PRELIMINARY STUDY OF SECOND HARMONIC GENERATION IN POLED TeO_2-Nb_2O_5-Li_2O-Sm_2O_3 GLASS

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ABSTRACT

Series of glass based on TeO_2-Nb_2O_5-Li_2O-Sm_2O_3 of 1mm thick is electrically thermal poled around 270°C (120°C below transition glass temperature, Tg), for 1 hour under applied de field of 2.5kV. The micrograph taken under SEM shows that the poling caused small particles occurs at voltage of 2.5kV on anode-side surface. Second order optical nonlinearities will be induced in tellurite glasses by the thermal poling technique. The induced will be measured via second harmonic generation using a fundamental beam from a 1064 nm mode locked Nd: YAG laser. The nonlinear regions will be characterized using the Maker-Fringe technique, in which the second harmonic signals were observed as a function of incident angle of the fundamental beam. The profile has contributions from a distinct region: a near-anodic surface.

Keywords: tellurite glass, electric thermal poling, scanning electron microscopy (SEM), second harmonic generation (SHG)

INTRODUCTION

The optical second harmonic generation (SHG) in poled oxide glasses which was originally discovered by Myers *et al.* [1] for poled silica glass is a very interesting phenomenon, indicates a long-range order in orientation of electric dipole moments is realized in a disordered lattice such as oxide glass. Attempts are in progress to achieve wave-guides for second harmonic waves using a glass material. Poled tellurite glasses are known to show second-order non-linear optical effects as well. The optical second harmonic generation in poled tellurite glasses indicates that the SHG is suppressed in tellurite glasses containing cations with large electron polarizability such as Na^+ ion and Li^+ [3, 8]. It is known that the second harmonic intensity increases as the number of TeO_3 trigonal pyramid and/or non-bridging oxygen increases in the glass network structure. This phenomenon was explained in terms of the flexibility of glass structure.

The electric dipole moments whose long-range orientation gives rise to the SHG are probably ascribed to asymmetrical structural units such as TeO_4 trigonal bipyramids and TeO_3 trigonal pyramids, and the orientation of these structural units in the direction of the external dc electric field can occur more readily in a more flexible glass network structure. In the present investigation, we examine the relation between second harmonic intensity and glass transition temperature of TeO_2 glasses to evaluate the mechanism of orientation of tellurite structural units under an applied dc field.

EXPERIMENTAL

Glasses were prepared from oxide powders of TeO_2, Nb_2O_5, Li_2O and Sm_2O_3 as starting materials using the conventional melt-quenching method. Detailed on the glass preparation has been reported elsewhere [4]. Both sides of the glass sample are then polished to get a sample plate of about 1 mm thick. The poling current was measured by physically contacted the sample to electrodes (made of stainless steel), before being heated at 270°C (120°C below T_g), for 60 min under applied dc fields of 2.5 kV. Then the temperature was decreased to room temperature while the voltage was held constant. The applied dc field was removed after the sample reached the room temperature.

The microstructure of the sample after the poling is investigated under the scanning electron microscopy (SEM). Figure 1 shows the schematic diagram for the thermal poling technique.

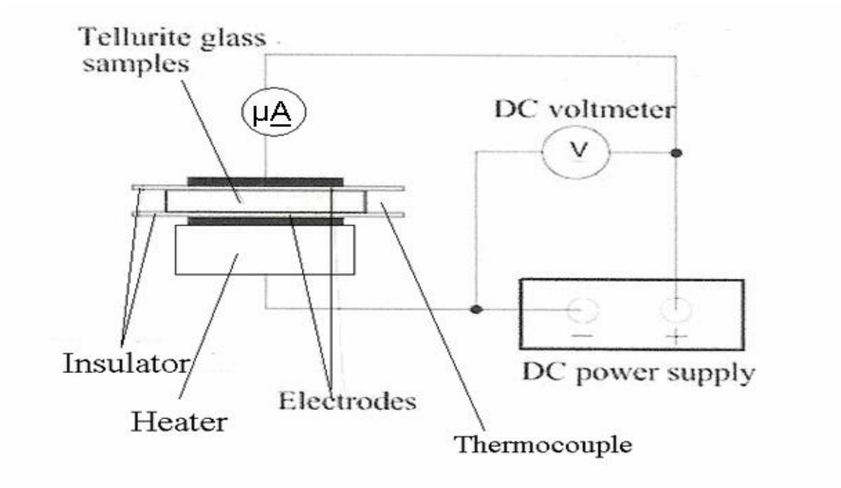

Figure 1: Apparatus for thermal poling the glass sample

RESULT AND DISCUSSION

In the process of thermal poling, a carrier-deficient negative charge layer was formed near the anode area in the sample; thus positive charge would accumulate in the sample near the anode surface. The appearance of charge on both of the electrodes was due to the charge balance. This is explained as shown in Figure 2.

