker results in the negative effects of increased resistance and increased defects due to accumulation of stress within the layer. Thickness of the separate confinement heterostructure (SCH) region is also discussed.

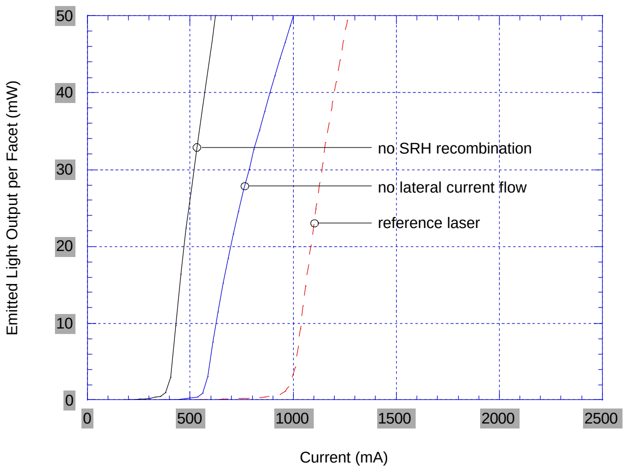

Figure 1.  Lasing threshold can be substantially reduced if either defect recombination or lateral current flow is removed from the model. This indicates that these two effects are important to laser design and laser geometries should be designed to reduce these effects

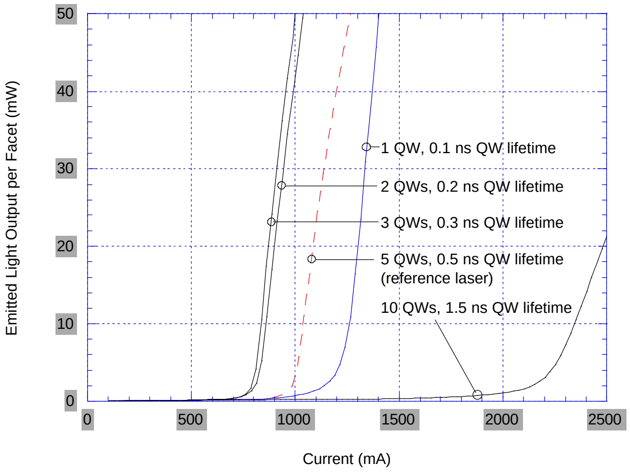

Figure 2. .  Laser light output is optimized for 2 or 3 quantum wells. The optimum number of QWs for a particular laser design will depend on factors such as facet reflectivity and carrier lifetime.  These calculations assume material quality dependent carrier lifetimes of 0.1, 0.2, 0.3, 0.5, and 1.5 ns for the 1, 2, 3, 5, and 10 QW active regions.

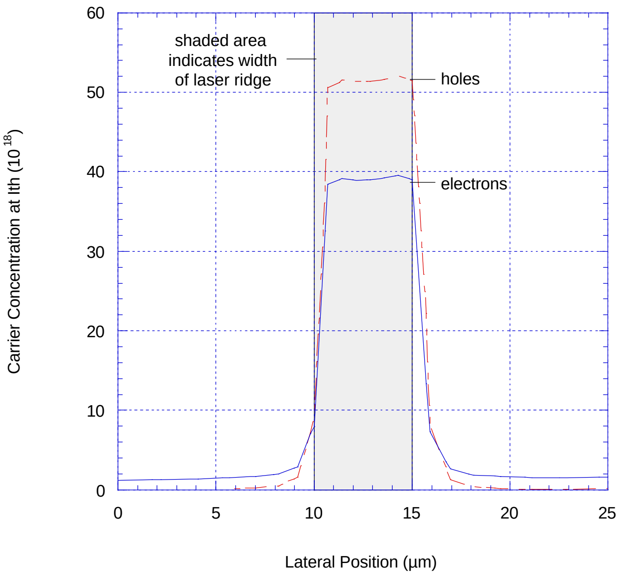

Figure 3..  Lateral carrier profile at threshold along the top QW. Both the electrons and holes are shifted noticeably to the right side of the ridge. The n-type contact pad is on the right side of the laser ridge, which explains this asymmetry.

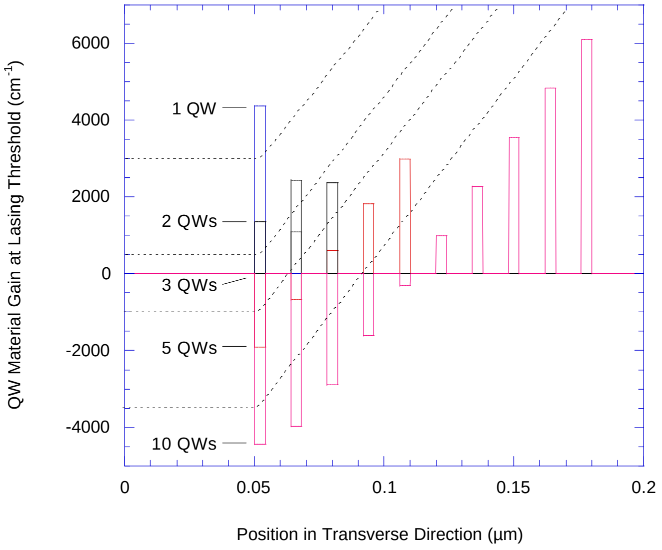

Figure 4.  Peak MQW material gain at threshold for material quality dependent lifetime of 0.1, 0.2, 0.3, 0.5, and 1.5 ns for the 1, 2, 3, 5, and 10 QW active regions.  Dotted lines are used to separate the 1, 2, 3, 5, and 10 QW examples.