ZnMgTe/ZnTe waveguide with two-step-index cladding layers structure

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(Introduction) Device that utilized Electro-Optic (EO) effects have been caught much attention. ZnTe is one of the attractive materials because of its high EO coefficient (4.5pm/V). In previous JSAP meeting, we have demonstrated that $Zn_{0.8}Mg_{0.2}Te$(0.6μm)/ZnTe(8μm) single-step-index waveguide device had better EO characteristic than that of bulk ZnTe (40μm) [1] (phase shift occurred in EO materials is a function of the applied electrical field). However, this waveguide structure had a large in-plane lattice mismatch (0.77%) between $Zn_{0.8}Mg_{0.2}Te$ cladding and ZnTe core layers due to the high Mg composition (Mg) and thick cladding layer. The large in-plane lattice mismatch would befall the degradation of crystal quality [2]. In order to decrease the in-plane mismatch between cladding and core layers, a low Mg% layers were introduced to lessen the lattice mismatch between cladding and core layers.

(Experiment) 2-step-index waveguide structures were grown on the (001) oriented conductive P-doped ZnTe substrate by MBE. The growth rate and growth temperature were about 0.5μm/h and 360℃, respectively. After the growth, layered structures were monitored by cross-sectional scanning electron microscope (SEM) to measure the thickness of each layer. The in-plane lattice mismatches and the crystal quality were evaluated using X-ray diffraction reciprocal space mapping (RSM). The EO characteristic of the waveguide was also evaluated by a homemade EO measuring system.

(Results) The 2-step-index waveguide layered structures with abrupt interfaces were confirmed by SEM. The RSM (Fig. 1) indicates the in-plane lattice mismatch between Mg24% layer and core layer was 0.75% while the in-plane lattice mismatch between Mg12% layer and core layer was 0.44%. Since the theoretical lattice mismatch between $Zn_{0.76}Mg_{0.24}Te$ and ZnTe was 0.98%, the low Mg% layer successfully decreased the lattice mismatch strain and improved the crystal quality of the waveguide structure. Compared to the single-step-index waveguide, the crystal quality degradation of $Zn_{0.76}Mg_{0.24}Te$(0.35μm)/ $Zn_{0.88}Mg_{0.12}Te$(0.45μm)/ZnTe(8μm) 2-step-index waveguide was suppressed even the Mg% and thickness of ZnMgTe layers was increased. The EO characteristic of it was also confirmed to have a similar phase shift at the applied electrical field compared with that of single-step-index waveguide structure. Other analyzations including the defect density of the 2-step-index waveguide will be discussed.

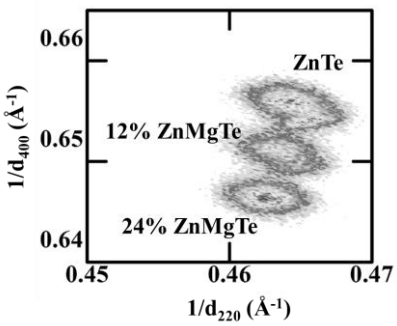

Figure 1 RSM of the (422) for 2-step-index waveguide

This work was supported in part by Waseda Univ. Research Initiatives, "Early Bird" grant for young researcher at Waseda Research Inst. for Sci. & Eng., collaboration between Mitsubishi Mat. Corp. & Faculty of Sci. & Eng., the Foundation of Ando Lab., JX Min. & Met. Corp. a Grant of the Strategic Research Foundation. And specially gratitude Dr.Togo of NTT Corp.

[1] 孫 惟哲、他 2015 春季応用物理学関係連合講演会 13p-A17-6
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