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THE EFFECT OF THE PROCESS OF CONSOLIDATION ON ELECTROOPTICAL CHARACTERISTICS OF SEMICONDUCTING CADMIUM OXIDE

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ABSTRACT

During the process of consolidation certain microstructural changes arise and affect the characteristics of the material. Certain modifications of the physical characteristics of semiconducting CdO produced by pressure and sintering, have been studied in this work.

Special attention has been paid to analysis of the electrical and optical properties which were the basis for finding out the dependance of the properties on the process applied.

1. INTRODUCTION

The interdependance of electrical and structural characteristics of consolidated dispersed materials has recently been the subject of many studies[1)]. A few authors have investigated some electrical characteristics of pressed and sintered CdO. thus,certain changes in the Hall coefficients[2)] with temperature and conductivity[3)] after pressing and sintering have been determined. On the other hand only a few studies have been published on the effect of sintering CdO on the infrared reflectivity spectrum. The photon-plasmon interaction[4)] has been researched mainly because of the great concentration of free carriers while the far infrared spectrum has been partly considered in our previous work[5)]. The results of examining the effect of compacting pressure on consolidation and electrical characteristics of dispersive nonstoichiometric[6)] CdO is provided in this work.

Modification of the electrical characteristics of dispersive CdO resulting from the effect of the sintering temperature and temperature calcining are shown in the first part of this work, whilst the reflectivity spectrum in the range 20-1600 cm^{-1} is given in the second part. The reflectivity spectra in the field of plasma frequency were numerically analysed with a fitting procedure, while reflectivity spectra in far infrared range were analysed by Kramers-Krönig integration.

2. EXPERIMENTAL WORK AND RESULTS

We used dispersive powder CdO p.a.(produced by "Chemica"-Zagreb) for our investigation. The powder was compressed at a pressure of $49.05 \cdot 10^7 N/m^2$ and the compacts were sintered in the temperature interval 473-1173 K.

These samples were used to measure the density and bulk resistance. The results are given in table I .

TABLE I

TAB1

d g/cm³	T [K]	ρ Ωcm
5,49	473	0,149
5,50	573	0,116
5,47	673	0,115
5,42	773	0,10
5,38	873	0,101
5,36	973	0,066
5,43	10,73	0,033
5,52	1173	0,0174

The reflectivity spectra were observed in the interval 200-4000cm^{-1} by means of a Perkin-Elmer type 577 spectrophotometer and in the range 100-400 cm^{-1} using a Beckmann FS 720 Fourier spectrometer All optical measurements given in this work were executed using samples sintered at 673 K for 4 hours. Fig. 1 shows a typical spectrum of reflectivity in the range 20-1600 cm^{-1}, determined at room temperature. The reflectivity spectra in the range 400-1600 cm^{-1} were analysed with a fitting procedure. The results of this numerical method are shown in fig.2 The solid line represents the theoretical curve while the points represent the experimental data.

Fig.2

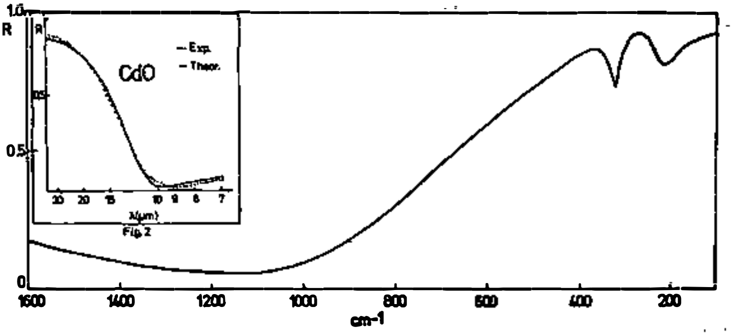

Fig.1

Fig.1. Infrared room temperature reflectivity spectrum of CdO in the range 20-1600 cm^{-1}.

Fig.2. Infrared room temperature reflectivity spectrum of CdO in the range 400-1600 cm^{-1}. The solid line represents the theoretical curve; points represent the experimental data.

In this way-the following parameters were obtained $\lambda_p = 11.75 \mu m, \varepsilon_{opt} = 6.47$ and $1/\tau\omega_p = 0.298 (\tau = 2 \cdot 10^{-14} s)$.

Kramers-Krönig analysis was made in the interval between the wave numbers 100 and 350 cm^{-1} and optical parameters of the reststrahlen peak were determined: $\omega_{TO}=259$ cm^{-1} and $\omega_{LO}=309$ cm^{-1}.

3. DISCUSSION

Dislocation of material which is compacted appears during the pressing process while sintering occurs by heating the compacts at a temperature above room temperature although the material recovers because dislocation appears. This usually happens at temperatures[7)] below the normal sintering temperature. Our investigations of sintering and bulk resistance of the sample of CdO show, that, during the procedure of sintering, happen the recovery of the material. Upon analysis of the data given in table I we observe that during heating the specific electrical resistance is reduced as a result of the increased density of dislocation.

As we know, dislocations are defective at low temperature and non-equilibrial and that is why we are able to observe their disappearance with increase of temperature[8)] as occured in our experimental work. We must stress that dislocation of alloys is connected with their electronical structure and it represents the resistance to conduction of electricity. It is well known that the concentration of effective carriers of electricity in sintered semiconducting oxides is given by the following equation:

$$n_{ef} = \frac{\sigma}{e\mu d},$$

where: σ-conductivity, e-electron electricity, μ- carrier mobility, d-density ratio of the pressed materials.

Fig.3 shows the dependence of the effective concentration of electron carriers and clearly implies that there are 2 stages with different conductive mechanisms. The intersections of lines I and II respond to the temperature of 600^{o}C. In view of the aforsaid, our opinion is that the influence of dislocation on conductivity appears up to this temperature, whereas above this temperature it is not of great importance to conductivity.

By analysing the reflectivity spectra in the plasma frequency range we see that the concentration of free carriers is in the range $10^{18}cm^{-3}$. This is two ranges higher than in the case when the concentration of electrons was obtained on the basis of electrical resistance.

In the spectral range $\lambda>\lambda_p$, when n>>k(fig.4) the slope of the straight line determines the effective mass of electrons of CdO at the concentrations $1.2\cdot10^{18}$cm^{-3} and this amounts to $m^*/m=0.025$. All values of the parameters obtained in this work are in accordance with the anticipated values$^{4)}$ determined on the basis of the dependence of their modification on the concentration which was tested in this work.

In the far infrared spectrum we can see a reststrahlen peak with a frequency of the transversal mode of ω_{TO}=259 cm^{-1}.

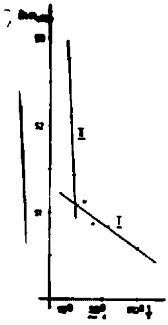

Fig.3. Dependence of the effective concentration with sintering temperature.

Fig.4. n^2 as function of λ^2.

4. CONCLUSION

We have investigated the process of recovering CdO during sintering in the temperature range 473-1173 K. On the basis of measurements of the electrical conductivity we have shown that the essential effect of line defectivity appears at 873 K. The research on the optical spectra has demonstrated that the concentration of electrons in sintered CdO was in the range 10^{18} cm^{-3} and the reststrahlen peak was in the range of 259(ω_{TO}) and 309cm^{-1}(ω_{LO}).

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