Extended Abstracts of the 2006 International Conference on Solid State Devices and Materials, Yokohama, 2006, pp. 684-685

P-8-6

Photoluminescence characterization of type Ⅱ $Zn_{0.97}Mn_{0.03}Se/ZnSe_{0.92}Te_{0.08}$ multiple-quantum-well structures

Jian-Jhin Shiu[1], Wei-Li Chen[1], Der-Yuh Lin[1], Chu-Shou Yang[2] and Wu-Ching Chou[2]

[1]Department of Electronic Engineering, National Changhua University of Education
1, Jin De Road, Paisha Village, Changhua 500, Taiwan, R. O. C.
[2]Institute and Department of Electrophysics, National Chiao-Tung University
1001, Ta Hsueh Road, Hsinchu 300, Taiwan, R. O. C.

1. Introduction

Wide-gap Ⅱ-Ⅵ semiconductor-related materials have already been successfully applied in a variety of photoelectronic devices, e.g., in photodetectors and light sources for the UV, blue and green spectral region.[1][2] Currently spintronics has attracted a good deal of attention owing to its potential application in quantum computation, as well as its interesting physical properties of its building materials. A spin injector, or spin aligners, consisting of Ⅱ-Ⅵ compound diluted magnetic semiconductors heterostructures, as well as Ⅲ-Ⅴ compound semiconductor heterostructures have been fabricated.[3] In this paper, we present the interesting optical properties of ZnMnSe/ZnSeTe multiple-quantum-wells (MQWs) using photoluminescence (PL) technologies including conventional PL, temperature-dependent PL and power-dependent PL measurements. The thermal activation energy (E_A) for quenching the PL intensity was determined from the temperature-dependent PL spectra. In power-dependent PL spectra, a giant blueshift of the PL peak energy was found and discussed.[4]

2. Results and Discussion

Two sets of $Zn_{1-x}Mn_xSe/ZnSe_{1-y}Te_y$ (x = 0.03, y = 0.08) multiple-quantum-wells (MQWs) grown on GaAs substrates by molecular beam epitaxy (MBE) were studied by photoluminescence (PL), temperature-dependent and power-dependent PL measurements. For the samples A, B, and C (D, E, and F), the thickness of the ZnSeTe (ZnMnSe) layers is fixed at 20 nm and the thickness of ZnMnSe (ZnSeTe) layers is varied among 5, 3, and 1 nm, respectively. As shown in Figs. 1and 2, the PL data reveal that the band alignment of the ZnMnSe/ZnSeTe system is type Ⅱ. Comparing with the theoretical calculation based on the Schrodinger equation, the valence band offsets can be estimated. From the power-dependent PL spectra shown in Fig. 3, it is observed that the peak position of PL spectra shows a blueshift under different excitation power. This effect can be interpreted in terms of the band-bending effect due to the spatially photoexcited carriers in a type-Ⅱ alignment, in which electrons are accumulated in the triangle-like well located in ZnMnSe layers and holes are localized in the ZnSeTe layers. The temperature-dependent PL spectra of sample A and its integrated PL intensity are shown in Figs. 4 and 5, respectively. The thermal activation energy (E_A) for quenching the PL intensity is determined to be 16.3 meV. Figure 6 shows the thermal activation energy, which can be regarded as the delocalization energy of electrons or holes, is found to decrease as the thickness of ZnMnSe and ZnSeTe layers decreases from 5 nm to 1 nm. This effect is attributed to the decreasing delocalization energy of electrons or holes resulting from decreasing the thickness of the electron or hole well materials.

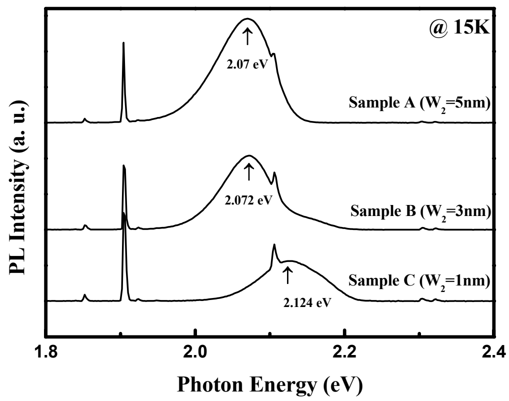

Fig. 1 PL spectra of the first set of sample at 15K. The spectra are displaced vertically for clarity. It is observed that the PL peak energy is much smaller than the bandgaps of building material of MQWs. A blueshift of 54 meV was found as W_2 (ZnMnSe) decreases from 5 nm to 1 nm.

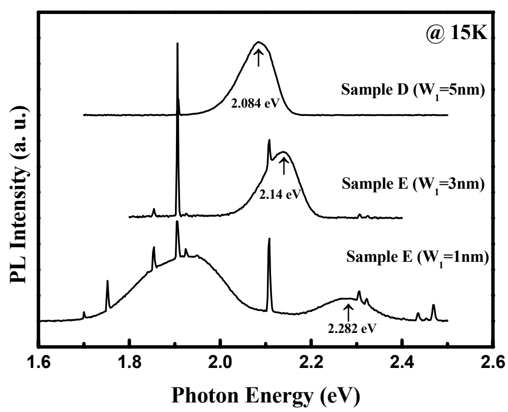

Fig. 2 PL spectra of the second set of sample at 15K. The spectra are displaced vertically for clarity. A blueshift of 198 meV was found as W_1 (ZnSeTe) decreases from 5 nm to 1 nm.

