6. Infrared Nonlinear Optics

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6.1 Infrared Nonlinear Processes in Semiconductors

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Four-wave spectroscopy has been used to study the Raman allowed $1s(A_1) \rightarrow 1s(T_2)$ transitions of As donors in Ge at 1.8 K, using magnetic field B up to 12T.[1] With $\vec{B} \parallel [111]$ the $1s(T_2)$ states split into six levels (including spin), two with high and four with low diamagnetism. An anticrossing, predicted by People and Wolff,[2] has been observed between donor levels of opposite spin. Valley repopulation, due to breaking of the tetrahedral symmetry by the magnetic field, is also observed. A theory has been developed, which, with no adjustable parameters, provides good agreement with experiment.

Hole-induced optical nonlinearities have been studied in p-type GaAs and p-type Ge, using four-wave spectroscopy.[3] The measured values of the third-order nonlinear susceptibility $\chi^{(3)}$ agree with those predicted by the intervalence band population modulation mechanism. Dispersion of $\chi^{(3)}$ yields intervalence band relaxation time in the picosecond regime, in agreement with those calculated for optical phonon emission.

With uniaxial stress X parallel to the magnetic field $\vec{B} \parallel [111]$, we have studied stress-induced electric dipole spin resonance contribution to the second-order nonlinear susceptibility $\chi^{(2)}$ via far infrared generation at the difference frequency in the 100 μm regime.[4] A quantitative analysis of the data yields $|C_2| = 0.35 \pm 0.1$ eV for the interband strain matrix element. This value of C_2 is appreciably smaller than those reported previously.[5] We have also observed a stress-induced decrease in the electron g-factor which is in agreement with the calculated values.

The lineshape for the spin-flip transition in n-type InSb has been investigated by four-wave spectroscopy with CO_2 lasers. In contrast to lineshapes obtained previously with pump laser frequency close to the bandgap, the lineshape in our experiment shows a pronounced

asymmetry. At low laser powers, an extra peak is also observed. The extra peak and asymmetric lineshape cannot be understood in terms of magnetic joint-density-of-states alone.

References

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