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Electrical Resistivity Peculiarities in Differently Annealed Non-Stoichiometric Cadmium Oxides Material at Low Temperatures

Abstract

Cadmium oxide is an unusual 11-VI semiconductor system. Although it has technological importance for solar cell and other Applications, has not been explored much, particularly on its non-stoichiometric forms. These forms might be responsible for some of its poorly understood properties. Differently heat-treated CdO samples show widely varying electrical resistivity at room temperature. Present measurements on three such. Samples show that a low temperature minimum in the resistivity vs. temperature curve is most prominent for the sample fired at 275° C. This sample shows an anomalously large absorption coefficient in the range 380-500 nm compared to other samples fired at different temperatures. We think that stoichiometric Variations may be the key factor in the tuning the material properties of CdO.

Keywords: Cadmium Oxide materials, Electrical Resistivity, Optical Absorption

Krishan Chandra Verma
Assistant Professor,
Deptt.of Physics,
Veerbhumi Govt. P.G. College,
Mahoba, U.P., India

Introduction

In recent times, materials with high electrical conductivity and large optical transmittance in the solar energy range (500-600 nm) are being searched elaborately to meet the solar cell Requirements [1]

Review of Literature

Cadmium oxide CdO, may be one of the most promising candidates due to our recent finding that its properties can be tuned by firing it at different temperatures. In fact CdO is an unusual II–VI oxide with a rock salt structure and a very low band gap at room temperature [2] It appears that the intrinsic defect centers of CdO i.e. Cd interstitials or oxygen defect centre's can modify [3-6] its properties to a large extent (inducing a metal-like conductivity at room temperature [4], for example).In the present experiment, electrical resistivity measurements down to 36K and room temperature electronic absorption study has been carried, out for differently heat-treated.

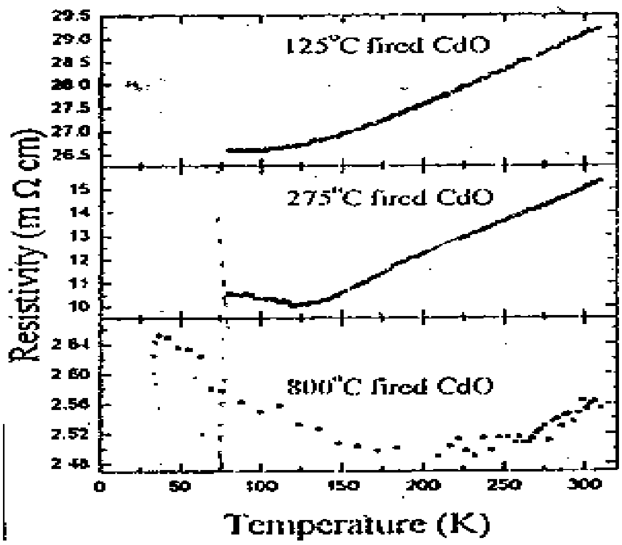

Fig 1: Temperature variation of resistivity in cadmium oxide samples produced by 36 hour heat treatment at the indicated temperatures. Difference in the resistivity scale implies very low resistivity for the 800°C fired sample

Experimental Outline

Coffee-brown extra pure (99.9%) cadmium oxide samples from E. Merck (India) have been palletized under same pressure and fired separately for 36 hours at 125^0 C, 275^0 C,and 800^0 C. Powder X-ray diffraction on all the pellets show only the standard lines of the CdO material and no matching with that of the lines of the compound CdO_2. Resistivity of the samples has been measured by conventional four probe technique using a Keithley 182 nanovoltmeter and a Lakeshore constant current source. In a Leybolt Cryogencrator set-up. Electronic absorption studies in the range 350-1200 nm have been carried out in a Hitachi U-350 I spectrometer.

Aim of Study

Aim of present study was to assess the Band gap and electrical resistivity peculiarities in differently Annealed Non-Stoichiometric Cadmium Oxides Material at Low Temperatures. And other properties will be probed in future. Because differently heat treated cadmium oxide materials has a potential application in batteries, solar cells and fuel cells.

