Study on Thin-Sheet $LiNbO_3$ Optical Modulator with Broad Bandwidth and Low-Driving-Voltage for Practical Use

2008

Jungo Kondoh

This work was examined on a $LiNbO_3$ optical modulator for practical use, which could operate with a broader bandwidth and a lower-driving-voltage for a future high-speed optical transmission systems. Most of low-driving-voltage $LiNbO_3$ optical modulators have been developed using Z-cut $LiNbO_3$ substrates with SiO2 buffer layer. In this work, X-cut $LiNbO_3$ optical modulator without the buffer layer was adopted because of temperature stabilizing and decreasing of DC bias drift. In addition, the $LiNbO_3$ substrate was made thin to obtain a broad bandwidth and a low-driving-voltage, and an optical modulator structure for mass-productivity and high reliability was researched. As a result, it was found that a thin-sheet $LiNbO_3$ optical modulator, which consisted of a thin-sheet X-cut $LiNbO_3$ substrate fabricated by precise lapping and polishing, a low-dielectric-constant layer, and an X-cut $LiNbO_3$ supporting substrate, had possibility to achieve driving voltage of 2 V at over 40 Gb/s. In order to realize this modulator, structure design for the satisfaction of velocity matching and impedance matching and optical waveguide design for single mode and high on-off extinction ratio were optimized. Then, a low-dielectric constant layer was selected, which had high reliability on adhesive strength, dielectric properties, and outer exhaust gas. Moreover, packaging techniques were established. A fabricated thin-sheet $LiNbO_3$ optical modulator module achieved driving voltage of 2 V at 43.5 Gb/s. Furthermore, this modulator was tested temperature cycling and dc bias drift on basis of the standard for optical communication systems, and high reliability and durability were realized. Thin-sheet $LiNbO_3$ optical modulator has potential for over 40 Gb/s optical transmission systems and millimeter-wave systems.