Defect Density Reduction in Core layer of ZnTe Electro-Optical Waveguide by Low Lattice Mismatched Interfaces

W. Sun,[a] T. Nakusu,[a] K. Odaka,[a] M. Kobayashi,[a,b] and T. Asahi,[c]

[a] *Waseda University, Department of Electrical Engineering and Bioscience, 3-4-1 Okubo, Shinjuku, Tokyo,169-8555, Japan*

[b] *Waseda University, The Kagami Memorial Research Institute for Materials Science and Technology 2-8-26, Nishiwaseda, Shinjuku, Tokyo, 169-0051, Japan*

[c] *JX Nippon Mining & Metals Corp. 1-1-2, Otemachi, Chiyoda, Tokyo, 100-8164, Japan*

ZnMgTe(Cladding)/ZnTe(Core) thin film waveguide has been proposed to form a practical Electro-optical (EO) device due to the high EO coefficient of ZnTe (r_{41}= 4.5 pm/V) [1]. For low loss ZnMgTe/ZnTe waveguide, large refractive index difference between layers can be achieved by adding Mg content (Mg %). However, high Mg% results in lattice mismatch enlargement (lattice mismatch between ZnTe and MgTe is 4.1%), and misfit dislocations at interfaces would befall and degrade the crystal quality. In previous study, waveguide with Mg 20%, 0.6 µm cladding layer was found to have high-performance [2]. However, large in-plane lattice mismatch (0.8%) between ZnMgTe and core layers, and high defect density in core layer at the interface region was observed (4×10^9 /cm^2). Therefore, low Mg % interlayers were introduced to create a series of low lattice mismatch interfaces and circumvent the effect of the large lattice mismatch (two-step index waveguide). In this study, two kinds of structures were considered to realize a low loss two-step index waveguide. One structure was designed to insert 0.1 µm low Mg% interlayers, and cladding layer thickness and Mg % were kept about 0.6 µm and 20%, respectively (sample 1). The other structure was designed to have the cladding layer 0.3 µm with Mg 20% and Mg 10% 0.45-µm-thick interlayer (sample 2).

By cross-sectional transmission electron microscope observation, both samples had lower defect densities (2×10^8 /cm^2 for sample 1; 2×10^9 /cm^2 for sample 2) than the single-step index waveguide in core layer at the interface region. It indicates that extra interfaces with lower lattice mismatches were successfully helped to improve crystallographic properties. The interlayer worked efficiently even if thickness was only about 0.1 µm thick. With the reduction in defect density of the ZnTe layer, the EO property of the device is expected to be improved. However, the propagation loss was not improved by the introduction of the low Mg % interlayers when the average Mg % of ZnMgTe layers was insufficient. By carefully control of the average Mg %, ZnTe waveguide with a series of low lattice mismatches interfaces could have better crystal quality without dropping the optical confinement.

[+] Author for correspondence: sun@fuji.waseda.jp

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