Solid State Science and Technology, Vol. 18, No 1 (2010) 260-265
ISSN 0128-7389

CHARACTERISTIC OF AN ELECTRICALLY THERMAL POLING OF 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 has successfully been made by melt quenching technique. The glass of 1mm thick is then electrically thermal poled around 270°C (120°C below transition glass temperature, T_g), for 1 hour under applied dc field of 1.5kV-2.5kV. It is observed that the poling current decreased drastically of a depletion layer near the anodic side. The micrograph taken under SEM shows that the poling caused small particles to occur at optimized voltage of 2.0kV at this layer. It is also observed that the poling would induced a formation of a clustered phase in sample doped Sm^{3+}.

INTRODUCTION

Tellurite glasses posses interesting glass forming ability, glass structure and physical properties. As for the physical properties of the tellurite glasses, they have high refractive index, high infrared transmittance and large third order nonlinear susceptibility [2]. Generally, glass with inversion symmetry in macroscopic scale does not generate in principle second order optical nonlinearity. However, it has been well recognized that it is possible to break inversion symmetry in a microscopic scale through techniques such as thermal poling to induce second order optical nonlinearity [3].

Narazaki et al. [4] have proposed that the large electric field in the anode-side glass surface region possibly leads to an orientation of asymmetrical tellurite structural units such as TeO_4 trigonal bypiramid and TeO_3 trigonal pyramid which posse's electric dipoles. Therefore, it is the aim of this paper to present the latest development on the characteristic of the thermally poled of TeO_2-Nb_2O_5-Li_2O-Sm_2O_3.

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 [6]. 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 1.5-2.5 kV. Then the temperature was decreased to room temperature while the voltage was held

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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.

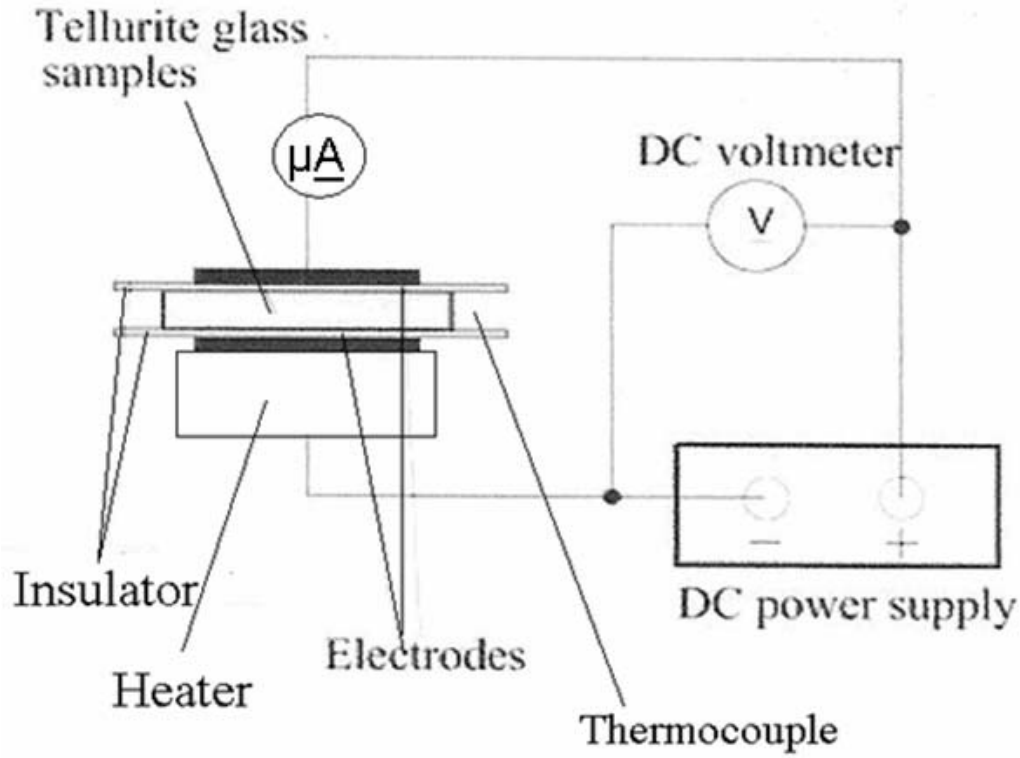

Figure 1: Apparatus for thermal poling technique

RESULT AND DISCUSSION

Figure 2 shows a typical of a poling current against the poling time. As can be seen, the poling current drastically decreased as the poling time is increase of about 6 min.

The drastic change in poling current is possibly due to the contraction of electrodes and ion injection from the atmosphere, according to Fuxi [4]. In the process of thermal poling, a carrier-deficient negative charge layer was formed near the anode area in the sample thus; positive charges 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 3.

