IOP PUBLISHING JOURNAL OF PHYSICS D: APPLIED PHYSICS

J. Phys. D: Appl. Phys. **43** (2010) 225501 (6pp) doi:10.1088/0022-3727/43/22/225501

Electropyroelectric technique for measurement of the thermal effusivity of liquids

R Ivanov[1], E Marin[2,3], I Moreno[1] and C Araujo[1]

[1] Facultad de Física, Universidad Autónoma de Zacatecas, Calz. Solidaridad Esquina Paseo de la Bufa s/n, C. P. 98060, Zacatecas, Zac., México

[2] Centro de Investigación en Ciencia Aplicada y Tecnología Avanzada, Instituto Politécnico Nacional, Legaría 694, Colonia Irrigación, C. P. 11500, México D. F., México

E-mail: emarin63@yahoo.es and emarinm@ipn.mx

Received 11 February 2010, in final form 28 April 2010
Published 18 May 2010
Online at stacks.iop.org/JPhysD/43/225501

Abstract

The photopyroelectric method has been recognized as a reliable and useful tool for the measurement of the thermal properties of condensed matter samples. Usually the photothermal signal is generated using intensity modulated light beams, whose amplitudes are difficult to maintain stable. In this paper we describe a variant of this technique that uses amplitude modulated electrical current as excitation source, via Joule heating of the metal contact on one side of the pyroelectric sensor. The possibilities of this method, called by us the electropyroelectric technique, for thermal effusivity measurements of liquid samples are shown using test samples of distilled water, ethanol and glycerine. The results obtained for this parameter agree well with the values reported in the literature . Our measurement uncertainties are about 3%, a fact that opens several possible applications.

1. Introduction

Among the photothermal (PT) techniques [1] the photopyroelectric (PPE) method [2] has been recognized as a reliable tool for the measurement of the thermal properties of condensed matter samples. The two most widely used experimental variants are the direct or back (d-PPE) [3] and the inverse or front (i-PPE) [4] detection configurations for thermal diffusivity, α, and thermal effusivity, e, determination, respectively. In the former variant the sample is directly illuminated by an intensity modulated laser beam and the signal is measured with a pyroelectric (PE) sensor at the opposite side, whereas in the inverse method the modulated light beam impinges on the PE surface. Part of the absorbed light energy is transformed into heat that propagates through the sample and the PE sensor inducing periodical temperature oscillations that are often called thermal waves. Due to the good thermal contact with the sensor that can be achieved for liquid samples one of the most established fields of application concerns the thermal characterization of this kind of materials.

[3] Author to whom any correspondence should be addressed.

The use of a light beam as energy source, which is common to both measurement configurations, has some disadvantages: among them, the stabilization of the laser beam modulated intensity is difficult to achieve due to the influence of several parameters such as temperature fluctuations and vibrations. On the other hand, the light intensity reaching the measurement cell can fluctuate due to the presence of dust in the ambient air, moisture and contamination in the optical parts of the experimental systems. Moreover, in the direct configuration the PPE signal is strongly influenced by the sample's optical properties, which are sometimes not well known, and in both configurations it sometimes becomes necessary to use a thin layer of black paint to increase optical absorption of the PE surface, whose influence is often neglected or misinterpreted.

For these reasons, in this paper we propose, instead of the modulated laser beam, the use of an amplitude modulated electrical current as excitation source of thermal waves via Joule heating of the metal contact on one side of the PE sensor. To the best of our knowledge the only previous attempt to use electrical heating to generate the PE signal was made by Shen *et al* [5], who used a thin film resistive metallic strip as the source of thermal waves by means of its periodical

