Spectral Response of GaAs/AIGaAs and InGaAs/GaAs Multiquantum Well Structures

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ABSTRACT

GaAs/AlGaAs and InGaAs/GaAs multquantum well (MQW) structures were fabricated by Molecular Beam Epitaxy (MBE) technique. Spectral response of these two quantum structures were investigated by photocurrent measurements. The response peak of the *GaAs/* AlGaAs MQW is at 684 om and InGaAs/GaAs MQW exhibits responses maxima in 700-800 om spectral regions. The absorption of these two MQW structures depend on their multiplication of the same quantum well width.

1. INTRODUCTION

Multiquantum Well (MQW) is a key structure for high efficient and novel devices.(J) This structure could be realized by Molecular Beam Epitaxy (MBE) technique.(2) Most of compound semiconductors with different compositions are used in these molecular design materials. Two semiconductor of thin molecular layers and of different bandgaps are designed in a sandwich manner, i.e. narrow bandgap and wide bandgaps like GaAs and AlGaAs or InGaAs and GaAs alternate to form a synthetically modulated structure. The thickness of narrow bandgap material is controlled in the order of 10-200 A. Therefore, the motion of electron and hole in the direction perpendicular to the heterointerfaces is quantized. Quantum well structure could be multiplied by repeating the sandwich structure up to a desirable value with. This is called Multiquantum Well (MQW) structure. The density of quantized energy states becomes extremely high and provides high transition probability for quantized pastilles both upward (absorption) and downward (emission). Therefore, it has not only high potential to use MQW structure for high.sensitivity photodetecters and efficient laser diodes having low threshold current and narrow lasing spectrum(3)but also has a feasibility to make use of MQW for photovoltaic application in many aspects, i.e. efficiency and designable spectral resPonse due to multiplication of quantum well and quantum well width. However, there are many efforts to integrate this MQW in photovoltaic cell structure but no significant results are reported.(S)

GaAs/AlGaAs MQW is mainly used in short wavelength laser diode. Lasing wavelength could be controlled by GaAs well width between 750-800 nIn. This red laser is widely used in compact disc and laser printer. InGaAs/GaAs MQW is another material system with strained layers and is suitable for long wavelength laser fabrication. Lasing wavelength could be determined by the In composition in InGaAs and InGaAs well width at about 900 nIn. This infrared laser is mainly used as pumping source for Et doped fibre to amplify laser transmissionin oplicalfibre at 1.55~ wavelength. On the contrary, these two MQW structures, GaAs/AlGaAs and InGaAs/GaAs, could be possible for light detection and conversion at the corresponding wavelengths.

This fundamental research work is aiming at the investigation of spectral response in these two MQW structures. The experimental methods in our study could be done by photocurrent depending on sample preparation and the nature of substrates.

2. FABRICATION OF MQW STRUCfURE

The GaAs/AlGaAs MQW struture was grown by molecular beam epitaxy on a semi-insulating GaAs substrate. The cross section of the structure is also shown in figure 1. The layer, starting from the substrate side, consisted of a 2.0 m undoped GaAs buffer layer, a 5,500 A undoped AlGaAs barrier layer, 49 periods of 120 A undoped GaAs wells and 930 A undoped AlGaAs barriers, a period of 120 A undoped GaAs wen and 2,750 A undoped AlGaAs barrier, and finally a 90 A undoped GaAs cap layer.

After the MBE growth, Au was evaporated on 100 m striped line mesas defined by chemical etching down to the GaAs buffer layer, alternate with 1OO m striped line on the cap layer to give the electrode spacing 200 m and 500 m square sample was cleaved.

