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Photocapacitance of Schottky Barriers on Zinc Cadmium Selenide Solar Cells

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Abstract:*Schottky barriers on Zinc Cadmium Selenide Znx Cd1-x Se mixed crystals grown from the vapor phase have been investigated. The barrier height and uncompensated donor density have been determined in this composition. Deep levels were also investigated in these diodes using photo capacitance techniques, which revealed the presence of two of about dominant levels with activation energies 0.2, o.4, 0.55, 0.85 eV above the top of the valence and one with an activation energy at about 0.85 - 0.95 eV below the conduction band.*

Keywords: *Photocapacitance , Schottky , Barriers , Solar Cells , Deep levels*

1. Introduction

(The viability of the ZnxCd1-x Se single crystal system has been known for some time and the full range of composition (0< x > 1) was demonstrated as early as 1951 [Forgue et al, 1951(2)) since the band gap varies from 1.74 ev to 2.67 eV, covering most of the visible and near infra-red parts of the electromagnetic. As a consequence it has received some interest as a phosphor material for color television screens [Lehman, 1961](1) The single crystals of Znxcd1-X Se has obvious potential for poto-elecronic applications. Single crystal growth from the vapor pase was reported in 1969 and more recently by [Burger and Roth, 1984] (3) and by [Bassam et al, 1988]. (4-6)

The structure of Znxcd1-X Se undergoes a transition from Wartzite to Sphalerite at x = 0.5, being hexagonal when x > 0.5 and cubic when x > 0.5. The lattice parameter was found to vary linearly with composition up to the transition point. The result to be described in this paper relate to the properties of Schottkey diodes of the Znxcd1-X Se solar cells with compositions where x =0.5 and 0.55. The barrier height were characterized using photoelectric, and current- voltage measurements. Photo capacitance studies were also carried out to provide a preliminary survey of some deep levels in the material.

2. Experimental

The single crystal materials used in this study were grown from the vapor phase [Piper and Polich, 1961]. Samples (4 x 4 x 2 mm3) were cut from the boules and mechanically polished down to a grit size of 1 mm using alumina powder. After cleaning and a final etch in 2% bromine in methanol solution for about 2 minutes and then for a further 2 minutes in concentrated HCI, the samples were loaded into a vacuum coating system and a 1 mm diameter gold dot was evaporated into one of the large one faces to form the rectifying contact. Indium was deposited on the reverse face for use as an injecting contact.

Dark current-voltage (I-V) characteristics were measured at room temperature, capacitance-voltage (C-V) measurements were made using a boonton 72 B capacitance meter. The spectral dependence of the steady state photo capacitance was measured using a barr stroud type VL2 prism monochromator with a tungsten light source and Boonton 72 B differential capacitance meter.

3. Electrical Characteristics

The electrical characteristic of Au Znxcd1-X Se diodes could be measured for compostions x = 0.5 and x = 0.55 gave good rectifying characteristics with little reverse bias leakage. The results are shown in Figure 1.

Figure: 2 shows, a plot of the logarithmic dark current versus the applied bias for Au - ZnxCd1-xSe single crystals with x = 05.2 and x = 0.58. The ideality factor can be determined from the forward bias I-V characteristics.

Thus, from the plot of lnl against V, the ideality factor 'n' can be calculated where l is the dark saturation current density and equal to the InI intercept. From the slope of the plot of In I against forward voltage, the values of the ideality factors (n) where calculated. The values of n fall in the range 1.0 - 1.2

According to (Card and Rhoderick, 1971).(7) the deviation from the ideal situation (n = 1) can be described to many reasons, for instance the presence of surface states and an oxide layer. The ideality factor increases with an increase in the insulating layer thickness which was present after the etching process prior to the deposition of the gold. The spectral response of the photocurrent has been measured as a function of wavelength in the range 320. <720 nm.

TABLE I:

Sample	Js	(n)	I-v (eV)	Photo current (eV)
$Zn_{0.52}$ $Cd_{0.48}Se$	$1X\ 10^{-5}$	1.1	0.65	1.28
$Zn_{0.58}$ $Cd_{0.42}Se$	$3\ X\ 10^{-4}$	1.1	0.6	1.32

The barrier height was determined from the long wavelength side of the response curves by plotting the quantity R against photon energy hv. The results are shown in Figure: 3. and summarized in Table 1.

