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Design and Optimisation of Optically Pumped Terahertz Quantum Wells Lasers

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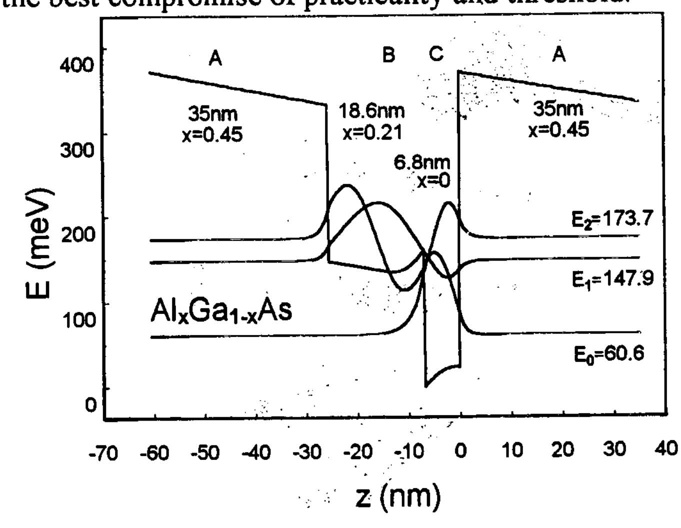
Research on designing optically pumped terahertz (far infrared) lasers based on intersubband transitions has been carried out for the past decade [1, 2]. In particular, asymmetric stepped quantum wells (QW) can be used to form the energy subbands. Conventionally, the QWs structure is modulation-doped at the barrier between two successive QWs to realise a two dimensional electron gas in the ground subband. However, this causes deformation of the well potential and produces parasitic wells. We propose a modulation doping position at the edge of the stepped well to minimise the potential distortion caused by the doping. As a result, parasitic potential wells are eliminated (see figure below), and the sensitivity of the energy levels to dopant concentrations is substantially reduced. Another problem traditionally associated with the optically pumped terahertz QW lasers is the poor overlap of the laser mode and the active layer. We suggest a stacked design to juxtapose two quantum well slabs in order to improve the waveguide mode overlap. As a result, the percentage of overlap between the active quantum wells layers and the laser mode increases from 9.8 % for an optimised single slab scheme to 68.4 % for the stacked double slabs with two highly doped layers acting as a plasma waveguide. A potential problem with the stacked design is the misalignment of the two slabs. A diffraction integral model [3] is established to simulate the laser cavity tolerance to this possible misalignment. Our model results show that the diffraction loss due to small (a few micrometers) misalignment or difference in slab lengths is negligible compared to other losses in the laser system. We also compare the different optical pumping schemes for the terahertz lasers. On balance, we have concluded that the stacked, doped confinement design offers the best compromise of practicality and threshold.



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