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Short communication

Measurement of electrical conductivity of $Zn_{50}Se_{50}$ alloy at different temperatures

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The electrical conductivity of $Zn_{50}Se_{50}$ from room temperature to 180 ^{o}C has been studied. The sample was prepared using melt cooling technique. Then the sample was characterized in terms of its crystal structure and lattice parameter using X-ray diffraction method. The material was found to be polycrystalline in nature. The electrical conductivity of the sample with voltage at different fixed temperature ranging from room temperature to 180 ^{o}C has been determined. The variation in electrical conductivity is explained on the basis of structural changes in the sample with temperature.

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1. Introduction

ZnSe is an important material with large direct energy band gap, which allows transmission of high-energy photons and high intensity light fluxes. Besides this ZnSe is advantageously used for the manufacture of window, lenses and partial reflectors for power laser devices [1,2]. On the other hand, the high emmissivity of this compound makes it highly versatile in the fabrication of light emitting and laser diodes, ultra-violet detectors and fast response photo résistance [1,3]. Practical application of ZnSe is as working material in optoelectronic devices and as a transparent material in power laser optics.

Avdonin et al. [4,5] have studied the electrical conductivity and luminescence in ZnSe crystals doped by transition methods and gold, respectively.

Jianyong Ouyang and Yongfang Li [6] has reported the electrical conductivity of thin films of Polypyrrole with the variation in voltage at room temperature. However no effect of voltage on the conductivity on ZnSe material has been reported in the literature. In the present paper the investigation has been made to study the electrical conductivity of $Zn_{50}Se_{50}$ polycrystalline material with voltage. Besides that, an effort has also been made to study the temperature dependence of conductivity under ambient conditions in the bulk samples. The investigation of electrical properties with temperature offers the posibility to understand the mechanism of degradation in the material.

2. Experimental

Zn_{50} Se_{50} was prepared using slow cooling of melt. High purity (99.999 %) Se and Zn (in elemental form) were weighed in stoichiometric amount and sealed off in a vacuum of 10^{-5} Torr in a quartz ampoule. The sealed ampoule was then placed in a muffle furnace where the temperature was raised at the rate of 4 K/min up to 1173 K and kept at that temperature for 8 hrs, with frequent rocking to ensure homogenization of the melt. Subsequently slow cooling process was carried out. These ingots were then ground into fine powder. The X-ray pattern of the sample was taken at room temperature in order to study the structure of the material. The material was found to be polycrystalline in nature.

For conductivity measurement, bulk sample in the form of pellet (diameter 12 mm and thickness ≈ 2mm) was prepared by compressing the fine powder of polycrystalline material under a load of 5 tons. The pellet was mounted between two copper electrodes in a sample holder for I-V measurement. The voltage was applied across the pellet and the resulting current was measured by Keithley electrometer / high resistance meter-6517A. The temperature range of the study was from room temperature to 180 ^{o}C. To ensure proper connection of the sample, a homedesigned sample holder was used with copper electrodes.

3. Results and discussion

X-ray diffraction study was carried out on the sample using Brucker AXS diffractometer with an iron K_{α} radiation source (λ= 1.937355 Å) and the diffractogram was analysed to obtain information about various crystallographic aspects. XRD pattern of the sample was taken at room temperature. XRD pattern confirmed the nature and formation of ZnSe alloy. The electrical conductivity of the sample under test has been determined from the I-V characteristics of the samples at different temperatures, from room to 180 ^{o}C. Fig. 1 shows the variation of the electrical conductivity with voltage at different temperatures. The variation in the electrical conductivity with voltage is due to structural changes in the material arising due to modification in grain size and grain boundaries with temperatures. It is found that the grain boundary may act as a most efficient barrier to electrons in n-type material [7]. It is observed from the graph that up to 60 °C, the conductivity remains unchanged up to 10 V applied voltage. But the temperature of the sample was increased to 80 °C, 100 °C and 120 °C a sudden jump in conductivity has been observed at 7.5 V, 5.0 V and 3.5 V respectively. It is concluded from the observed data that these are the voltages identified as the potentially required to overcome the grain boundary barrier existing at that temperature. Fig. 1 shows that the grain boundary barrier potential decreases with increase in temperature. The decrement of this potential barrier is explained as follows. As the temperature is increased the amplitude of the atoms situated at the boundaries of the barrier increases. As a result of this enhanced motion the area of contact of the grains increases, which in turn decreases, the barrier height and hence reduces the grain boundary resistance due to production of parallel resistances at the contact points between grains. As the temperature increases further there is further an enhancement in the atomic motion leading to further drop in the value of the potential barrier. This explains the higher values of electrical conductivity at higher temperatures corresponding to thedifferent applied voltages.

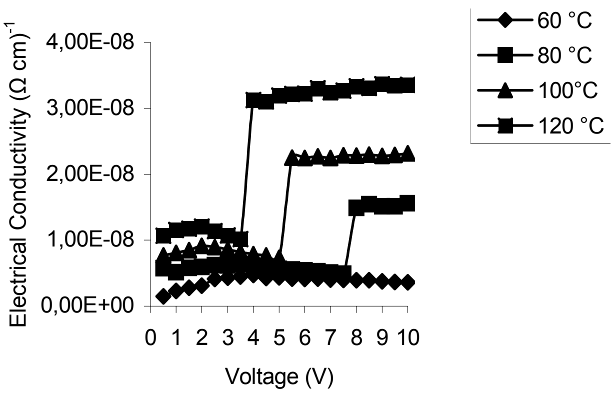

Fig. 1. Variation of the electrical conductivity with voltage.

4. Conclusions

The electrical conductivity of $Zn_{50}Se_{50}$ versus voltage has been investigated. A sudden jump in conductivity is observed because of the change in the structure of the material with temperature. Thus, the grain boundary barrier potential of $Zn_{50}Se_{50}$ can be determined.

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