Infrared Physics & Technology 71 (2015) 526–532

Contents lists available at ScienceDirect

Infrared Physics & Technology

journal homepage: www.elsevier.com/locate/infrared

Dynamic response of TGS ferroelectric samples in paraelectric phase

M. Trybus [*,1], B. Woś [1]

Mathematics and Applied Physics Institute, Rzeszow University of Technology, al. Powstańców Warszawy 12, 35-959 Rzeszów, Poland

HIGHLIGHTS

- Dynamic measurements of pyroelectric phenomenon during the phase transition in TGS single crystals were performed.
- We discovered the existence of some amount of order in the paraelectric phase in TGS single crystals
- Discovered phenomenon requires further experimentation and construction of improved models.

ARTICLE INFO

Article history:
Received 26 May 2015
Available online 2 July 2015

Keywords:
Triglycine sulfate
TGS
Domain switching
Pyroelectric
Ferroelectric
IR sensor

ABSTRACT

Triglycine sulfate (TGS) is well known and one of the most extensively studied model ferroelectric materials. Previous experiments proved some kind of order in the paraelectric phase which resulted in an electric response to the fast temperature pulses above the critical temperature T_c. This paper presents the novell method for experiments and studies of the electric properties of TGS, in relation to domain switching under precisely controlled temperature pulses. We designed a new virtual measurement device based on LABVIEW and redesigned the thermostatic sample holder with Peltier cells as heating/cooling elements.

1. Introduction

Triglycine sulfate (TGS) is well known and is one of the most extensively studied model ferroelectric materials [1–4]. The material undergoes second-order phase transition and shows the pyroelectric effect. Our previous experiments proved some kind of order in the paraelectric phase which resulted in an electric response to the fast temperature pulses above the critical temperature T_c [5]. In our present experiments we continue studies of the electric properties of TGS, in relation to domain switching, observing the samples' responses to precisely controlled temperature pulses. The charge released in the processes of domain switching was previously studied under manually controlled temperature growth. The novel method allowed us to conduct numerous experiments on temperature and electric parameters with high repeatability. We designed a new virtual measurement device based on LABVIEW and redesigned the thermostatic sample holder with Peltier cells as heating/cooling elements.

2. Measurement system

We used the sample holder described in our previous paper [6]. To improve the dynamic parameters of heat transport, brass electrodes were thinned and thermal sensors were placed much closer to the surface of the measured sample. A set of electric relays was added to allow easy manipulation of the powering of the Peltier cells (any combination of cooling and heating from both sides of the sample).

The pyroelectric effect was investigated with the use of well-established methods of pyroelectric current measurement [7,8]. Samples were placed in a thermostatic unit and the pyroelectric current of the short-circuited sample was measured under various temperature-growth profiles applied to the samples. We investigated the pyroelectric properties of triglycine sulfate (TGS) using fast temperature pulses in both ferroelectric and paraelectric phases. A schematic view of the measuring system is presented in Fig. 1, and a cross-section of the modified sample holder is shown in Fig. 2.

With the use of this setup, ferroelectric samples can be stimulated by temperature pulses with desired parameters (such as the duration, amplitude, or fill factor of the pulse). We used a pair of micro-Peltier cells for heating or cooling the sample from both sides. High-temperature gradients inside the sample can be

* Corresponding author. Tel.: +48 602454978.
E-mail addresses: m_trybus@prz.edu.pl (M. Trybus), bwos@prz.edu.pl (B. Woś).
[1] Tel.: +48 178651463

