Electrical properties of CdS<sub>x</sub>Se<sub>1-x</sub> single crystals

D RAJA REDDY, B K REDDY and P J REDDY
Department of Physics, S V University College, Tirupati 517 502, India

MS received 6 December 1982; revised 17 May 1983

Abstract. Electrical conductivity and Hall effect were studied on vapour phase grown CdS<sub>x</sub>Se<sub>1-x</sub> single crystals in the entire range of composition in the temperature range 90–300 K. The conductivities of the as-grown crystals varied significantly. High conducting samples were obtained by annealing either in vacuum or in cadmium vapour. Hall mobilities, carrier concentration and donor activation energies were calculated. No definite variation in mobility with composition was observed. Donor activation energy showed an increasing trend with increase of CdS content.

Keywords. Electrical properties; CdS<sub>x</sub>Se<sub>1-x</sub> single crystals; Hall effect.

1. Introduction

Transport phenomena in II–VI compounds and their solid solutions are as important as their optical properties and provide valuable information regarding the nature of carriers, band structure and scattering mechanisms. The Hall mobilities of charge carriers in the binary compounds are known to be limited by piezoelectric/optical mode/impurity scatterings in different degrees at low temperatures (Devlin 1967). The activation energies of unidentified donors in CdS were reported by Piper and Halsted (1960) and Subhan et al (1972). Woodbury and Aven (1974) reported similar donor activation energies for CdSe. However, similar studies on CdS<sub>x</sub>Se<sub>1-x</sub> single crystals are sporadic. Devlin and Shiozawa (1960) reported a mobility minimum at \( x = 0.5 \) in CdS<sub>x</sub>Se<sub>1-x</sub> crystals. According to Weng (1971) the electrical properties of flash evaporated CdS<sub>x</sub>Se<sub>1-x</sub> films are beyond control. Mochizuki and Igaki (1978) obtained an activation energy of 0.01 ± 0.02 eV for CdS<sub>0.8</sub>Se<sub>0.2</sub> crystals. In the present work the Hall effect and conductivity on vapour phase grown CdS<sub>x</sub>Se<sub>1-x</sub> single crystals were studied in the entire range of composition \( (x = 1, 0.9, 0.7, 0.5, 0.3, 0.1 \text{ and } 0) \) in the temperature range 90–300 K. The Hall mobilities, carrier concentrations, and donor activation energies are calculated and their variation with composition is discussed.

2. Experimental

CdS<sub>x</sub>Se<sub>1-x</sub> single crystal boules of 1 cm diameter and more than 2 cm in length were grown by a self-sealing vapour phase growth technique at about 1100°C in 100 torr argon pressure using 5 N pure CdS (M/s. Koch Light, England) and CdSe
DRaja Reddy, B K Reddy and PJ Reddy (M/s Balzers, Switzerland). The charge for the growth was prepared by sintering appropriate quantities of CdS and CdSe at 1000°C in argon (100 torr) for about 24 hr. The final composition was checked by wet chemical methods to 1% accuracy and also from x-ray lattice parameter determination. The chemical composition and the lattice parameters are given in table 1 and figure 1 respectively. Typical samples of $5 \times 5 \times 0.5 \text{ mm}^3$ size were prepared by polishing the cut pieces from

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{Variation of lattice parameters $a$ and $c$ with composition for CdS$_x$Se$_{1-x}$ crystals.}
\end{figure}

\begin{table}[h]
\centering
\caption{Results of chemical analysis of CdS$_x$Se$_{1-x}$ single crystals.}
\begin{tabular}{llll}
\hline
Target crystal & Estimated atomic percentage for 100 mol cadmium \\
& & Sulphur & Selenium \\
\hline
CdS & 99.7 & - & - \\
CdS$_{0.9}$Se$_{0.1}$ & 89.2 & 10.8 & - \\
CdS$_{0.7}$Se$_{0.3}$ & 68.9 & 31.1 & - \\
CdS$_{0.5}$Se$_{0.5}$ & 50.2 & 49.8 & - \\
CdS$_{0.3}$Se$_{0.7}$ & 29.6 & 70.4 & - \\
CdS$_{0.1}$Se$_{0.9}$ & 10.0 & 90.0 & - \\
CdSe & & & 99.8 \\
\hline
\end{tabular}
\end{table}