A STUDY OF TWO DEEP ELECTRON TRAPS IN ZnSe CRYSTALS

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The properties of two deep electron traps with activation energies $E_a=0.29$eV and $E_c=0.33$eV in ZnSe crystals are studied by CQILTS and DLTS techniques. The former trap is attributed to a defect and the latter is ascribed to an impurity or a complex center associated with an impurity.

1. INTRODUCTION

In recent years, interest in ZnSe has increased considerably as a potential candidate for blue light emitting diode$^1$. The role of deep levels in ZnSe crystal has been a major subject in the fabrication of low resistivity bipolar materials, but the exact nature is controversial$^2$. In this paper we describe the properties of two deep electron traps with activation energies of $E_a=0.29$eV and $E_c=0.33$eV in ZnSe crystals.

2. EXPERIMENTAL

Nominally undoped ZnSe crystals were grown by sublimation. ZnSe dice with thickness of 1mm were annealed in molten zinc at 900°C for 10C to obtain low resistivity. Er$^{3+}$ ions with energy of 10keV and dose of $1\times10^{15}$ cm$^{-2}$ were implanted into the low resistivity ZnSe substrate at room temperature. Annealing ZnSe:Er$^{3+}$ was performed in N$_2$ atmosphere. After annealing, a diode was fabricated by making an ohmic contact on the substrate and evaporating Au electrode on the implanted surface of the substrate. CQILTS spectra$^4$ were measured using a Model NJ-M-DLTS instrument added light pulse from a flash lamp.

3. RESULTS AND DISCUSSION

Fig. 1 shows the CQILTS spectra of undoped ZnSe (curve a), Unannealing ZnSe:Er$^{3+}$ (curve b) and ZnSe:Er$^{3+}$ annealed at 350°C for 20 min in N$_2$ atmosphere (curve c). From the Arrhenius plot the activation energies of four deep electron traps are obtained at $E_a=0.29$, $0.33$, $0.42$ and $0.72$eV, respectively. It was found that the concentration $n_2$ of $E_a=0.29$eV trap in ZnSe could be increased by Er$^{3+}$ ions implantation and decreased by annealing the ZnSe:Er$^{3+}$ crystal in N$_2$ atmosphere. We know that the implantation with high energy ions can produce the radiation damage and form some defects in the crystals, which can be removed by annealing. According to the experiment results, it is reasonable to think that the $E_a=0.29$eV trap could be ascribed to some defects which increased by radiation.
TABLE 1

<table>
<thead>
<tr>
<th>ZnSe No.</th>
<th>408</th>
<th>413</th>
<th>420</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>n(cm⁻³)</td>
<td>2.0×10¹⁵</td>
<td>7.0×10¹⁴</td>
<td>1.1×10¹⁴</td>
</tr>
<tr>
<td>n₂(cm⁻³)</td>
<td>1.2×10¹⁵</td>
<td>1.6×10¹³</td>
<td>1.8×10¹²</td>
</tr>
</tbody>
</table>

damage and disappeared by annealing.

In contrast the concentration n₂ of E_C-0.35eV trap remained unaltered as shown in Fig. 1. Table 1 shows the electron concentration (n) and the concentration (n₂) of E_C-0.35eV trap as a function of repetition of purification cycles (PC) of ZnSe materials. n is determined by measuring C-V dependence and n₂ is by DUTS. It is clear that n and n₂ decrease with increasing the number of purification cycles of ZnSe materials. Fig. 2 shows that the intensity of E₅ band related to the free exciton emission increases and the emission bands related to impurities decrease and disappear in the EL spectra at 77K with increasing the number of purification cycles of ZnSe materials. On the basis of mentioned results, it is possible to consider that the electron trap with activation energy of E_C-0.35eV can be ascribed to an impurity or a complex related to an impurity, such as a complex of a native defect and a residual impurity.

In conclusion, we describe the origin of two deep electron traps with activation energies of E_C-0.29eV and E_C-0.35eV in ZnSe crystals. The former is attributed to a defect and the latter is ascribed to an impurity or a complex center associated with an impurity.

FIGURE 2

EL spectra in No. 408, 413 and 420 ZnSe crystals.

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REFERENCES