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The variation of the pressure coefficient of resistivity in gallium arsenide with carrier concentration

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Abstract. The dependence of the resistivity of GaAs on pressure was investigated over a range of carrier concentrations. The change in effective mass of the electrons in the Γ_{1c} conduction band was found from measurements on samples with 10^{13} carriers cm^{-3}. In heavily doped material, where impurity scattering determines the electron mobility, the pressure coefficient of resistivity becomes strongly dependent on carrier concentration. The transition from polar to impurity dominated scattering occurs at about 10^{17} cm^{-3}.

Introduction

The variation in resistivity of GaAs single crystals with pressures of up to 10 kbar is examined as a function of carrier concentration. The results are presented in two parts. At low carrier concentrations, the pressure coefficient of resistivity is caused by the change in effective mass of the electrons in the Γ_{1c} conduction band, and this is related to the pressure coefficient of the direct gap through $\mathbf{k} \cdot \mathbf{p}$ perturbation theory. In heavily doped material, however, where the Fermi level has risen above the bottom of the conduction band, the pressure coefficient of resistivity becomes strongly dependent on the carrier concentration.

Experimental techniques

Full details of the preparation and characteristics of the n-type GaAs are shown in Table 1. The carrier concentrations range from 10^{13} cm^{-3} in undoped material to 10^{19} cm^{-3} in Se-doped material, while the Hall mobilities decrease from 8500 to 2000 cm^2 V^{-1} s^{-1} over the same region.

Four-probe resistivity measurements were made on a van der Pauw clover leaf at pressures of up to 10 kbar. A piston and cylinder device which contained a 1 : 1 mixture of paraffin and diala-C oil was used. Contacts to the crystal were passed through one piston using sheathed Chromel-Alumel thermocouples, brazed to the piston and sealed with epoxy resin. The pressures were recorded directly with a manganin gauge. A considerable increment in temperature accompanied each increase in pressure, but an equilibrium at 296°K was regained within a few minutes.

Table 1. The carrier concentrations and Hall mobilities at 300°K.

crystal	carrier concentration n (cm^{-3})	Hall mobility (cm^2 V^{-1} s^{-1})	dopant	method of growth
LE 39	$3{\cdot}9 \times 10^{13}$	8300	none	liquid epitaxy
A*	$7{\cdot}0 \times 10^{14}$	7700	unknown	unknown
LE 19A	$5{\cdot}0 \times 10^{15}$	6850	none	liquid epitaxy
LE 43A	$2{\cdot}6 \times 10^{16}$	5840	Se	liquid epitaxy
D 303A	$1{\cdot}1 \times 10^{17}$	4320	Se	vapour epitaxy
LE 152	$7{\cdot}3 \times 10^{17}$	3160	Se	liquid epitaxy
LE 168	$3{\cdot}0 \times 10^{18}$	2180	Se	liquid epitaxy

* The origin of sample A, which was used in preliminary measurements, was unknown.

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