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Swift heavy ion induced modification on the dielectric behaviours of pure and doped TGS crystals

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Abstract

Swift heavy ion beam irradiation has been used for creating the non-equilibrium condition in the ferroelectric crystals of TGS doped with alanine impurities. Dielectric measurements reveal that irradiated crystals retain their ferroelectric phase and T_c remains invariant. Dielectric peak, however, gets broaden and decreases with increasing fluence. Tangent loss also decreases. Dielectric dispersion in different crystals show interesting changes with fluence and is analyzed in terms of thermally generated electric field in the crystals that stabilizes the bi-domain structure.

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Keywords: Ferroelectrics; Dielectric dispersion; Irradiation induced effects; Ferroelectric domains

1. Introduction

Tri-glycine sulphate (TGS) is an important room temperature ferroelectric crystal most suitable for the pyroelectric detection of IR radiation [1,2]. Usually the measurements of dielectric properties of ferroelectrics crystals are performed under well-defined thermodynamic equilibrium conditions. Some attempts have, however, been made to experimentally investigate the changes of the basic microscopic properties of ferroelectric crystals while undergoing from thermodynamics equilibrium to non-equilibrium state [3,4]. It was shown that the dielectric properties are modified when a temperature gradient was created. We have attempted the SHI irradiation as a means of taking the system to non-equilibrium and studied the dielectric behaviour. Some preliminary results are presented in this paper.

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2. Experimental

Crystals of TGS were grown by solution growth method. Crystals grown from solutions having 11 and 15 molar percentage of L-alanine are referred to as LATGS11 and LATGS15, respectively. Crystals were cleaved according to morphology, polished and irradiated with 100 MeV oxygen beam at varying fluence and then electroded with silver paste and used for dielectric measurements. For irradiated crystals, the Monte Carlo 'TRIM' calculation shows the energy range up to which swift heavy ions penetrate into the crystals. The range for the 100 MeV oxygen beam used in the experiment is 100 μm and the crystal thickness used in the present work is approximately 1000 μm. The flow of charges and local thermal flux diffuse through the crystals and it creates a flux gradient. We believe that the situation created in the crystals due to SHI irradiation is that of thermodynamic non-equilibrium and use the basic premises of the model developed by Sajosch and Narz [4,5] to describe the experiment results.

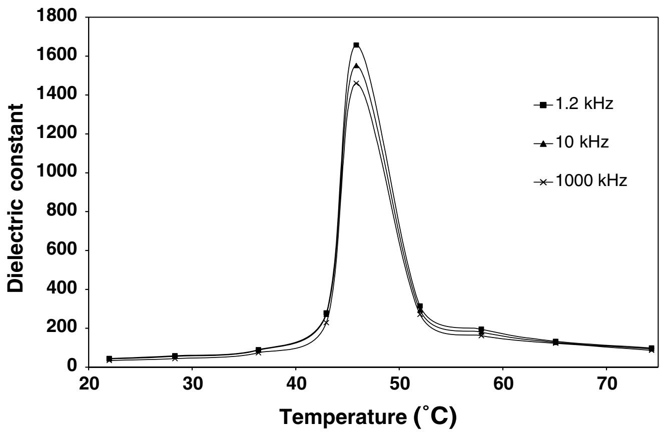

Fig. 1. Temperature dependent dielectric constant in pure TGS crystals irradiated with 100 MeV oxygen beam at fluence 10^{12} ions/cm^2.

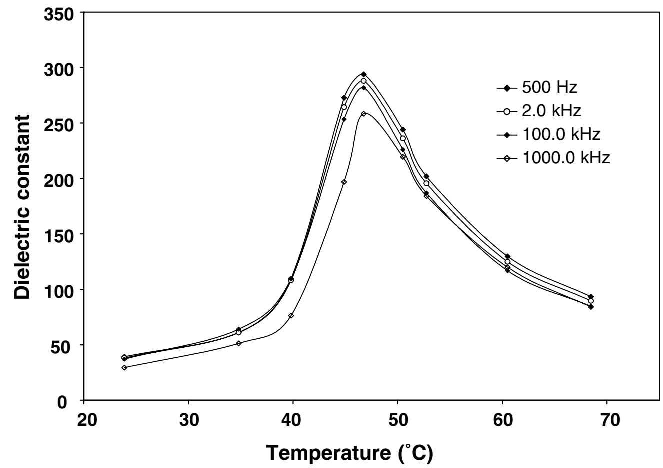

Fig. 2. Temperature dependent dielectric constant in 11% alanine doped TGS crystals irradiated with 100 MeV oxygen beam at fluence 10^{12} ions/cm^2.