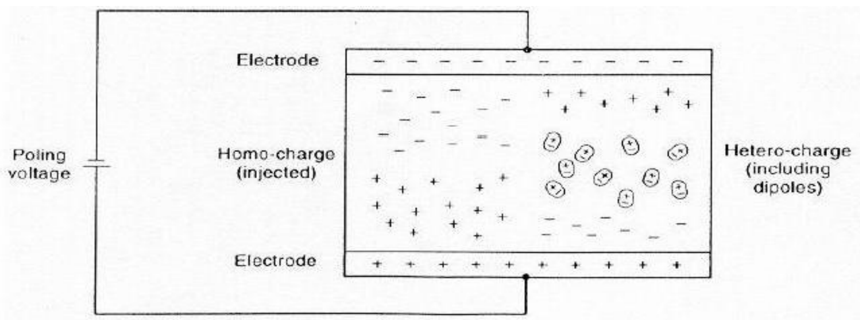

Figure 2: Schematic view of possible orientation phenomena in a poled glass sample.

When glass is pole under the dc bias at elevated temperature (below T_g), dipoles are formed in the medium due to the induced polarization of the dopant. As the dc bias is removed after the room temperature, the orientation of dipoles has been frozen and therefore the inversion symmetry of the medium has been broken. A similar result has also been observed elsewhere [5]. It should be noted that this phenomena is similar to those of SHG phenomena occurs in other glass system [6]. However, much work has to be done to clarify this phenomenon.

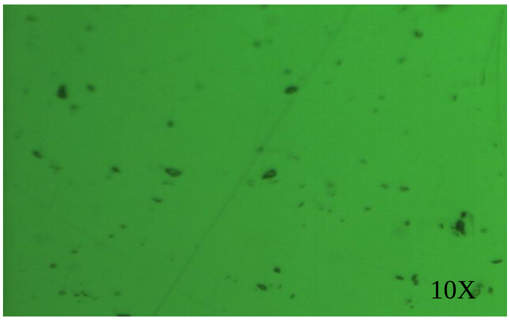

Figure 3: SEM micrograph of the $68TeO_2$-$20Nb_2O_5$-$10Li_2O$-$2Sm_2O_3$ after thermal poling at 2.5kV on anode-side surface.

In Figure 3, the formation of small particles is very clear. It is reported that some electrochemical reaction under the large dc field may convert the tellurite glass structural from the TeO_4 to the deformed TeO_3 resulting in possible precipitation of metallic tellurium of small particles [6]. This may perhaps due to the SHG phenomena in glass.

FUTURE STUDY AND RECOMMENDATION

The Maker-Fringe method [2] is utilized to measure second harmonic intensity for the poled glass samples (Figure 4). The p-polarized fundamental waves of pulsed Nd: YAG laser, the wavelength of which was 1064nm, is uses as incident light. The p-polarized second harmonic with wavelength 532nm is passed through a monochromator and detected using photo multiplier. The intensity of the second-harmonic wave determined by means of a digital oscilloscope.

Optically induced SHG being observes after poling treatment and the second harmonic coefficient d_{33} measures using the Maker-Fringe method [7]. The second order susceptibility is localized within a thin glass layer located close to anodic surface. The thermal poling has been proving that the anodic surface region get crystallization [8]. For the experiments are performs at a fundamental wavelength 1064 nm by Maker-Fringe measurements on z-cut tellurite glass of different thickness.

Due to the high refractive indices of tellurite glass [6] and the corresponding high surface reflectivity, these resonances give rise to distinct oscillation of the SHG signal which is superimposed on the regular Maker-Fringe pattern. For a correct description of the data, the finite waist diameter of the incident laser beam must be taken into account, since it leads to a decreasing overlap between successively reflected rays and, hence, to a decrease of the amplitude of the Fabry-Perot oscillations with increasing angle of incidence. The experiments should yields a lower bound for the non-linear coefficient d_{22}.

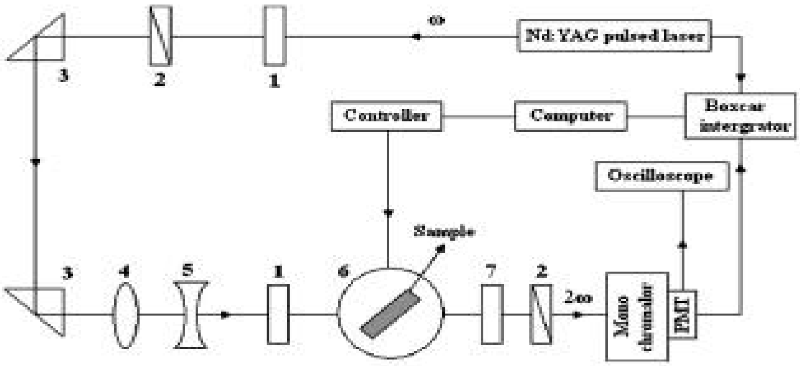

Figure 4: Schematic description of the SHG measurement system: (1) Vis cut filter; (2) polarizer; (3) Glan prism; (4) convex lens; (5) concave lens; (6) rotation stage; (7) IR cut filter

CONCLUSION

The thermally poled tellirite glass will found to exhibit SHG using Maker-Fringe method. The poled tellurite glass shows existing crystallization on anodic surface. The technique of poling was undertaken, which produce poled samples with combination electric and thermal application.

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