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

G.A.N. Connell

Surface Physics, Cavendish Laboratory, University of Cambridge, England  
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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  $\Gamma_{1c}$  conduction band was found from measurements on samples with  $10^{13}$  carriers  $\text{cm}^{-3}$ . 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  $10^{17}$   $\text{cm}^{-3}$ .

### 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  $\Gamma_{1c}$  conduction band, and this is related to the pressure coefficient of the direct gap through  $k \cdot p$  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  $10^{13}$   $\text{cm}^{-3}$  in undoped material to  $10^{19}$   $\text{cm}^{-3}$  in Se-doped material, while the Hall mobilities decrease from 8500 to 2000  $\text{cm}^2 \text{V}^{-1} \text{s}^{-1}$  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<br>$n$ ( $\text{cm}^{-3}$ ) | Hall mobility<br>( $\text{cm}^2 \text{V}^{-1} \text{s}^{-1}$ ) | dopant  | method of growth |
|---------|---------------------------------------------------|----------------------------------------------------------------|---------|------------------|
| LE 39   | $3.9 \times 10^{13}$                              | 8300                                                           | none    | liquid epitaxy   |
| A*      | $7.0 \times 10^{14}$                              | 7700                                                           | unknown | unknown          |
| LE 19A  | $5.0 \times 10^{15}$                              | 6850                                                           | none    | liquid epitaxy   |
| LE 43A  | $2.6 \times 10^{16}$                              | 5840                                                           | Se      | liquid epitaxy   |
| D 303A  | $1.1 \times 10^{17}$                              | 4320                                                           | Se      | vapour epitaxy   |
| LE 152  | $7.3 \times 10^{17}$                              | 3160                                                           | Se      | liquid epitaxy   |
| LE 168  | $3.0 \times 10^{18}$                              | 2180                                                           | Se      | liquid epitaxy   |

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