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Photoenhanced metalorganic chemical vapor deposition of ZnSe films using diethylzinc and dimethylselenide

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We report here for the first time on the growth of stoichiometric ZnSe films by photoenhanced metalorganic chemical vapor deposition (photo-MOCVD) from diethylzinc (DEZ) and dimethylselenide (DMSe). The alkyl DMSe was used instead of the hydrogen selenide of the conventional MOCVD[1-4] to avoid the undesirable premature reaction between alkyls and hydrides.

Figure 1 shows a schematic diagram of the growth apparatus. During growth, the substrates were irradiated by the UV light from a low pressure mercury lamp through the Suprasil quartz window. The mercury lamp emits two strong resonance lines at wavelengths 2537Å and 1849Å.

Figure 2 shows the effect of the UV light irradiation on the growth rate of the ZnSe thin films deposited on GaAs(100) substrates as a function of substrate temperature. In the non-irradiated condition (MOCVD process), no deposition occured below 350°C. When the substrates were irradiated by the UV light (photo-MOCVD process), ZnSe films could be deposited at lower temperatures. In the temperature range over 350°C, an enhancement of the growth rate as a dual effect of the UV irradiation and the pyrolysis was observed.

Single crystal ZnSe films were obtained on GaAs substrates by both photo-MOCVD and MOCVD at substrate temperatures above 450°C. In the temperature range below 350°C, the RHEED data showed a typical polycrystalline ring patterns. But, it is worth noticing that even at the substrate temperature of 150°C, polycrystalline films were obtained by photo-MOCVD process. Figure 3 shows the RHEED patterns of the ZnSe films deposited on glass substrates by photo-MOCVD and MOCVD. We obtained strongly (111)-oriented polycrystalline ZnSe films by photo-MOCVD at a substrate temperature of 400°C [Fig.3(a)]. In the non-irradiated condition, no preferred orientation was observed [Fig.3(b)] on the glass substrate. This indicates an enhancement of preferred orientation by the irradiation of the UV photons. Figure 4 shows the X-ray diffraction pattern of the ZnSe films deposited on a glass substrate by photo-MOCVD at a substrate temperature of 400°C, corresponding to the RHEED pattern of Fig.3(a). This pattern mainly consisted of a strong diffraction peak of (111) orientation. The half-maximum-width of the (111) diffraction peak was 0.218°. The grain size of the ZnSe film obtained from Scherrer's equation was 520Å.

We have measured the wavelength dependence of the optical absorption coefficient of the ZnSe films deposited on glass substrates. The optical bandgap of the films was evaluated as 2.67eV, which corresponds to that of bulk crystals. This indicates that stoichiometric ZnSe films were obtained. Furthermore, near-band-gap emission at around 450nm was observed by the photoluminescence measurement at 77K.

In conclusion, we have shown that the new photo-MOCVD process can improve the growth rate and the preferred orientation of ZnSe thin films. As a new optoelectronic material, photo-MOCVD ZnSe films are thought to be very promising.

References

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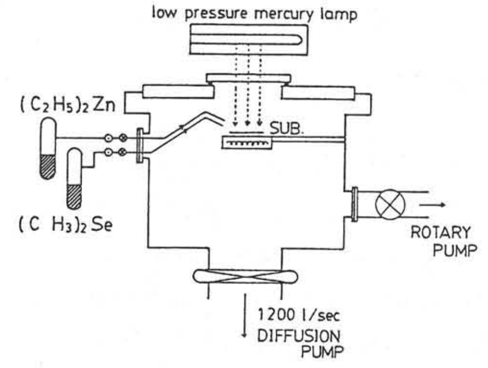


Fig.1. The growth apparatus

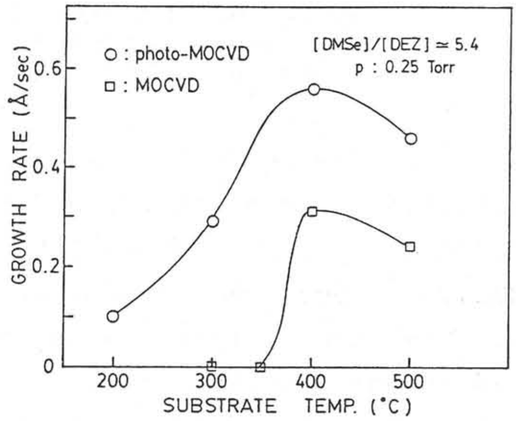
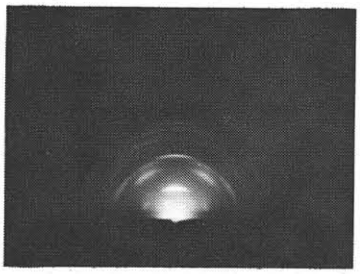
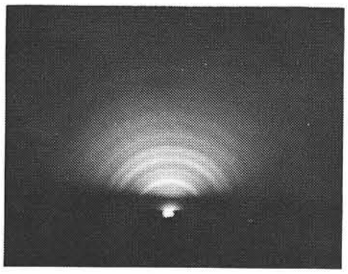


Fig.2. The effect of the UV light irradiation on the growth rate of ZnSe films



(a) Photo-MOCVD ZnSe/Glass Sub.



(b) MOCVD ZnSe/Glass Sub.

Fig.3. RHEED patterns

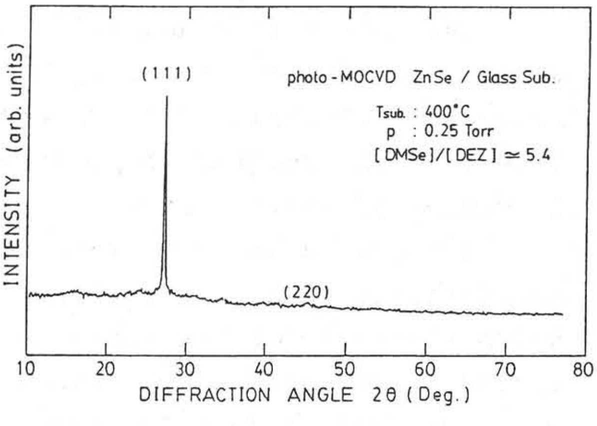


Fig.4. X-ray diffraction pattern of photo-MOCVD ZnSe films