Extended Abstracts of the 2011 International Conference on Solid State Devices and Materials, Nagoya, 2011, pp320-321

Growth of ZnMgTe/ZnTe Waveguide Structures and Analysis of the Light Polarization with the Electric Field

Yuki Kumagai[1], and Masakazu Kobayashi[1,2]

[1] Waseda Univ. Dept. of Elec. Eng. & Biosci., Lab. for Mat. Sci. & Tech.
3-4-1 Okubo Shinjuku-ku, Tokyo 169-8555, Japan
Phone: +81-3-5286-1684 E-mail: kmgiyuk0312@fuji.waseda.jp
[2] Waseda Univ. Lab. for Mat. Sci. & Tech.
2-8-26 Nishi waseda, shinjuku-ku, Tokyo 169-0051, Japan

1. Introduction

The optical device utilizing the electro-optical (EO) effect of ZnTe are attracting the interest, because electro-optic coefficients of ZnTe are larger than values of conventional compound semiconductors including GaAs, ZnSe, and ZnS [1-2]. Bulk state was typically employed to EO devises of ZnTe. One of the problems of the bulk state was that controllable optically phase difference was not substantial. Another problem was that the scattering loss of the transmitted light was large when the light was incident in the bulk. The solution of these problems was a waveguide structure with a thin layer of ZnTe core. The optically phase difference of the thin film will be larger than that of the bulk, and the light loss can be suppressed [3].

The refractive index of ZnMgTe was smaller than that of ZnTe, and waveguide structures consisting of ZnMgTe/ZnTe/ZnMgTe on ZnTe (001) substrates were grown by molecular beam epitaxy (MBE). One of the problems of ZnMgTe/ZnTe/ZnMgTe waveguide structure was that the crystal quality would be inclined to get worse due to the lattice mismatch between layers (could be up to 4.1 %). By means of calculated critical layer thickness of the expression of Matthews and Blakeslee, crystal quality was studied for this structure [4]. The multimode characteristics of the guided light wave were observed from this structure in the horizontal direction.

In this study, an electric field was applied in perpendicular direction to the ZnMgTe/ZnTe/ZnMgTe waveguide structure, and the polarization characteristics of the transmitted light in ZnTe core layer were studied.

2. Experiment

ZnMgTe/ZnTe/ZnMgTe layered structures were grown on (001) ZnTe substrates by MBE (VG, V80H). Elemental Zn (6N super), Mg (6N), and Te (6N super) were used for source materials. After the chemical treatment, the substrate was introduced into the growth chamber and the surface oxide was removed using the atomic hydrogen [5-10]. Then ZnTe buffer layers (20 nm to 0.5 μm) were grown at 360°C and the ZnMgTe/ZnTe/ZnMgTe layers were followed. The nominal growth rate of ZnTe and ZnMgTe was about 0.5 μm/h. Total thickness of ZnMgTe cladding layers were 0.1~1.5 μm and the thickness of ZnTe core layers were varied from 1 nm to 5 μm. The mole fraction of Mg in the cladding layer was varied from 4 % to 15 %. The ZnTe capping layer (20 to 80 nm) was grown on top of the ZnMgTe/ZnTe waveguide structure. After the growth of waveguide structures, 300nm wide Au stripes were vacuum evaporated on top of the sample. Then mesa etch was performed using a sulfuric acid based etchant (H_2SO_4 : H_2O_2 : H_2O = 3:1:1, 20 °C for 1 min.). The mirror edge was obtained by cleaving the sample with the length of about 2mm. Figure 1 shows the sketch of the Optical phase shift measurement setup. A near-infrared laser beam whose wavelength was 794nm and diameter was about 50μm was irradiated to one of the cleaved edge through a polarizing plate. Then, the transmitted light was carefully monitored using a CCD camera from the other end of the cleaved edge through another polarizing plate. The measurement was performed at a room temperature. The electric field was applied along (001) direction using a DC voltage source.

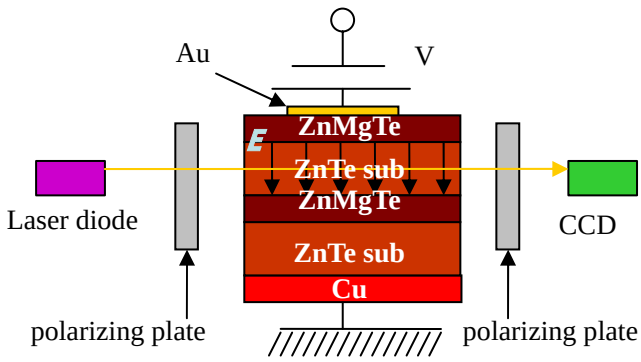

Fig. 1 sketch of the polarization effect measurement setups.

3. Result and discussion

Figure 2 shows the transmitted light intensity as a function of the rotation angle (the angular difference between the incident and transmit side polarizing plate) of the polarization plate. The Mg mole fraction in

ZnMgTe layer was about 8 %. The layer thickness of ZnTe and ZnMgTe for this sample was 5μm, and 1μm, respectively. The applied voltage across the sample was about 1 V. The transmitted light intensity at 90 degrees of the rotation angle couldn't be observed because the transmitted light intensity was near to background intensity. The transmitted light intensity of the sample without the electric field was larger than that with an electric field for the rotation angle between 0 degree and 60 degrees. On the other hand, the transmitted light intensity with the electric field was larger than that without the electric field at 120~180 degree. These phenomenons were occurred by the EO effect.

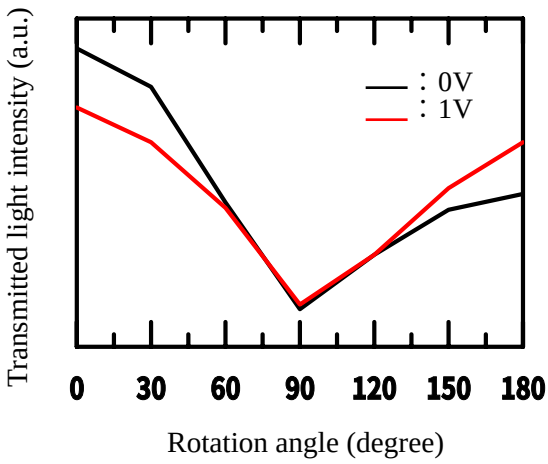

Fig. 2 intensity of transmitted light and polarization plate rotation angle

4. Conclusions

The transmitted light intensity was studied along with the polarization. The electric field was applied and its effect on the polarization was measured. The rotation of polarizing light wave direction with electric field was observed and the EO effect of the ZnMgTe/ZnTe waveguide structure was confirmed.

Acknowledgements

This work is supported in part by Waseda University High Tech Research Center Project, Organization for University Research Initiatives, and MEXT KIBAN-KEISEI. Authors acknowledge JX NIPPON MINING & METALS CO., LTD. for the technical support. The author (Y. Kumagai) would like to thank Kato Foundation for Promotion of Science.

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