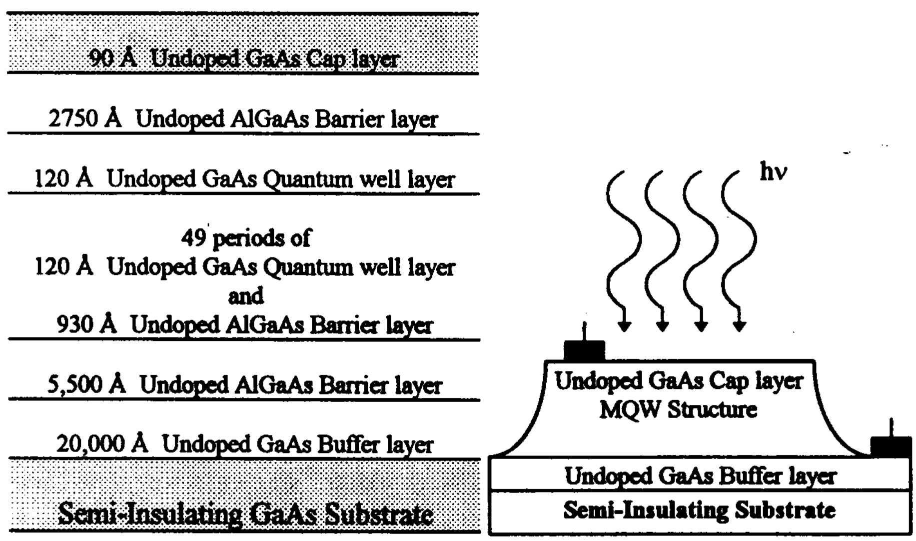

Figure 1. Structure of the GaAs/AlGaAs MQW.

The InGaAs/GaAs MQW structure was similar but grown on a n-type GaAs substrate. The structure plays its role as strained quantum well and consisted of four stacks of quantum well. The first stack bad a period of 25 A undoped InGaAs well and 1,500 A undoped GaAs barrier, the second stack bad a period of 38 A undoped InGaAs well and 1,500 A undoped GaAs barrier, the third stack bad a period of 51 A undoped InGaAs well and 1,500 A undoped GaAs barrier, and the fourth stack bad a period of 76 A undoped InGaAs well and 1,500 A undoped GaAs barrier. A AulZn top contact and AulGe bottom contact are made to the structure as shown in figure 2.

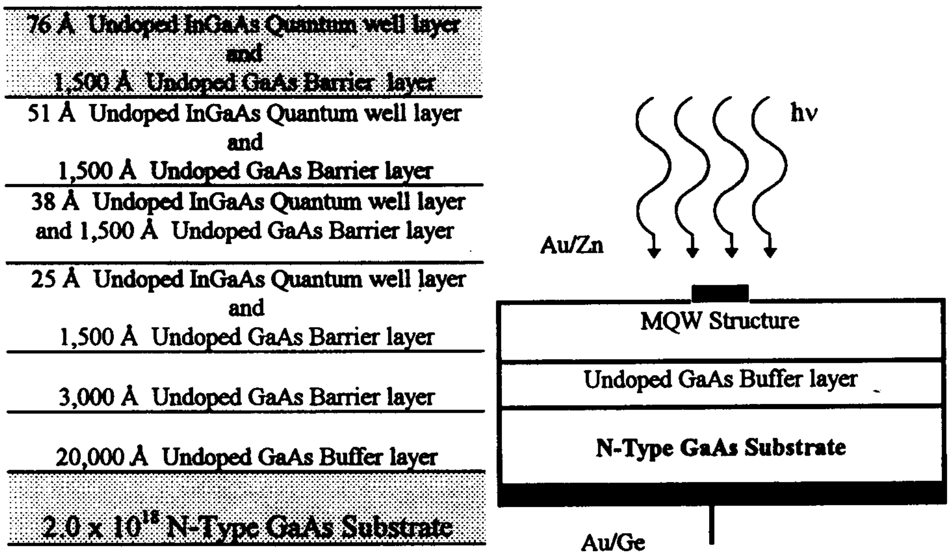

Figure 2. Structure of InGaAs/GaAs MQW.

3. MEASUREMENT PROCEDURES AND RESULTS

An Ar-ion laser with an emission wavelength of 488 nm was used for the photoluminescence (PL) measurement to confirm the existence and emission spectra of *GaAs/AlGaAs* and InGaAs/GaAs MQW structures. The PL measurement of both structures were performed at low and room temperature.

The room temperature photocurrent spectra of GaAs/AlGaAs and InGaAs/GaAs MQW structures were obtained using a light source and monochromator under low bias voltages.

