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Study Effect of external biasing field on Pyroelectric behavior of a triglycine sulphate single crysta

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Abstract

In the present work, samples of triglycine sulphate were cut from a large single crystal, They were polished, furnished with silver paint electrodes on the major surface and subjected to pyroelectric current measurements in the vicinity of the phase transition point (T_c) ≈49°C.

The results show that the peak value of pyroelectric current decrease with increasing the external biasing field.

Key words: pyroelectric , triglycine sulphate , external biasing field.

الملخص:

فى الدراسة المقدمة تم تقطيع عينات من بلورة أحادية كبيرة من كبريتات ثلاثى الجليسين. ثم صقلت هذه العينات وزودت بأقطاب من دهان الفضة على السطحين الكبيرين وأجريت عليها قياسات التيار البيروكهربي تحت تأثير مجال تغدية خارجي فى مدى درجات الحرارة الواقعة على مقربة من التحول الطورى (490C). ولقد وجد من خلال قياسات التيار الكهربي أن قيمة النهاية العظمى للتيار البيروكهربي تنخفض مع زيادة المجالات الانحيازية الخارجية

الكلمات الافتتاحية: البيروكهربي ، كبريتات ثلاثي الجليسين ، مجال تغدية خارجي .

Introduction

Pyroelectricity is the manifestation of the temperature dependence of the spontaneous polarization of certain solids which may be either single crystals or polycrystalline aggregates. A fundamental theory in pyroelectricity was established by Max Born [1]

]He derived an expression for combined effect of thermal pressure and piezoelectricity, called "apparent" pyroelectricty and the true pyroelectricity which is considered as dielectric polarization produced by an "internal electric field".

The pyroelectricity can be derived thermodynamically from reversible interactions that may occur among thermal, mechanical and electrical properties of a crystal. These properties are stored in a crystal in amounts each being proportional to the product of an intensive and differential of an extensive variable. According to the method of classical thermodynamics.[2]

This work aims at studying effect of external biasing field on Pyroelectric behavior of a triglycine sulphate single crystal. . This property has a special significance in view of the different applications .

It is known as pyroelectric material which finds application in the fabrication of infrared detectors, pyroelectric vidicon tube operating at room temperature, in the fabrication of capacitors, transducers and sensors .[3]
triglycine sulphate which its chemical formula is. $(NH_2CH_2COOH)_3.H_2SO_4$ is a crystal which is ferroelectric below the transition temperature of 322 K. In this phase, it has the monoclinic space group $P2_1$. In the paraelectric phase, this crystal has the space group $P2_1/m$ which is monoclinic and has a centre of inversion symmetry. [4-7]

The cell parameters in the ferroelectric phase at temperature equals 298 K are as follows:
a = 9.419A° , b= 12.647 A° , c= 5.727 A° , β = 111.32 A°

And triglycine sulphate crystal is a hybrid organic – inorganic crystal and a ferroelectric material widely used in pyroelectric detection and thermal imaging devices (e.g. pyroelectric vidicon). [8

](TGS) single crystals are considered as a potential material for infrared (IR) detection by virtue of their high pyroelectric coefficient (λ) and low dielectric constant (ε') [9].

However, the tendency of the crystals to depolarize with time is a serious drawback[10].

This crystal has become the object of active experimental research for two reasons Firstly, it is one of very few ferroelectric crystals known to exhibit a second order Phase transition and hence offer possibilities of the observation of genuine critical (i.e. fluctuation – dominated) phenomenon , very close to T_c . Secondly, it is an order – disorder uniaxial ferroelectric material.

Many studies been conducted regarding triglycine sulphate crystal and effecting addition of suitable materials on their properties:

Farhana Khanum and Jiban Podder.[11] studied Structural and Optical Properties of Triglycine Sulfate Single Crystals Doped with Potassium Bromide

Lucian Pintilie et.al.[12] studied Pyroelectric Properties of Alanine Doped TGS SingleCrystalline Thick Films under Constant Electric Stress

D.Narayanasamy , P. Kumaresan and P.M.Anbarasan .[13]studied Effect of Dyes on TGS Crystals for IR Detector Applications.

Mariusz Trybus. [14]

studied Measurements of pyroelectric response of TGS single crystals using the compensation method.

Bogusław Fugiel andToshio Kikuta.[15] studied TGS crystal as a maximum temperature thermometer

Tsuneomi Kawasaki et.al. [16] studied Asymmetric autocatalysis triggered by triglycine sulfate with switchable chirality by altering the

direction of the applied electric field.

Experimental

A. Materials

The crystal was synthesized from chemically pure glycine acid and concentrated sulphuric acid in the molar ratio 3: 1 and grown in the ferroelectric phase

C. Preparation of test samples

On account of the high solubility of (TGS) in water, we used the wet thread method in cutting the samples from plane – parallel plates perpendicular to the ferroelectric b-axis. The crystal plates were etched by water on a wet piece of soft cloth stretched on a glass plate until the required dimensions were obtained $(0.9\times0.5\times0.2)\ cm^3$.

