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INVESTIGATION OF DEEP LEVELS IN HEAT-TREATED ZnSe CRYSTALS BY ODLTS TECHNIQUE

Shouyin WANG and Xiwu FAN (X.W. Fan)

Changchun Institute of Physics, Academia Sinica, Changchun, China

Three deep acceptor levels, formed by heat-treated undoped ZnSe crystals in vacuum are found by ODLTS method. Two deep acceptor levels of them, E_V + 0.30eV, E_V + 0.72eV, are attributed to the deep acceptor levels related to the Cu-G and Cu-R centers, respectively, which could be produced by existence of the residual copper impurity in ZnSe crystal.

1. INTRODUCTION

There is considerable interest in blue electroluminescence (EL) emitted by forward-biased ZnSe MIS diodes[1]. Recently we reported the effect of heat treatment for substrate ZnSe during fabricating an insulating layer in vacuum on EL of ZnSe MIS diodes[2]. In this paper we have first reported three deep acceptor levels in heat-treated ZnSe crystals in vacuum by ODLTS method[3], and identified that two levels of them E_V+0.30eV and E_V+0.72eV, were attributed to the deep acceptor levels related to the Cu-G and Cu-R centers in ZnSe crystal, respectively.

2. EXPERIMENTAL

Nominally undoped ZnSe crystals grown by sublimation[4] were used in this study. ZnSe were cut from the boules and heated in molten zinc to reduce their resistivities. The ZnSe dice with low resistivities were heated in vacuum at 400°C for 20 min to form the insulating layer (I), then the ZnSe MIS diodes were prepared. In order to obtain superior Cu-G or Cu-R center, two different methods, diffusing Cu impurity at low[5] or high[6] temperature, were used respectively.

EL emission spectra in ZnSe MIS diodes were measured using a Model 44W spectrometer with a C31034 photomultiplier. ODLTS measurements were performed using a Model NJ-M-DLTS instrument added light pulse from a flash lamp.

3. RESULTS AND DISCUSSION

Fig. 1 shows the ODLTS spectra in ZnSe MIS diodes, when the substrate ZnSe was heated (curve a) or unheated (curve b) in vacuum, respectively. Two donor deep levels with activation energy of E_C-0.29eV and E_C-0.33eV, respectively, appeared in unheated ZnSe crystal, but besides two donor deep levels, there are three acceptor deep levels with activation energy of E_V+0.30, 0.72 and 0.83eV in heated ZnSe crystal.

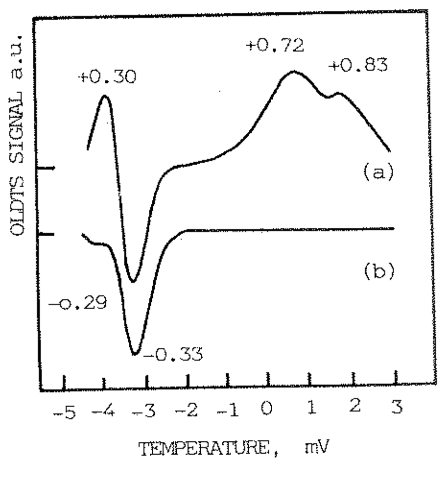

FIGURE 1
ODLTS spectra of the ZnSe crystals, e_{max}=9.48s^{-1}.

Fig. 2 shows the EL emission spectra in ZnSe MIS diodes, when the substrate ZnSe was heated

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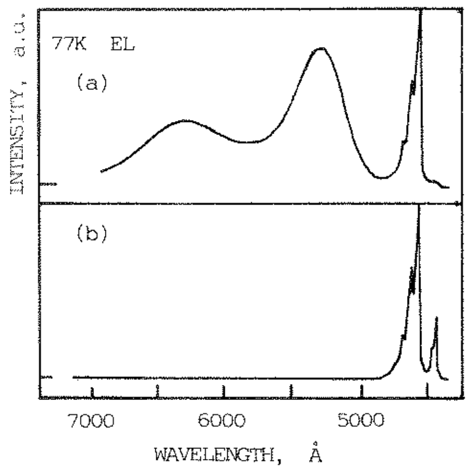

FIGURE 2
EL spectra of the ZnSe crystals at 77K.

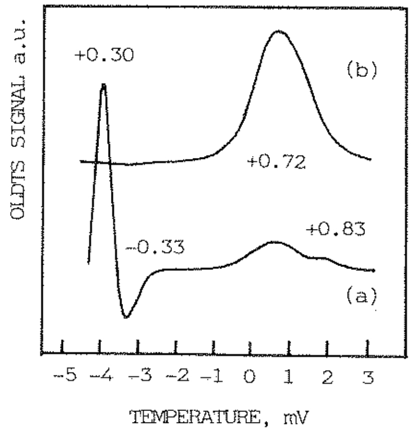

FIGURE 3
ODLTS spectra of ZnSe:Cu crystals, $e_{max}=9.48s^{-1}$.

(curve a) or unheated (curve b) in vacuum, respectively. Only near band edge emission bands appeared in unheated ZnSe crystal, but besides the near band edge emission bands there are two deep center emission bands peaked at 5300 Å and 6320 Å, respectively, in heated ZnSe crystal.

For the ZnSe crystal doped with Cu diffused at low temperature[5,6], there is a strong Cu-G center emission band peaked at 5300 Å in EL spectrum at 77K and also a strong deep acceptor level with activation energy of E_V+0.30eV in ODLTS spectrum as shown in Fig. 3(b). For the ZnSe crystal doped with Cu diffused at high temperature[6], there is only one Cu-R center emission band peaked at 6320 Å in EL spectrum at 77K and also only one deep acceptor level with activation energy of E_V+0.72eV in ODLTS spectrum, as shown in Fig. 3(a). The results mentioned above indicated that two deep acceptor levels of E_V+0.30eV and E_V+0.72eV correspond to the deep acceptor levels related to the Cu-G and Cu-R centers, respectively, in ZnSe crystal.

In summary, two deep acceptor levels, E_V+0.30eV and E_V+0.72eV, formed by heat-treated ZnSe crystal in vacuum correspond to the acceptors related to the Cu-G and Cu-R centers, respectively, which could be attributed to existence of residual copper impurity in ZnSe crystals.

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