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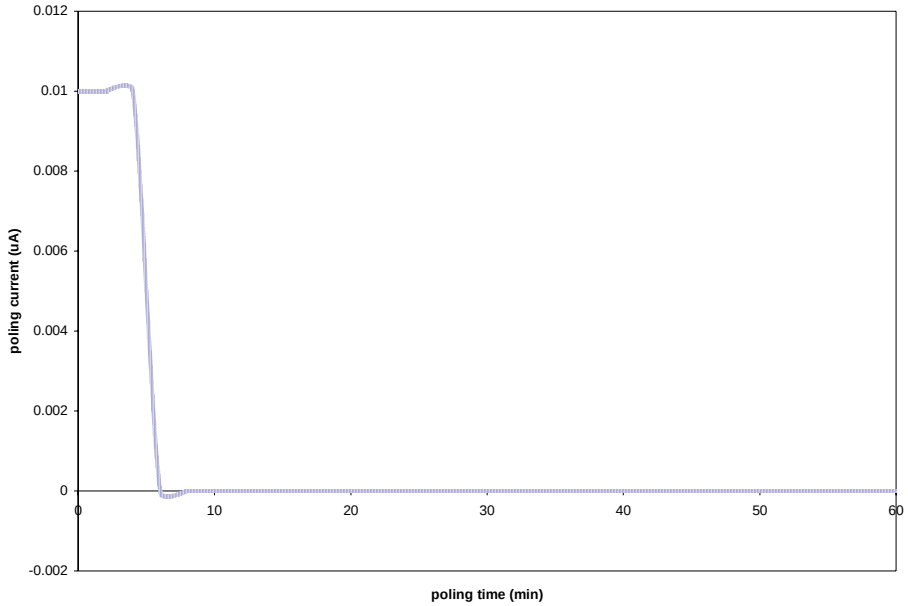

Figure 2: A variation of a poling current against the poling time with dc voltage at 2.0kV for $68TeO_2$-$20Nb_2O_5$-$10Li_2O$-$2Sm_2O_3$ at 270 °C.

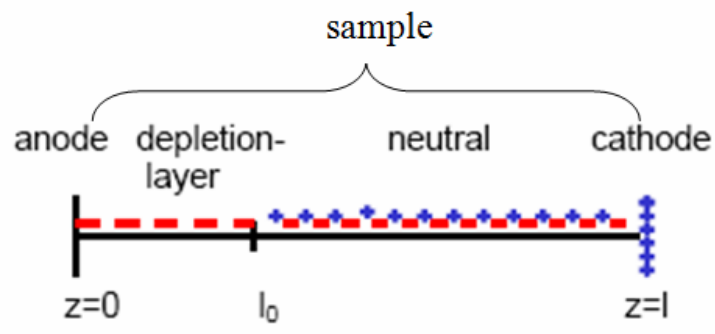

Figure 3: Charge distribution in the electrode after poling.

Figure 4 shows the microstructure of the anode-side sample after subjected to thermal poling at (a) 1.5kV (b) 2.0kV and (c) 2.5kV respectively. Both microstructures of Figure 4(a) and 4(b) show no indication of any crystallization.

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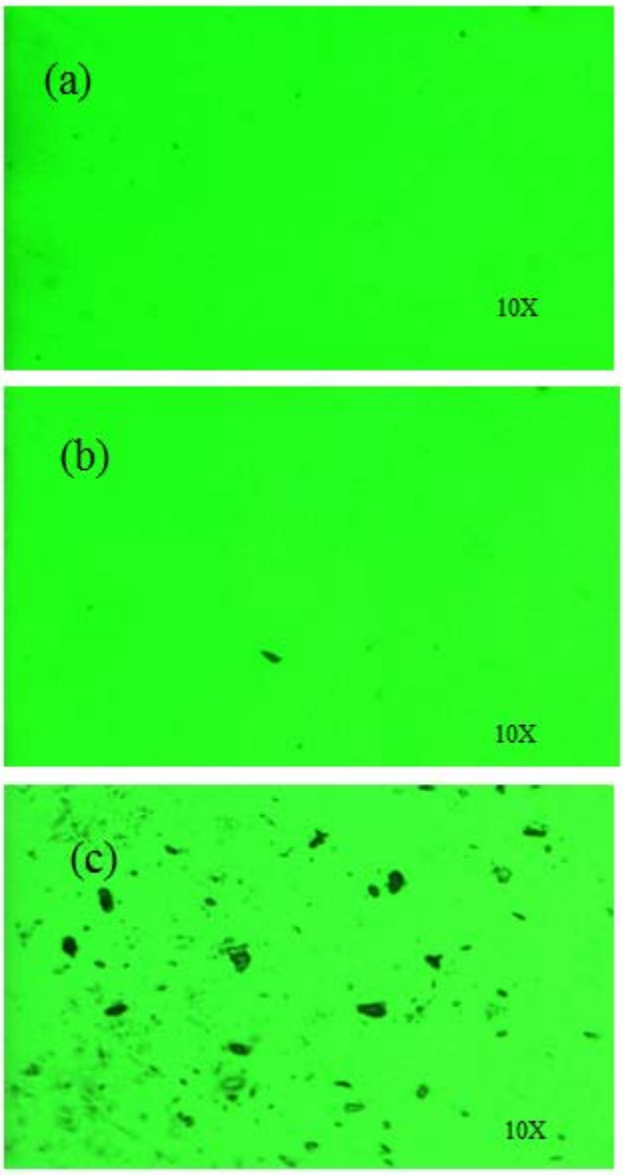

