Conduction mechanism in codeposited AgSe thin films

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Abstract. Thin films of AgSe of varying compositions and thicknesses have been formed on glass substrates employing the three-temperature method. I–V characteristics and thermoelectric power, \( \alpha \), of annealed samples have been measured as functions of composition, thickness and temperature of the films. Films exhibit n-type conductivity. Nonohmic conduction in films of \( \text{Ag}_x\text{Se}_{1-x} \) \((0 < x < 0.5)\) and \( \text{Ag}_x\text{Se}_{1-x} \) \((0 > x > 0.5)\) have been accounted for on the basis of the theory of Rose of defect insulator containing shallow traps and on Schottky emission respectively.

Keywords. Thermoelectric power; I–V characteristics; space charge limited current; Poole–Frenkel; Richardson Schottky emission.

1. Introduction

Silver selenide is a good thermoelectric material in bulk solid state. A survey of the literature (Chouching–Liang and Pinsker 1962; Abdullayev et al 1980, 1983; Tomoyose 1980; Constantinescu 1981, 1983; Ramzan Zade et al 1981; Saito et al 1981; Bernede and Bouchairi 1983; Honing and Thomas 1987; Damodara Das and Karunakaran 1989; Sharma et al 1990) shows that there are few studies of electrical properties of AgSe system in bulk as well as in thin states over the entire range of composition. Since the chemical composition of the deposits affects the transport properties critically, we have studied in detail transport and galvanomagnetic properties as affected by the concentration of the two components (AgSe) here.

2. Experimental

Thin films of AgSe (99-999%) were prepared by vacuum evaporation method (Nikam and Aher 1993). Silver was evaporated directly from a preflashed conical basket of tungsten wire and selenium powder from conical mica crucibles with nichrome wire windings. The evaporation was done at room temperature in an IBP TORR-120 coating unit, under a vacuum of the order of \( 10^{-5} \) torr. The flux rate from each source could easily be adjusted by controlling the current through each filament. Both elements were simultaneously heated. After adjusting the flux rates from the two sources by varying the source current, films of varying compositions were obtained. They were annealed at \( \sim 100^\circ\text{C} \) for 8 h in vacuum.

The methods employed to determine composition, thickness and uniformity of the film were similar to those reported earlier (Nikam and Pawar 1990, 1991a, b). The composition of the films was determined by employing absorptiometric spectroscopy at 620 nm (Charlot 1964). To check the uniformity of the film as regards its composition, different portions of the film were subjected to absorptiometric spectroscopic analysis. The analysis confirmed that the films were of uniform composition and thickness.
Film thickness was measured using multiple beam interferometry. Film thickness \(d\) has also been measured by gravimetric (Nikam and Aher 1993) method:

\[
d = \frac{M}{gxA} \text{ cm,}
\]

where \(A\) is surface area of the film, \(M\) the mass of the film, and \(g\) the density of the film material expressed as

\[
g = x_1g_1 + x_2g_2,
\]

where \(g_1, g_2\) and \(x_1, x_2\) are densities and atomic fractions of Ag and Se elements respectively. Films prepared for Seebeck effect and \(I-V\) characteristic measurements had composition ranging between \(\text{Ag}_{10}\text{Se}_{90}\) and \(\text{Ag}_{80}\text{Se}_{20}\) and thickness between 1200 and 5000 \(\text{Å}\). The thermoelectric power \(\alpha\) was measured using the integral method in vacuum by pressure contacts (Nikam and Pawar 1985, 1990, 1991a, b). The distance between hot and cold ends was \(\sim 3\) cm. Thermal emfs were measured by means of a microvolt potentiometer (Ajco) connected to a sensitive spot galvanometer (Ajco, p-42).

For \(I-V\) measurements, films of AgSe of different thicknesses and compositions were grown over Al base electrodes on clean glass substrates held at 300 K through suitable masks in a dynamic pressure of \(10^{-5}\) torr. Aluminium counter electrodes were vacuum-deposited over the AgSe films to complete the sandwiched structure.

The \(I-V\) characteristics were measured using a DC microvoltmeter (Ajco model 79016), a vacuum tube voltmeter (Ruttonsha Simpson model 321 I), a standard resistance, etc.

3. Results

Thermoelectric power \(\alpha\) of all Ag–Se deposits was measured using the integral method. All values of thermoelectric power were negative indicating that electrons were the majority carriers, which is in agreement with the results reported earlier (Kienel 1960). Figure 1 shows the plot of thermal emf as a function of temperature

![Figure 1. Variation of thermal emf as a function of temperature difference for Ag\textsubscript{10}Se\textsubscript{90} (0 < x < 0.5) films of thickness 3300 Å.](image)