Two thin copper wires were attached to the major opposite surfaces of the sample. The two current leads were pressing on the coated surfaces and kept in position by a trace of UHU glue which fixes the wire near its end to the upper side of the crystal. Good electrical contact between the wire and coated surfaces was insured by a minute speck of the conducting

silver paste. In this way, loading or stressing of the crystal is kept at minimum.

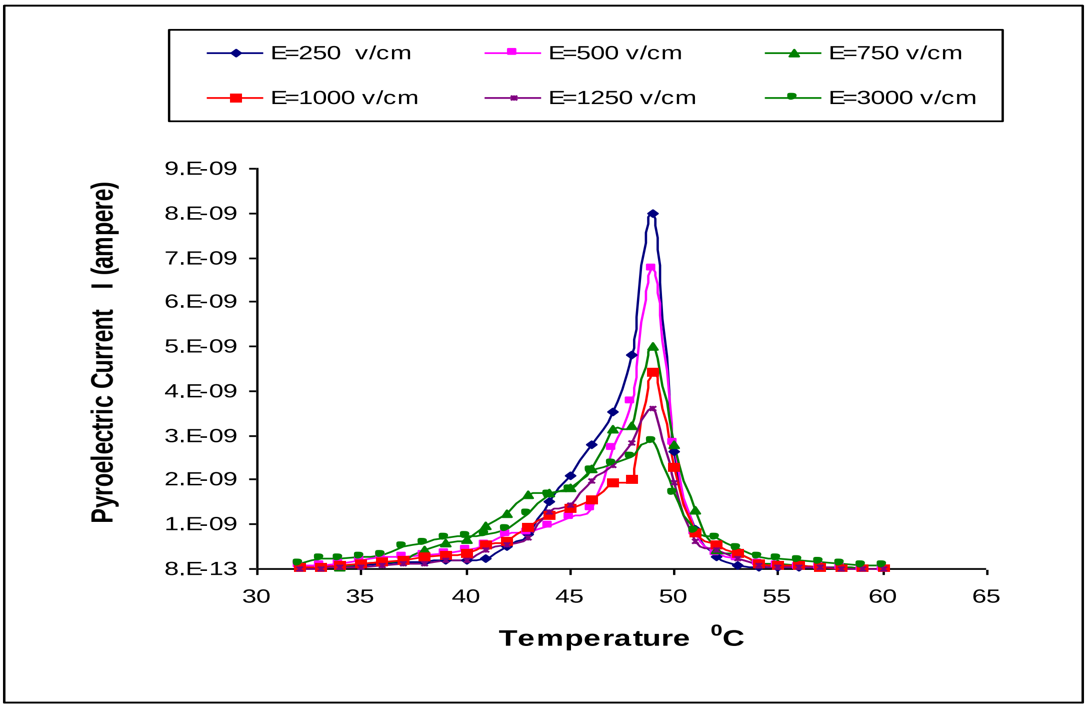
D. Pyroelectric current measurements.

The pyroelectric current measurement in the presence of different

External biasing fields (250, 500, 750, 1000, 1250 and 3000 v/cm).We use the Pico

Figure 1:shows the temperature dependence of pyroelectric current for TGS sample at different external biasing fields.

Figure (1) shows the temperature dependence of the pyroelectric current (I) at different external biasing fields. It is noticed that the peak value of the pyroelectric current decreases with increasing the biasing field.



The table (1) illustrates the maximum pyroelectric current(Imax) at different external biasing fields (E) at transition temperature (T_c =49ºC)

external biasing fields (E v/cm)	pyroelectric current(Imax Amper)
250	$7.99*10^{-9}$
500	$6.73*10^{-9}$
750	$4.99*10^{-9}$
1000	$4.41*10^{-9}$
1250	$3.39*10^{-9}$
3000	$2.87*10^{-9}$

Figure (2) shows the relation between the maximum pyroelectric current and external biasing field at transition temperature. It is found that increasing the biasing field lead to gradual decreasing in peak value of the pyroelectric current from its initial higher value. In fact, the external biasing field assists in establishing the polarized state, whose current is generally lower than that of the unpolarized one [17] .