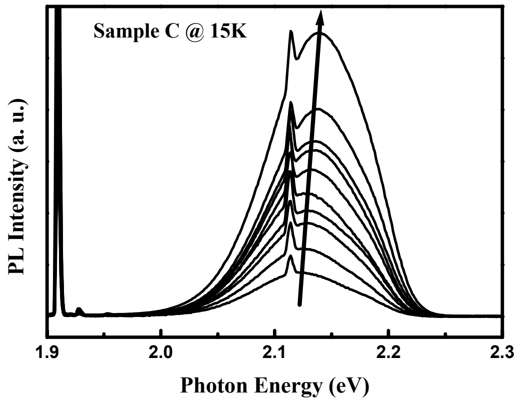

Fig. 3 PL spectra of sample C under different exication power at 15K. Because increasing the excitation power makes the band-banding effect more pronounced, the accumulated electrons and holds will be confined in a narrower region near the interface. Thus an increase in the excitation density raises the steepness of the confining potential, therefore, the electron quantization energy is increased and the blueshift is occurred.

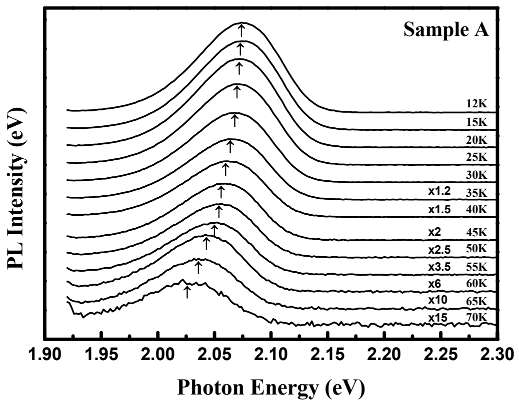

Fig. 4 The temperature-dependent PL spectra of sample A in the temperature range from 12K to 70K. The PL peak positions shift toward high energy indicated by the arrows as the temperature decreased.

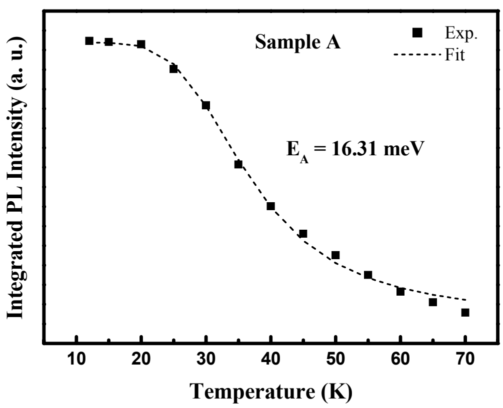

Fig. 5 Variation of integrated PL intensity with temperature of sample A.

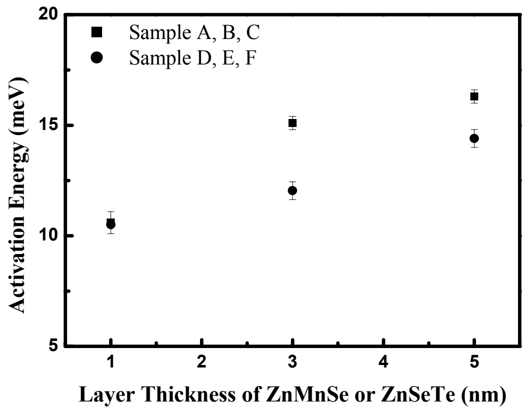

Fig. 6 The thermal activation energy determined from temperature-dependent PL spectra for each sample.

3. Conclusions

We have performed the optical characterization of ZnMnSe/ZnSeTe MQW structures using PL, excitation power- and temperature- dependent PL measurements. From photoluminescence measurements, It was observed that the band alignment of the ZnMnSe/ZnSeTe system is type Ⅱ. In the temperature-dependent PL spectra, the thermal activation energy that is responsible for quenching the PL intensity is determined. The activation energy tended to decrease as the thickness of ZnMnSe and ZnSeTe layers decreased. A larger amount of blueshift is observed in power-dependent measurements. This effect can be interpreted in term of the band-bending effect due to the spatially photoexcited carriers in a type-Ⅱ alignment.

.

Acknowledgements

The authors gratefully acknowledge the support of the National Science Council of the Republic of China under Project No. NSC 94-2112-M-018-003.

References

[1] C. S. Yang, C. C. Cheng, M. C. Kuo, P. Y. Tseng, J. L. Shen, J. Lee, W. C. Chou, S. Jeng, C. Y. Lai, T. M. Hsu and J. I. Chyi, Thin Solid Films **429** (2003) 243.

[2] C. S. Yang, D. Y. Hong, C. Y. Lin, W. C. Chou, C. S. Ro, W. H. Lan and S. L. Tu, J. Appl. Phys. **83** (1998) 2555.

[3] C. M. Lin and Y. F. Chen, Appl. Phys. Lett. **85** (2004) 2544.

[4] Y. T. Shih, Y. L. Tsai, C. T. Yuan, C. Y. Chen, C. S. Yang and W. C. Chou, J. Appl. Phys. **96** (2004) 7267.