Doping Layers in Quantum Cascade Lasers.

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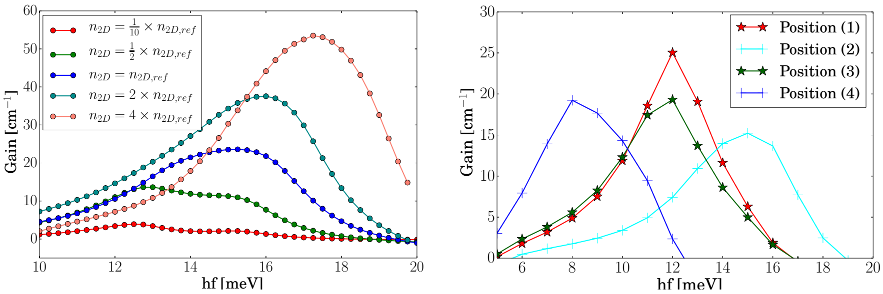

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Figure 1: The calculated gain for cases i) and ii) for the asymmetric two well laser presented in the thesis. i) The gain increases with increasing density. ii) The gain also depends on the position, note that the same photon frequency have different gain (red versus green).

Quantum Cascade Lasers (QCLs) are semiconductor devices which in contrast to other semiconductor lasers which utilise transitions across the band gap, are based on inter subband transitions. Hence radiation in the mid-IR and THz range of the electromagnetic spectrum is received. QCLs are important because they can be used in many research areas such as chemistry, physics and medicine. The THz QCLs however have a limited operating temperature due to the properties of their structure. Therefore it is important to research and develop better structures which can operate at higher temperatures. The position and density of the doping layers are two important attributes which have been investigated in this thesis work.

The work has been theoretical in character and addresses three different issues i) the impact of the doping density, ii) the position of the doping layer, iii) adding migration effects (due to diffusion of the added impurities when the laser is grown). The results were simulated in a computer program using Non-Equilibrium Green's Function Theory.

During this investigation it has been found that when changing the doping density the photon energy and gain change accordingly. Hence the same periodic structure will have a different laser output by just increasing or decreasing the doping density. This is in response to increased scattering and a shift in the potential due to bending of the conduction band edge. This investigation has also shown that the laser output is highly dependent on where the doping layer is placed. So when constructing the QCL, the position of the doping layer and the doping density have to be taken into account carefully in order to receive the desired frequency. Dopant migration has been simulated and it is probable that this accounts for the bias polarity dependence reported in experimental results on symmetric QCLs; even though the migration must be large in order to affect the theoretical results.

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