SERC GRANT GR/C25531 FINAL REPORT
AUGER RECOMBINATION IN SEMICONDUCTORS AND QUANTUM WELL HETEROSTRUCTURES

Summary

In the CHCC Auger process in a semiconductor an electron and a heavy hole recombine and another electron is excited. The rate for this non-radiative process is proportional to the modulus squared of the overlap integral of the Bloch periodic parts of the wavefunctions of the recombining carriers. We have made extensive calculations of this overlap integral, examining its dependence on the semiconductor material and on the wavevectors of the electron and the hole. Our work shows that previous estimates of the overlap integral are in error by many orders of magnitude for particular wavevector values and that this is likely to lead to serious inaccuracies in the calculation of Auger rates. The results are of technical significance because of the detrimental role of Auger recombination in semiconductor lasers used in optical fibre communications.

It has also been shown that the approximation that is used to express the Auger rate in terms of the overlap integral is itself unreliable for relatively wide bandgap materials such as GaAs, but is a very good approximation for narrower gap materials like InSb.

The theory of Auger recombination in quantum well heterostructures has also been developed. This work was motivated by the emergence of the quantum well laser. In these calculations the simplest model of the electronic states was used and results have been obtained for CHCC Auger rates in InGaAsP/InP quantum wells appropriate to laser wavelengths of 1.3 μm and 1.55 μm, as used in optical fibre systems. Comparison with the results in bulk material show that lower dimensionality does not have a significant effect on Auger rates except in very narrow wells.

In the course of the calculations on overlap integrals a program derived from the Chelikowski and Cohen non-local pseudopotential bandstructure calculation was implemented in Durham. This is now finding application in a number of new problems including studies of the electronic states in superlattices using complex bandstructure techniques. A simpler envelope function approximation approach was also developed for application to low dimensional structures.

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