http://dx.doi.org/10.1016/j.infrared.2015.06.015
1350-4495/

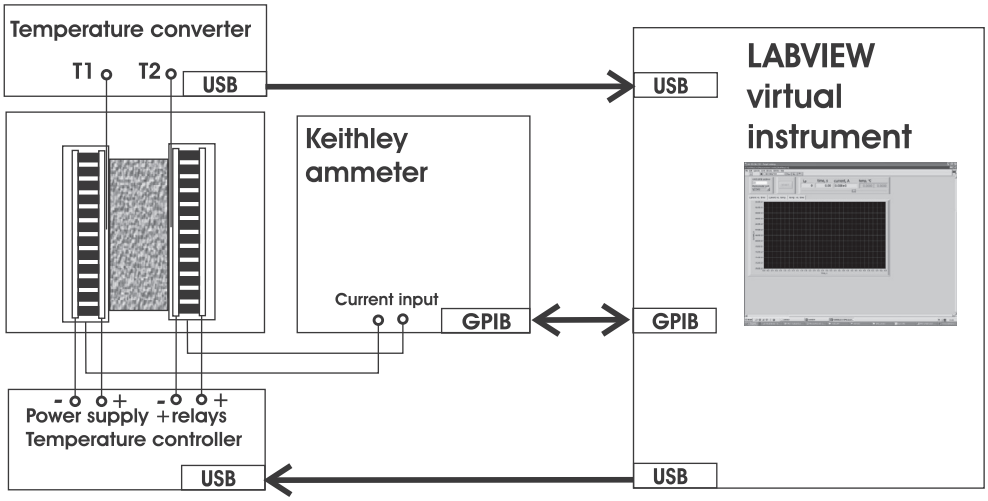

Fig. 1. Schematic view of the measuring system.

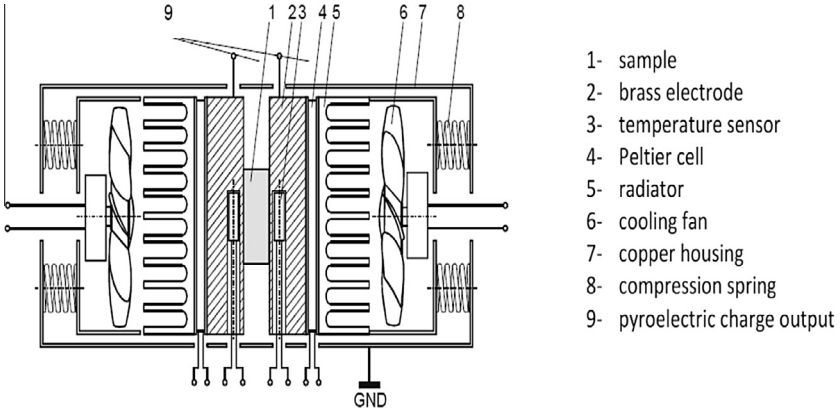

Fig. 2. Cross-section of sample holder with Peltier cells.

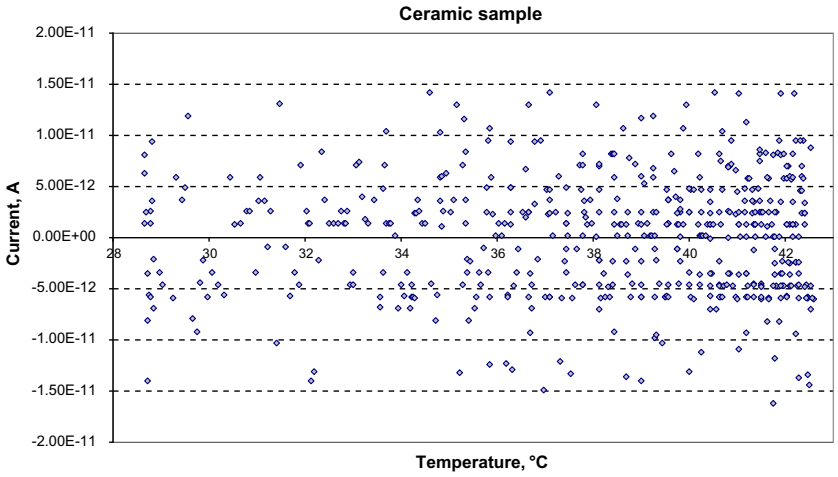

Fig. 3a. Electric response of the ceramic sample to the heat excitation shown in Fig. 3b.

obtained when samples are cooled from one side and heated from the other at the same time. Thanks to the modifications, the time constant of the designed sample holder is smaller than that of the existing one, and temperature waveforms can be programmed with the use of text files of defined structure.

3. Software design and implementation

A new virtual instrument interface was designed in LABVIEW. The interface allows fully automated temperature control as well as the observation of the measurement process. The temperatures