According to (AI-Bassam, 1990.) (5,8,9) the barrier heights found from the current voltage measurement were sometimes in disagreement with those determined from capacitance voltage and photocurrent measurement. They suggested that the disparity between these estimates of barrier heights can be attributed to the pres interfacial layer between the gold contact and the semiconductor. Similarly, the capacitance voltage characteritic usually produce straight lines. The uncompensated donor density Nd was calculated from the slope of the C-2 versus V plot and is given in table (2).

TABLE II:

Sample	Nd (x16 cm)	Vd (eV)	ϕC-V (ev)	$Ec – E_f$ (eV)
$Zn_{0.52}$ $Cd_{0.48}Se$	0.8	1.76	1.9	0.135
$Zn_{0.58}$ $Cd_{0.42}Se$	12	1.6	1.73	0.124

The un compensated donor density Nd increases with increasing x, and its behaviour as a function of composition is similar to that observed for Cd1-x Znx Se, in that case, it was suggested as due to reduction in the carrier mobility, possibly because of alloy scattering, and resulted in a very large increase in the resistivity. Also the carrier density decrease as the zinc content increase. (Kwok and Chau 1980) (10) and (Chow et al. 1981) (11) showed that the carrier density increased. Initially, with increasing zinc, also found that the carier density decreases as the zinc content of Cd1-x Znx Se Zn0.52 Cd0.48.

4. Photo Capacitance Results

Figure 4. shows photo capacitance (PHCAP) spectra taken from Au – Zn0.5 Cd0.5 Se The first threshold leading to an increased PHCAP was observed at photon energy of about 1.0 eV, indicating that there is process excitation of the electron from a level 1.04 eV below the conduction band. As the photon energy was increased, a second threshold was observed at hv = 1.7 eV at 285 K and hv = 1.6 eV at 85 K corresponding to the emptying of an acceptor at about 0.38 and 0.52 eV above the valence band.

The results are in good agreement with, results which have been reported for Zn0.25Cd0.75 Se crystal by (Lewis etal 1986) (12) and (Burger and Roth, 1984 (3) for Zn03 Cd07 Se who identified a level located at 0.49 eV below the conduction band. They attributed this center to Cd vacancy - Cu interstitial pairs. (Lewis et al) reported that five deep levels have been observed, two electron traps with activation energies of 0.54 and 1.04 eV with respect to the conduction band, and three with activation energies of 0.2, 0.55 and 0.85 eV relative to the valence band. They suggested that the activation energy of this level is close to that widely reported at about, 0.62 ev above the valence band edge in CdSe (Ture et al. 1985) (13) which has been associated with double ionised Cd vacancies. The other principal center observed here at 1.0 ev may be related to the trap reported by (Al-Bassam,et al 14-18) with an activation energy of 1.04 eV with respect to the conduction band. Lewis etal suggested that this level would be primarily, an electron trap.

5. Conclusion

Schottky barriers on Zinc Cadmium Selenide Znx Cd1-x Se mixed crystals grown from the vapor phase have been investigated. The barrier height and uncompensated donor density have been determined in this composition. Photocapacitance of Schottky Barriers on Zinc Cadmium Selenide Solar Cells. were also investigated in these diodes using photo capacitance techniques, which revealed the presence of two of about dominant levels with activation energies 0.2, o.4, 0.55, 0.85 eV above the top of the valence and one with an activation energy at about 0.85 - 0.95 eV below the conduction band.

