Mapping 3D Electric Fields using Electric Field Induced Second Harmonic Generation in $LiNbO_3$ Crystals

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Abstract – *Strong electric-field-induced-second-harmonic-generation effect was observed in bulk Lithium Niobate. We utilize this effect to map three-dimensional electric field distribution with high spatial and temperal resolutions.*

1. Introduction

With the developments of high speed microwave and optoelectronic devices, demands of techniques for measuring ultra-fast electrical field variation are growing up. Among several techniques, such as using Pockels effect and EO sampling technique [1], utilizing Electrical-Field-Induced Second-Harmonic Generation (EFISH) has several advantages. With a strongly focused sampling beam, the nonlinearity in EFISH can provide high spatial sectioning capability for 3D electric field imaging. It is easier to detect EFISH signals than to detect signals of EO sampling and Pocket effect [2]. Due to the tensor nature of cubic nonlinear susceptibility, EFISH signals are dependent on polarizations of input light and electrical fields we desire to measure. This characteristic allows us to map the three-dimensional electrical field vector. In addition, EFISH effect in $LiNbO_3$ crystals is not involved with electron motion. Therefore, the response time in crystals is supposed to be much shorter than that in other materials, such as polymers, liquid crystals and semiconductors. With the short-response-time nature, using EFISH technique in crystals has the potential to characterize ultra-high bandwidth devices. In this letter, we report the large voltage-dependent EFISH signal in bulk Lithium Niobate crystal. This EFISH effect in LiNbO3 was then applied to calculate for high resolution 3D imaging of electric field distribution.

2.Experimental setup and results:

We choose Lithium Niobate crystal as EFISH material owing to it has high electrical resistivity, its high transparency in visible and infrared regions, and its high EO effects. In our preliminary study, two asymmetric Aluminum electrodes were deposited on a z-cut Lithium Niobate substrate with a 20μm wide and 0.3 μm deep gap between them. A mode-locked Cr:forsterite laser beam operating at 1230nm was focused on the sample between two electrodes with a 2.6μm spot size. A filter and an analyzer were put before detector to block 1230nm fundamental and to select a particular output polarization, separately. We dropped out second harmonic background by modulating applied voltage and measure EFISH signal by lock-in detection. Typical EFISH signal response versus applied voltage in Lithium Niobate crystal was fitted. The slope is about 5.95×10^{-7} V/V, showing linear dependence on EFISH signal with applied voltage. $\chi^{(3)}_{yyyy}(2\omega,0,\omega,\omega)$ was then calculated to be roughly on the order of 10^{-21} m^2/V^2.An image example of electrical field distribution between two parallel but asymmetric electrodes using the EFISH effect in Lithium Niobate was taken. The electric field component in y-direction (the direction perpendicular to the electrode) is shown. 3D resolution is on the order of 1 μm. We observed asymmetric distribution of electrical fields arising from asymmetric electrodes. Detailed vector analysis and results of EFISH sampling will be present in the conference.

REFERENCES

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