3. Results and discussion

Virgin and irradiated TGS crystals were subjected to dielectric measurements. The temperature dependent dielectric constant for the energy fluence of 10^{12} ions/cm^2 for pure TGS at kilohertz range is shown in Fig. 1. Results

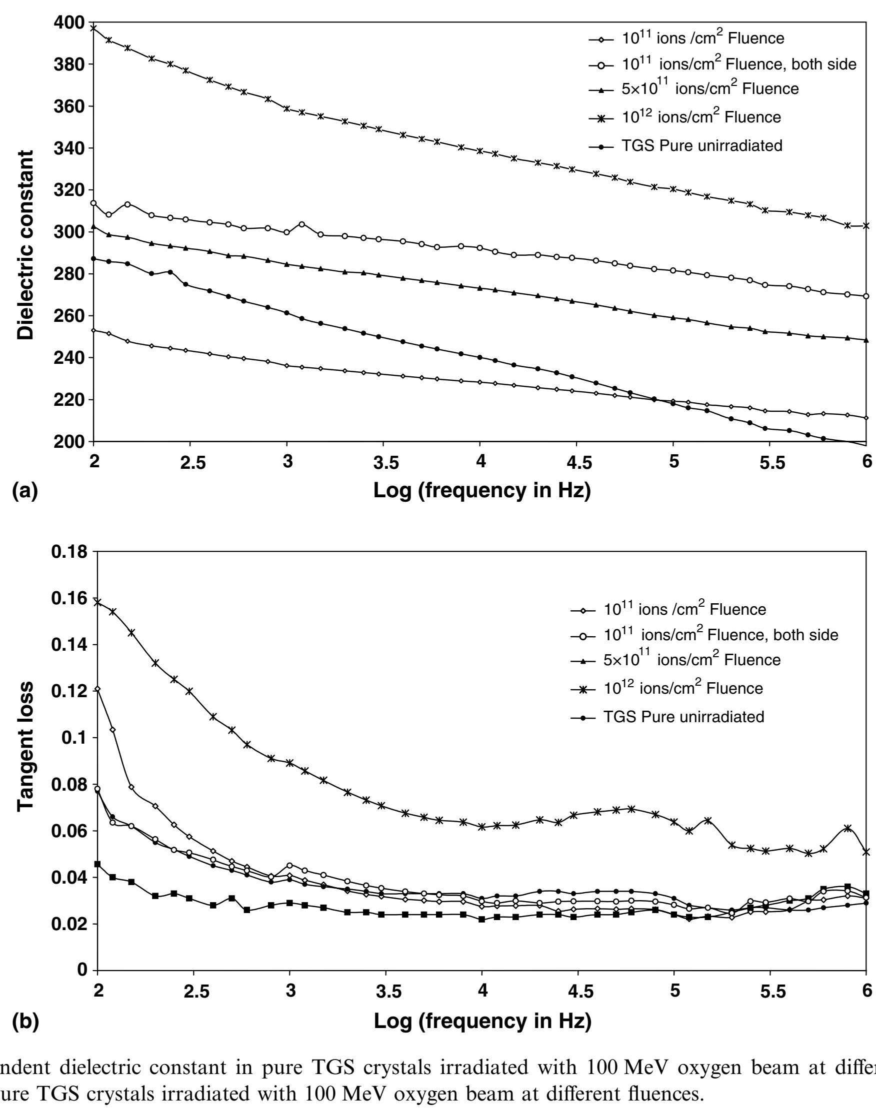

Fig. 3. (a) Frequency dependent dielectric constant in pure TGS crystals irradiated with 100 MeV oxygen beam at different fluences. (b) Frequency dependent tangent loss in pure TGS crystals irradiated with 100 MeV oxygen beam at different fluences.