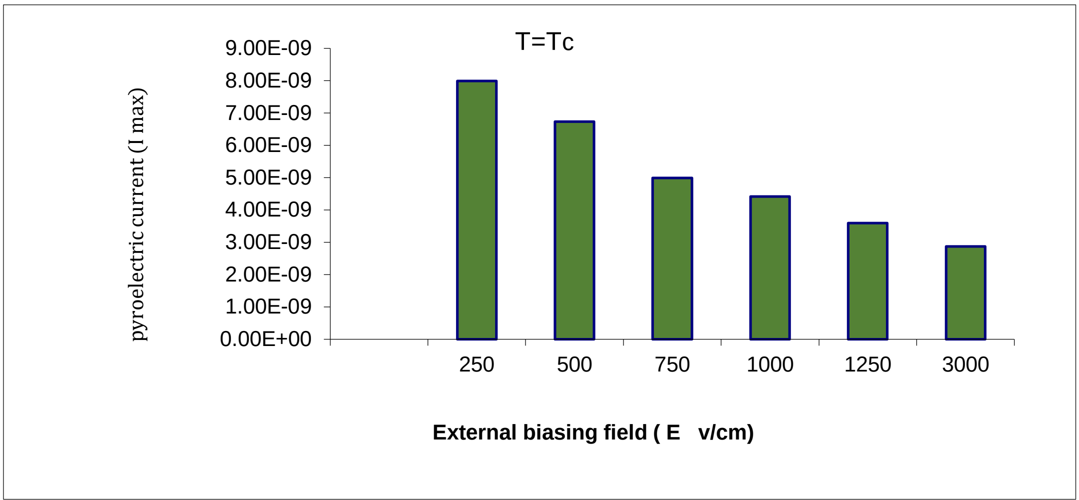


Figure 2:shows the pyroelectric current (Imax) versus external biasing field at transition temperature (TC).

Figures (3,4) shows the pyroelectric current versus external biasing field at temperature below and above transition temperature there are some irregularities in the value of pyroelectric current, This may be associated with residual polarization remaining in clamped domains.

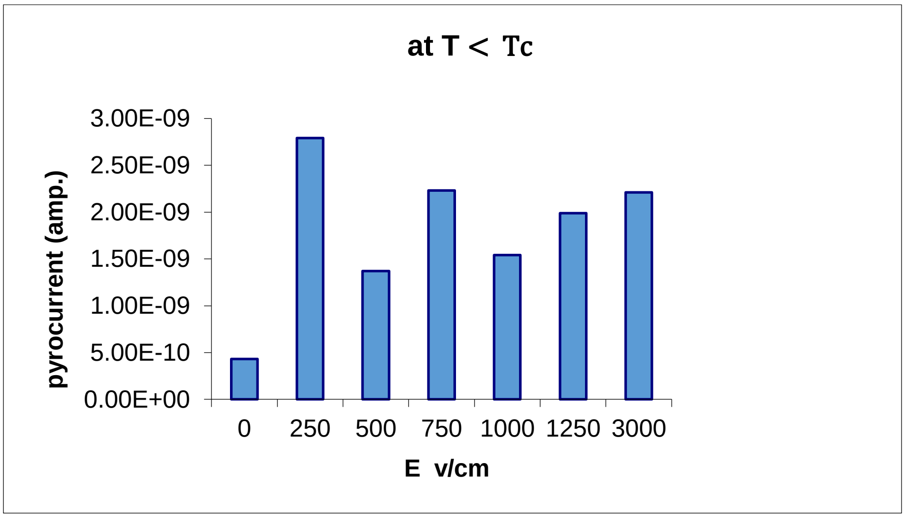


Figure 3:): shows the pyroelectric current versus external biasing field at temperature below transition temperature

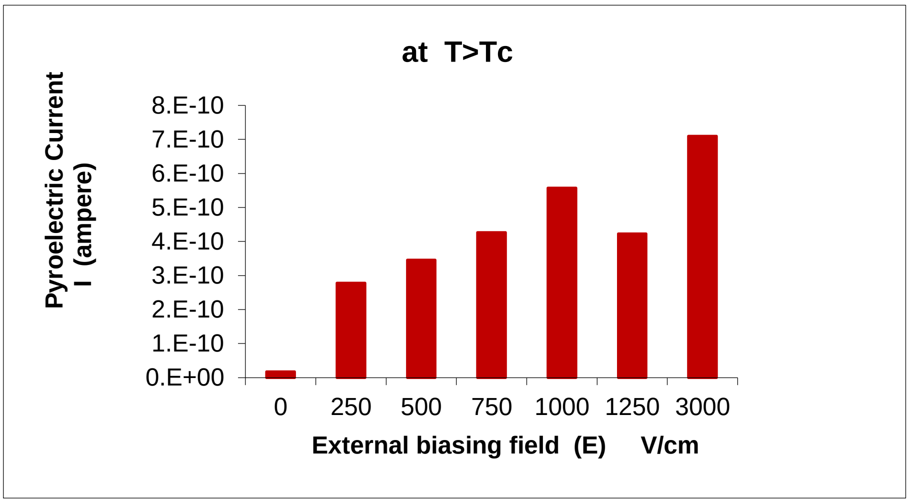


Figure 4:shows the pyroelectric current versus external biasing field at temperature above transition temperature.

Conclusions

The following conclusion may be drawn from the obtained results that The existence of external biasing field during the measurements lead to that decrease the pyroelectric current and that increasing the biasing field lead to gradual decreasing in peak value of the pyroelectric current from its initial higher value.

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