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First Epitaxial Growth of Zincblende ZnSe/MgS Superlattices

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1. Introduction

Wide-band-gap II-VI semiconductors have been of great interest because of its attraction for basic physics and of their applications to blue/green light emitters. In wide-band-gap II-VI semiconductors, exciton binding energies are larger than those in III-V semiconductors and further enhancement of the excitonic effects is expected by the quantum confinement in superlattices (SL's). However, most of II-VI heterostructures proposed up to now have band offsets localized to either conduction or valence band edges. For example, ZnSe/ZnSSe quantum wells have nearly flat conduction bands,[1] while ZnMnSe/ZnSe quantum wells have little barrier heights in the valence bands.[2]

Among II-VI semiconductors, MgS has the largest energy gap that is estimated to be 4.5 eV.[3] However, MgS naturally forms the Rocksalt structure and the zincblende MgS has not been realized before. In this paper, we propose ZnSe/MgS SL's that will have the strong quantum confinement both in the conduction band (0.67 eV) and in the valence band (1.01 eV) as shown in Fig. 1. First successful epitaxial growth of zincblende ZnSe/MgS SL's is reported. Photoluminescence (PL) peaks observed from these SL's showed the blue shift that is consistent with a theoretical calculation.

2. Experimental

ZnSe/MgS strained SL's were grown on semi-insulating GaAs (001) substrates with atmospheric-pressure (A.P.) metalorganic vapor phase epitaxy (MOVPE). For the growth of MgS, bis-methyl cyclopentadienyl-magnesium ($(MeCp)_2Mg$) and di-isopropyl sulfide (DiPS) were used. For the growth of ZnSe, di-ethyl zinc (DEZn) and di-ethyl selenide (DESe) were used. Since the decomposition of $(MeCp)_2Mg$ was observed above 450 °C, the growth temperature was set to 490 °C. During the growth, the growth rate was monitored *in-situ* by a He-Ne laser with an optical multiple reflection in the films. Characterization of SL's were carried out with a four-crystal X-ray diffraction measurements and PL measurements.

3. Results and discussion

Figure 2 shows the X-ray diffraction measurement on a ZnSe (71.6 Å)/MgS (43.0Å) SL with the 21 periods. Clear SL satellite peaks were observed around the GaAs (004) peak. The observed peak positions were plotted in the form of $\sin\theta$ in Fig. 3 and the linear change with the order of the subpeaks shows the clear evidence that the observed subpeaks were diffracted from the SL structure. From this slope, one period of this SL was estimated to be 114.6 Å. These results prove that the grown SL has the zincblende structure. This is the first successful growth of the zincblende MgS structure. Figure 4 shows the dependence of the PL peak energy on the well width of SL's measured at 12 K. Solid and dotted lines are the transition energies of C1-HH1 and C1-LH1 calculated considering the strain effect and assuming the bulk exciton binding energy of 20 meV. The measurements shown by the closed circles are in a reasonable agreement with the calculation. The red shift of the PL peaks may indicate the enhancement of the exciton binding energy in SL's is now under study with more detailed measurements.

4. Conclusions

We have proposed ZnSe/MgS SL's that will have large band offsets for electron and hole quantum confinements. The SL's were grown with MOVPE by selecting appropriate precursors for Mg and S. The growth of zincblende ZnSe/MgS SL's was identified by the X-ray diffraction measurements. The PL peaks showed the blue shift consistent with the calculations. This successful report of the stable zincblende ZnSe/MgS SL's will open the new way toward physics based on the exciton effects as well as the applications for high performance blue emitters.

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References

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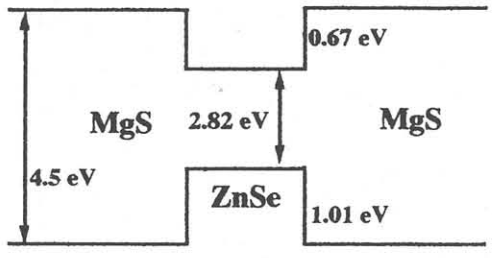

Fig. 1 Band diagram of ZnSe/MgS heterostructures. Band offsets of the conduction band and the valence band are 0.67 eV and 1.01 eV, respectively.

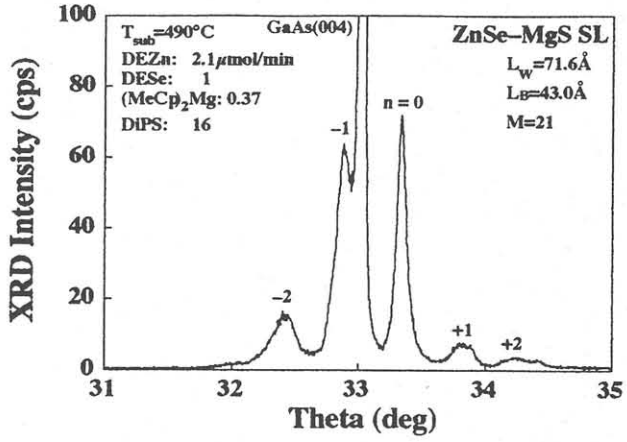

Fig. 2 X-ray diffraction pattern of a ZnSe (71.6 Å)/MgS (43.0Å) SL with the 21 periods.

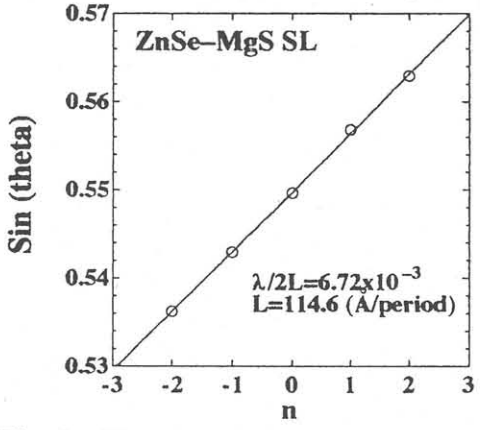

Fig. 3 The observed peak positions plotted in the form of sinθ.

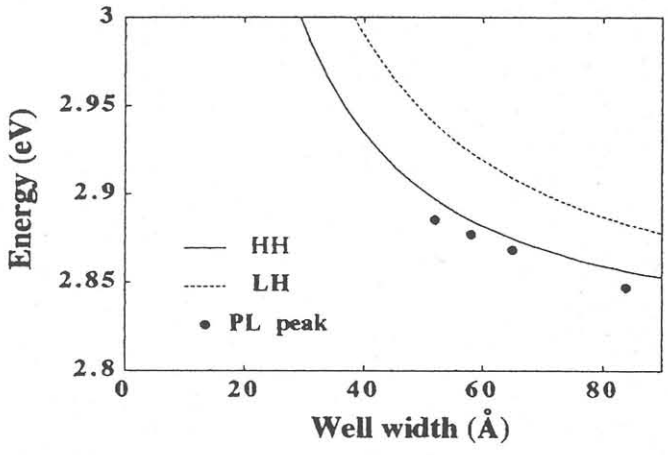

Fig. 4 Well width dependence of the PL peak energies obtained at 12 K on ZnSe/MgS SL's.