STUDIES ON THE DIFFERENT PROPERTIES OF LITHIUM NIOBATE FOR PHOTONIC DEVICE APPLICATIONS

Abstract

Ferroelectric lithium niobate (LiNbO₃) is one of the most widely used materials for optical communication networks and integrated photonic device applications. But till date all of the properties of the crystal are not well explored and hence requires lots of research. In this work some critical parameters of the crystal, such as its electro-optic parameters, coercive field, internal field, etc. and their dependencies on domain configurations are examined. Subsequent investigations of those parameters are made possible by using room temperature electric field poling which, in the present work, is slightly modified from the conventional methods. Domain inversion of the crystal is verified by chemical etching of the poled samples followed by identification of poled regions under an optical microscope. When light is allowed to pass along the optic axis of a z-cut LiNbO₃ under an applied electric field, due to electro-optic effect of the crystal there will be a net phase-change at the output, which is measurable by an interferometer. Using a Mach-Zehnder interferometer experimentally obtained halfwave voltage, required for 180° phase change, is compared with the theoretically estimated one. A good agreement has validated the experimental procedure. The same interferometer when used for poled LiNbO₃, has exhibited much lower halfwave voltage and indicates an enhancement of the corresponding electro-optic parameter, r₁₃. Again internal field of the crystal is examined by monitoring the measured halfwave voltages for different types of samples with various domain configurations. Time-temperature evolution of internal field for domain inverted LiNbO₃ is also performed. It is reported that the strengths of internal field for as-bought LiNbO₃ and annealed domain inverted LiNbO₃ crystal are same with a visible change of direction of the crystallographic z-axis of the crystal. But for frustrated domain inverted crystal the strength of internal field is reported to be a function of time elapsed after the domain inversion process. Appropriate crystallographic defect model is employed to explain those observed phenomena. Again components causing internal field of the crystal are explored and their quantitative strengths are reported. Finally a theoretical model to achieve tunable differential polarization phase modulation using specially shaped bulk LiNbO₃ crystal is discussed.

Submitted by

Ranjit Das

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(Ranjit Das)