PROPERTIES OF EPITAXIAL LAYERS OF Cd_{1-x} Zn_x Se

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INTRODUCTION

The expanding requirements of microelectronics, optoelectronics, and optics evoke considerable interest in epitaxial films of solid solutions on the basis of AIIIBVI compounds. An analysis of existing, individual papers on thin films CdS_xSe_{1-x} [1, 2]; CdSe_xTe_{1-x} [1, 3]; ZnS_xTe_{1-x} [4]; Zn_xCd_{1-x}S [5, 6]; CdS_xTe_{1-x} [7, 8] showed that the most extensively used method of synthesizing layers of a reproducible composition is explosive evaporation. However, the comparatively low substrate temperatures (T_s < 400°C) and high supersaturation result in the growth of fine-crystal films whose properties yield considerably to the properties of corresponding monocrystals. For example, the carrier mobility in such layers does not exceed several units.

The use of a quasi-closed volume permits a considerable rise in the substrate temperature and the synthesis of highly perfect layers at low supersaturations, which have properties close to the properties of monocrystals [9, 10], and a controlled change in the gas phase composition by the insertion of a metal or chalcogenide, which differs from the component of the main compound, will afford the possibility of obtaining multi-component epitaxial structures.

Results on some properties of epitaxial layers, grown in a quasi-closed volume by evaporating CdSe + Zn in order to obtain films of the solid solutions Cd_{1-x}Zn_xSe for which there is practically no results on the synthesis and properties in the literature, are presented in this paper.

EXPERIMENTAL

The films were synthesized in a 10^{-5} torr vacuum in a quartz detachable unit consisting of two coaxially disposed evaporation chambers filled with CdSe and metallic Zn powders marked "special purity." The
Fig. 2. Dependence of the forbidden bandwidth on the composition of Cd$_{1-x}$Zn$_x$Se.

Fig. 3. Influence of the zinc partial pressure on some film parameters, obtained at $T_s=630^\circ$C (a) and $T_s=430^\circ$C (b).

evaporation temperature ($T_e$) of cadmium selenide is 700°C ($P_{CdSe}=4.31\cdot10^{-5}$ atm). The pressure of the zinc being evaporated was governed by the temperature of the source and was computed from data in the monograph [11]. Muscovite or fluorphlogopite mica was used as substrates. The film composition was found by means of the change in the lattice parameters $a_{CdSe}$, $c_{CdSe}$ which were determined by an x-ray diffraction analysis on a URS-50IM. The forbidden band width was computed by means of the wavelength corresponding to the absorption band edge by extrapolating the dependence $D^2=f(\lambda)$. The carrier mobility was determined by measurements of the Hall effect under alternating current and in an alternating magnetic field. Layers of 1-10μ thickness were investigated.

RESULTS AND DISCUSSION

Evaporation of cadmium selenide and zinc in a quasi-closed volume results in the production of a gas phase consisting of Se$_2$ molecules and Cd and Zn atoms above the substrate. It is most probable that for $\gamma_{Zn}=P_{Zn}/P_{Cd}\ll1$, where $P_{Cd}$ is the pressure of the cadmium being formed during dissociation CdSe, the zinc will exert a doping effect and for $\gamma_{Zn}\approx1$ the growth of solid solution films of Cd$_{1-x}$Zn$_x$Se is possible. Hence, synthesis of the films and their properties were studied in a broad range of pressures of the zinc being evaporated, $1.3\cdot10^{-7}$ atm < P$_{Zn}$ < 7.9\cdot10^{-4}$ atm, which corresponded to $3\cdot10^{-3}<\gamma_{Zn}<18.3$.

For a quantitative convergence of the results, the forbidden bandwidth ($E_g$) was determined by the abovementioned method for pure CdSe and ZnSe, found to equal 1.69 and 2.59 eV, respectively. The lattice parameters for hexagonal CdSe are $a=4.301$ Å and $c=7.007$ Å according to an x-ray diffraction analysis. In conformity with the results obtained and with the results in [12], the composition of the solid solutions was determined by means of the dependences

$$x = \frac{4.301 - a_{CdSe}}{4.301 - 3.996}, \quad x = \frac{7.007 - c_{CdSe}}{7.007 - 6.523}.$$

The clarity of the diffraction peaks and the steepness of the absorption edge indicated the homogeneity of the specimens in composition in the whole range under investigation.

Dependences of the forbidden band width and composition of the films on the zinc partial pressure in the gas phase are presented in Fig. 1. The results presented for three substrate temperatures ($T_s$) show graphically that an increase in the synthesis temperature permits obtaining epitaxial layers of solid solutions at both a lower zinc pressure and overlapping a larger range of compositions. This is caused both by the