Figure 4: SEM micrograph of the 68 TeO_2-20Nb_2O_5-10Li_2O-2Sm_2O_3 after thermal poling at different voltage on anode-side surface (a) 1.5kV (b) 2.0kV and (c) 2.5kV.

However, in Figure 4(c), the formation of small particles is very clear. The reason why such a phenomena occurred is still not understood. This is probably because the poling technique never reaches near to the crystallization temperature. However, it is reported that some electrochemical reactions 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 as small particles [2]. This may perhaps due to the second harmonic generation (SHG) phenomena in glass.

For sample doped with Sm^{3+} that experienced the thermal poling at 270°C at 20kV, the

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micrograph shows a formation of a clustered phase. This is shown in Figure 5.

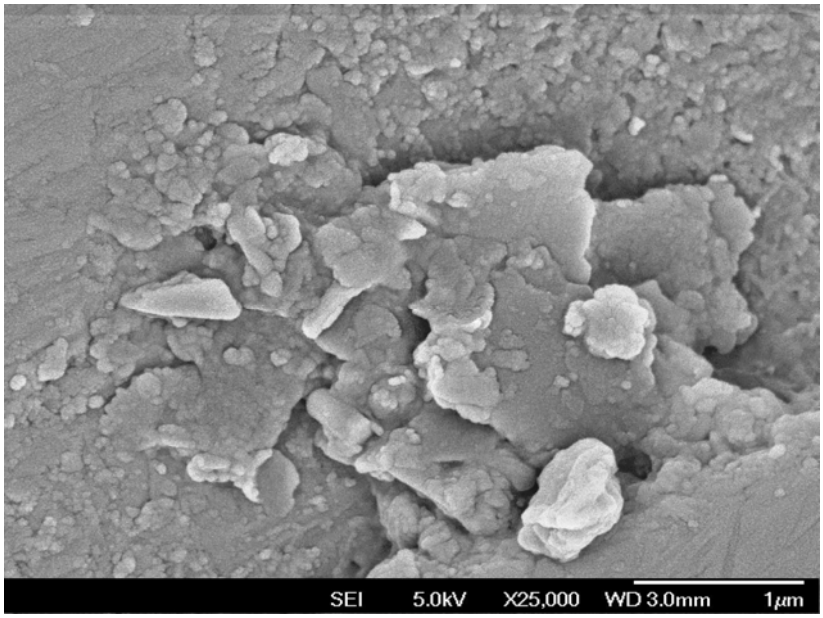

Figure 5: SEM micrograph of the glass doped with Sm^{3+} after poling at 2.0kV at 270°C.

It is assumed that during the thermal poling, the structural changes in glass could occur due to the dipole orientation that probably originate from defects and color centers in the medium. When the glass is poled under the dc bias at elevated temperature, 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 [4]. It should be noted out that this phenomena is similar to those of SHG phenomena occurs in other glass system [2]. However, much work has to be done to clarify this phenomenon.

CONCLUSION

In the present work, the thermally poled tellurite glass produces a poling current that indicates the formation of a depletion layer near the anodic-side. This is manifested by the precipitation of small in the layer. As the glass is doped with Sm^{3+}, the formation of the clustered phase might be due to SHG phenomena.

ACKNOWLEDGEMENT

The authors would like to thank the Academic Science of Malaysia (ASM) for financial support through SAGA grant vote 73707.

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REFERENCES

[1]. K.Tanaka, K.Kashima, K.Hirao, N.Soga, A.Mito, H.Nasu, J.Non-Crystalline Solids **185** (1995), pg 123-126
[2]. N. Tamagawa, Y.Benino, T.Fujiwara, T.Komatsu, Optics Communications **217** (2003) pg 387-394.
[3]. Alexander StrauB, Sven Bruckner, Ulrich Ropke, Hartmurt Bartelt, *Thermal Poling Silica*, Dgao Proceedings 2005.
[4]. Fuxi Gan, Lei Xu, (2006) *Photonic Glasses,* World Scientific, pg 153-186
[5]. Hongbing Chen, Haiping Xia, Congshan Zhu, Fuxi Gan, Materials Letters **50** (2001) pg 333-336.
[6]. Nuraffera Binti Mohd Nasir (2007), *Physical and Optical Characterization of Samarium Oxide doped Niobium Tellurite Glasses*. Universiti Teknologi Malaysia: Master Thesis.

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