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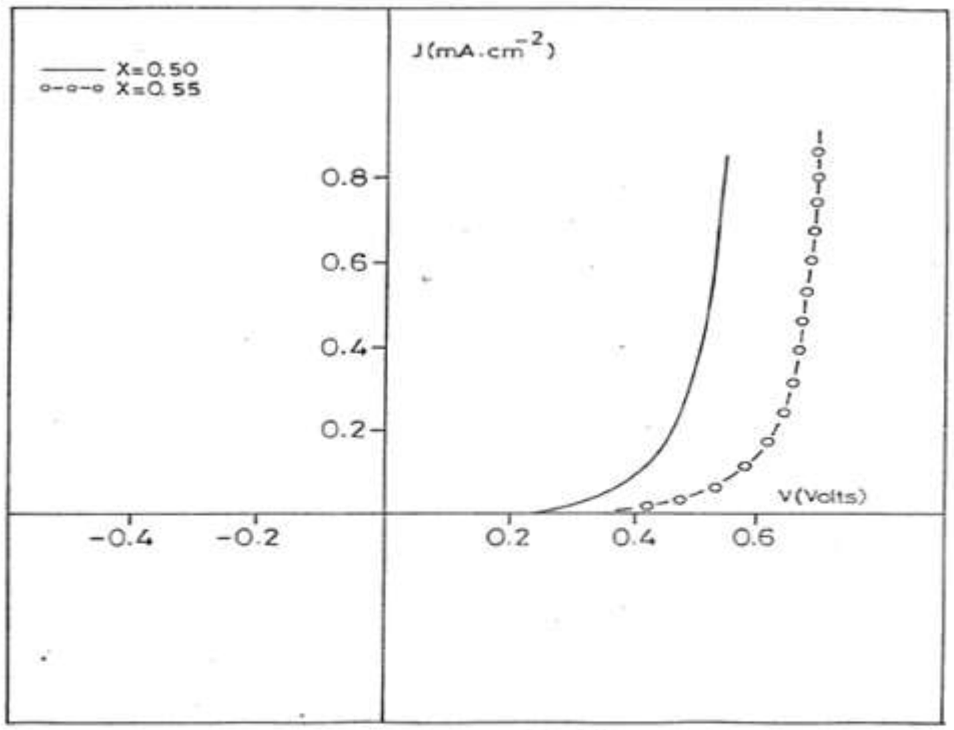


