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B-5-3 Molecular Beam Epitaxy of ZnSe and ZnTe Thin Film Single Crystals

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The II-VI compounds are important materials for optoelectronic devices, because of wide transparency range from the visible to beyond 10 μm and high electrooptic coefficients. In view of the application to optoelectronic devices, such as integrated optics and light-emitting devices, the fabrication of thin crystalline film with high quality has been required.

In this paper we report the fabrication and the evaluation of thin crystalline films(thickness ∿ 1 μm) of several II-VI compounds such as ZnTe and ZnSe grown on GaAs and Ge substrates by molecular beam epitaxy(MBE) method. The In doped ZnTe films are also grown by MBE. The epitaxial growth was conducted in a high vacuum system with an ultimate vacuum of ∿ 5×10^{-10} Torr. The deposition of ZnTe was accomplished by evaporating ZnTe set into the effusion cell, while doping of In into ZnTe was made by simultaneous deposition of In set into another effusion cell. In the case of ZnSe, Zn and Se are individually set into each cell. The molecular beam intensities of each element are controlled by controlling the temperature of the effusion cells. The evaluation of the epitaxial layer was made with a reflection high energy electron diffraction(RHEED), a phase-contrast microscope(PCM), a scanning electron microscope(SEM), an ion microprobe analyser(IMA), resistivity, and photoluminescence(PL), taking into account the application to integrated optics and light-emitting devices. The results of the evaluation are summarised in the following table.

	ZnSe	ZnTe	ZnTe:In
RHEED	streaks	streaks	spots
SEM	smooth and featureless		ripple-like
PCM	smooth and flat		
IMA	Zn,Se,Ga,SC*	Zn,Te,Ga,SC	Zn,Te,Ga,In,SC
resistivity	10^4 - 10^5 ohm-cm		larger than 10^5 ohm-cm
PL	blue edge emission + orange emission	green edge emission + red emission	

* SC indicates surface contamination.

The RHEED pattern of epitaxial layer of ZnSe is shown in Fig.1, which consists of streaks. The streaky pattern indicates the growth of flat and smooth surface, which is consistent with the SEM and PCM observation. This property of MBE layer is of considerable importance for processing with planar technology. The surface of the MBE layer becomes planar and smooth(sourface roughness < 50 A) compared to that of GaAs substrate. Composition analysis was made with IMA. The depth profile of the concentration of Ga and Zn in MBE layer and GaAs substrate reveals the interdiffusion of Ga into ZnTe and Zn into GaAs. Fig.2 shows the PL spectra of ZnTe and ZnSe MBE layers grown on (001)GaAs. The experiment was done with Ar^+ laser(4880 A) of 100 mW for ZnTe at 2 K and with N_2 laser(3371 A) for ZnSe at 77 K. The spectra consists of strong edge emission and broad emission bands at longer wavelength. The decline of the film quality causes two effects: the diminish of the edge emission and the reduction of PL intensity. The fact that the sharp line can be observed in the ZnTe and ZnSe films suggests the growth of high quality films.

In conclusion, the fabrication of thin films of II-VI compounds with MBE is very much promising for the optoelectronic devices, especially for integrated optics and light-emitting devices, because the films grown with MBE is not only planar and smooth, but emitts strong emission when illuminated by the laser light. Especially ZnSe emitts strong blue emission at room temperature.

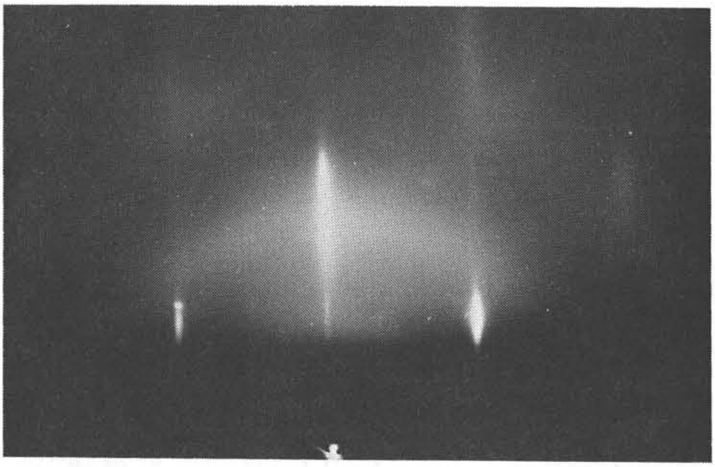

Fig.1 RHEED pattern of ZnSe MBE layer. 50 keV [100] azimuth.

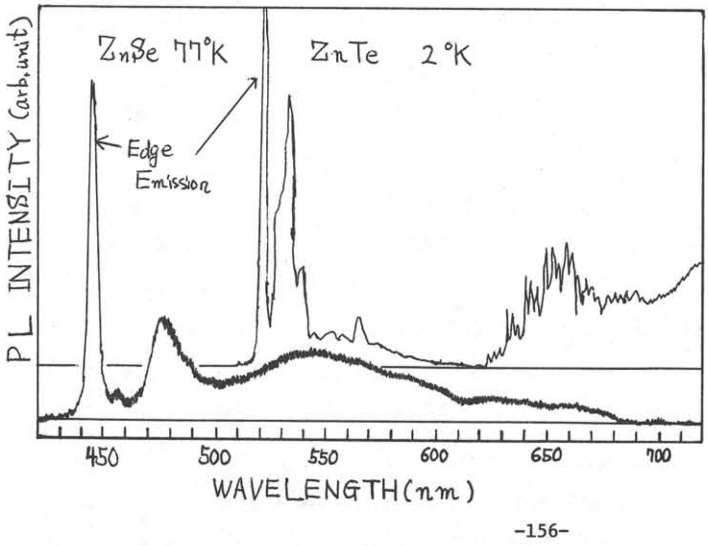

Fig.2 PL spectra of ZnTe and ZnSe MBE layers.