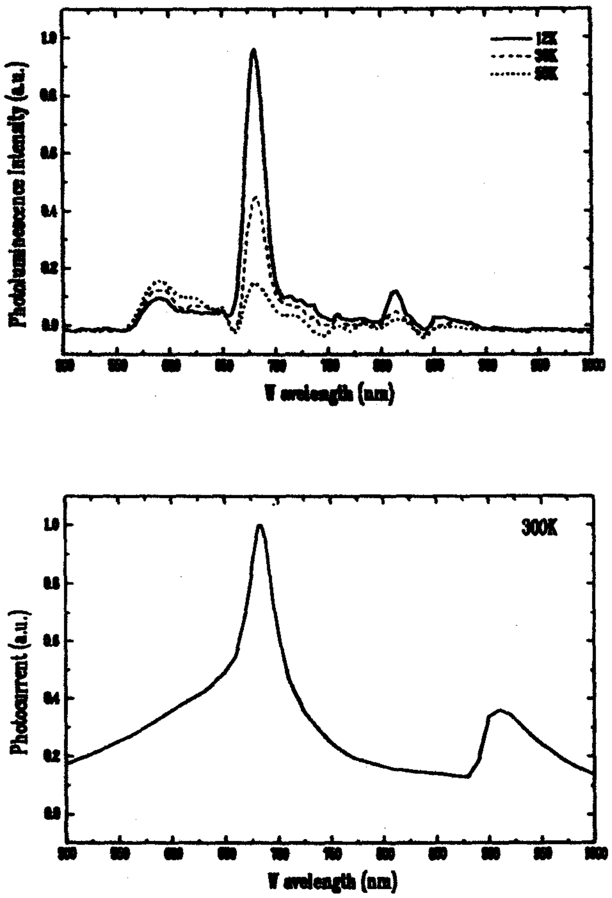

Figure 3. Photoluminescence and Photocurrent spectra of GaAs/AlGaAs MQW structure.

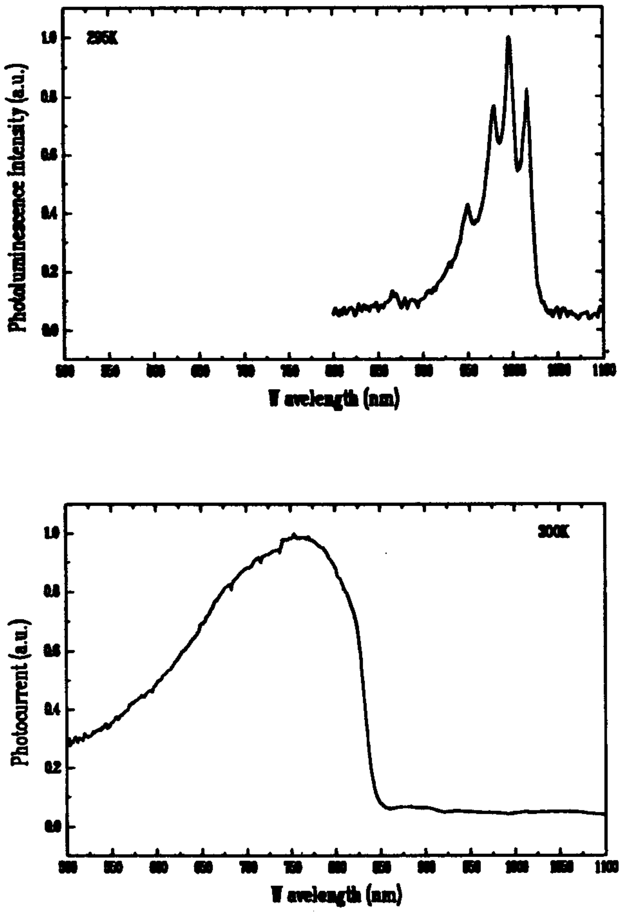

Figure 4. Photoluminescence and Photocurrent spectra of InGaAs/GaAs MQW structure.

4. DISCUSSION

GaAs/AlGaAs MQW structure presents the PL spectra with a high intensity peak at 670 nm. This PL peak is seen as a temperature dependent. As the temperature is increased, the exciton become dissociated and characterized as a free carrier. The photocurrent spectra is cleary seen even at the room temperature at the wavelength correspond to the PL spectra and also bad a broader peak near 900 om.

The PL measurement of the InGaAs/GaAs MQW was setup at room temperature and has the spectra response at long wavelength due to its strained quantum well but there is a photocurrent spectra only in 700-800 om spectral regions because no multiplication of the same quantum well width was done in this MQW sample so the absorption mainly occured in the GaAs barrier and substrate.

5. CONCLUSION

GaAs/GaAlAs and InGsAs/GaAs MQW structures were prepared by MBE techniques. The spectral response of the structure is observed by the photoluminescence and photocurrent measurements. The optimal response at the incident radiation wavelength could be controlled by the multiplication of the quantum well and the well width.

6. ACKNOWLEDGMENT

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