Figure: 1 Dark I -V characteristics for Au - $Zn_x Cd_{1-x} Se$

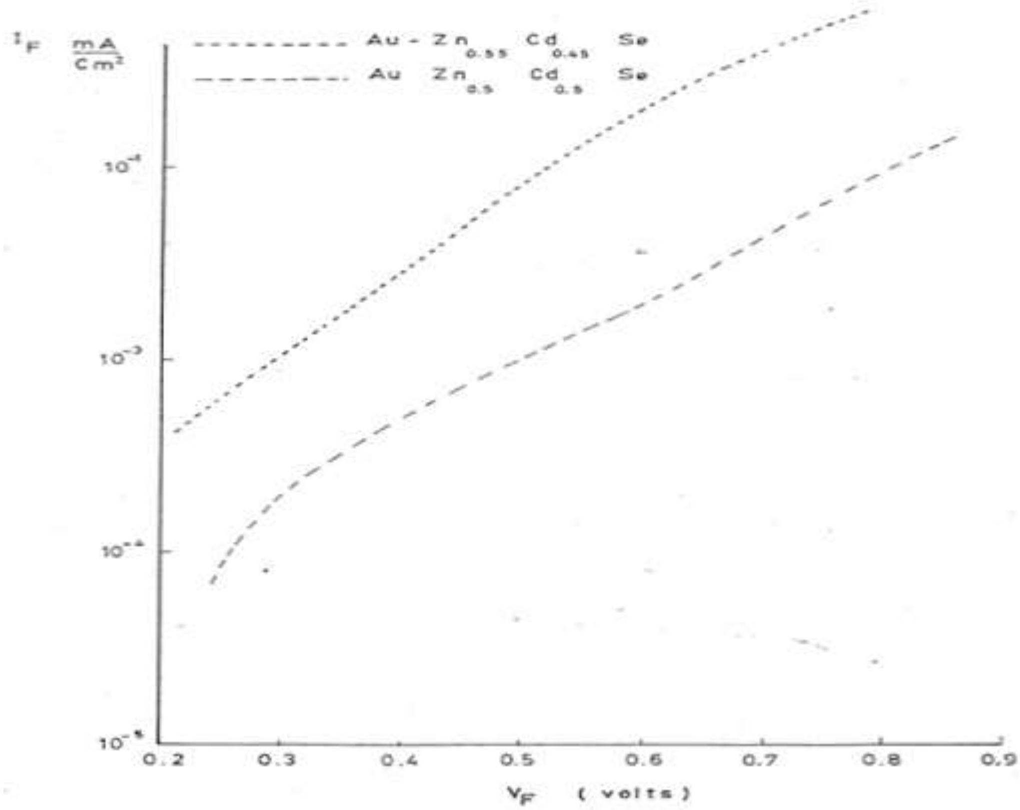


Figure:2 Log I- V for Au -Zn_x Cd_{1-x} Se

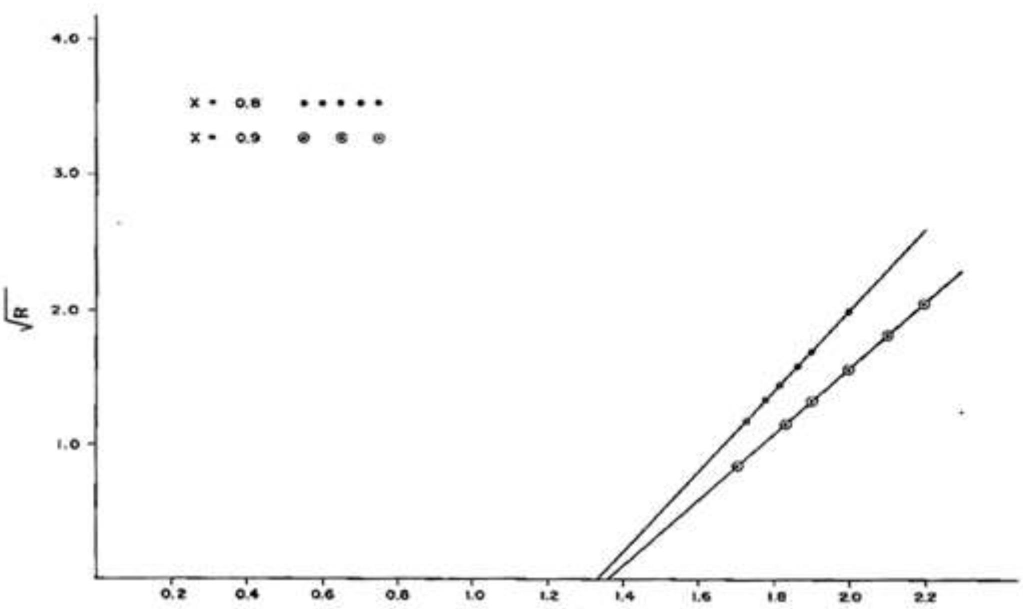
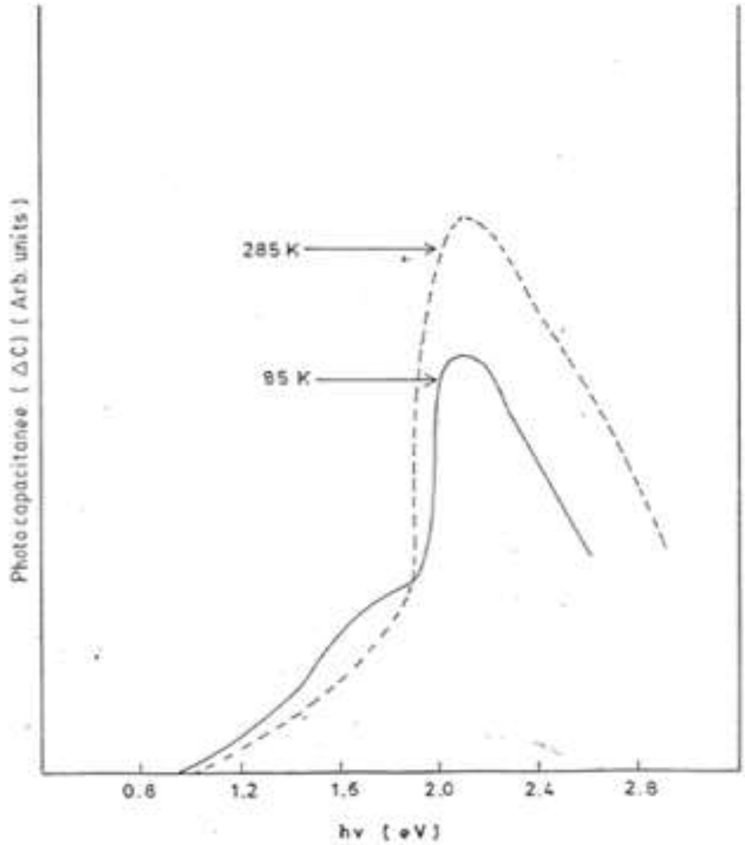


Figure 3. Squareroot of the Normalized Photocurrent R as a Function of Photon Energy for $Zn_XCd_{1-X}Se$ (0.8<X<1) Schottky Diodes.



function of Photon Energy for Au Zn_x Cd_{1-x} Se.

Figure:4 Photocapacitance speactra for Au - $Zn_{0.5}$ $Cd_{0.5}$ Se at 285 k and 85 k.