Results and Discussion

First let us note that our XRD has clearly shown only the CdO phase in the samples. Attaching electrical leads [6] to these samples is difficult. If the leads are not fine line elements, the resulting uncertainty or error in measuring the separation between the voltage leads may make the absolute value of the measured resistivity uncertain just by a factor. This does not affect our present study of the temperature variation of resistivity. Moreover, there is van dcr Pauw (vdP) four probe techniques, determining the sample "width" and "length" electrically. This removes the uncertainty possible from uncertainty in directly measuring the Sample dimensions. We applied this to room temperature resistivity measurements [6] in CdO. But, this vdP technique is too complex for low temperature measurements, and therefore, not been used here. It is neither needed in the study of temperature variation, as elaborated already.

Our 125°C fired sample is practically identical to the as supplied and highly resistive CdO material. Results of the present experiments have been shown in Fig. 1 and Fig. 2. Our Rutherford Back Scattering [6-8], positron annihilation [6] and thermo gravimetric [9] investigations showed that due to heat treatment at higher and higher temperatures, more and more oxygen was lost from the as-supplied or the 125^oC fired sample.

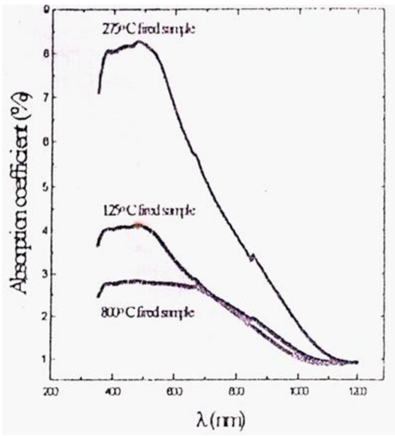

Fig.2: Electronic absorption for different CdO Samples

In Fig. 1, all the samples show metal-like temperature dependence near the room, temperature but with varying degree of metallicity.The temperature coefficient of resistivity is low (0.0007 m Ω cm/K) for the for the 800^0C fired sample compared to the other samples. But 800^0C fired sample show the lowest room temperature (RT) resistivity, comparable to values for various HTSC [10]. Large variation in the RT resistivity values in CdO has been reported also by others [1], The occurrence of a low temperature resistivity minima in the 275°C fired sample is prominent. This sample shows anomalously high absorption coefficient in the range 380-500 nm range (Fig. 2). The direct and indirect band gaps of all the samples have been estimated. It shows that indirect band gap is not changed due to beat treatment and is nearly same for all the samples (~0.74eV) [11]. But the sample with highest firing, temperature shows, a lowering of direct band gap compared to others (from 1.75eV to 1.34eV). This is generally understood to be the result of an increase of carrier concentration [1]. This is consistent with our observation of lowest resistivity in the 36-300 K range. The, other two samples with relatively lower carrier concentrations show a blue shift of the absorption edge [12] (Fig. 2), which is due to the well-known Moss-Burstein effect [1]. In CdO it is believed that the energy separation of the Cd 4s and O 2p levels determines the degree of hybridization of these levels [13] and hence controls the material properties. Naturally, non-stoichiometry in such compounds alters the band structure to a large extent [14]. The difference in the temperature vs. resistivity behavior (and also the RT resistivity variation) for differently hear-treated samples (Fig. 1) is a direct observation of the band structure modification. There are different explanations [3] if the observed resistivity minima. However such minima have been fairly widely reported is rare earth manganites and disordered alloy systems.

Conclusion

Band gap and low temperatures measurements show that stoichiometric defects in differently annealed cadmium oxide samples, can lead to reduction of its direct band gap (from 1.75eV to 1.34eV) and explained the interestingly [15] higher electrical conductivity of some of the differently heat treated cadmium oxide samples. Its association to the corresponding changes of colour.

End Notes

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