IOP PUBLISHING JOURNAL OF PHYSICS D: APPLIED PHYSICS

J. Phys. D: Appl. Phys. **42** (2009) 125504 (8pp) doi:10.1088/0022-3727/42/12/125504

Differential sensor in front photopyroelectric technique: II. Experimental

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Received 28 March 2009, in final form 7 May 2009
Published 5 June 2009
Online at stacks.iop.org/JPhysD/42/125504

Abstract
We describe the differential cell design and the experimental (optical and electronic) setup for the differential front photopyroelectric technique, whose theory has been developed in the first part of this paper (Ivanov *et al* 2008 *J. Phys. D: Appl. Phys.* **41** 085106). We will show first how the direct (non-differential) front photopyroelectric theory described in our previous paper reproduces well the experimental results. The usefulness of the differential technique is demonstrated by means of experimental measurements of the thermal effusivity in binary ethanol–water and glycerol–water mixtures, based on a theoretical methodology that simplifies the measurement procedure and diminishes the experimental uncertainty.

1. Introduction

Among the photothermal (PT) techniques [1] the photopyroelectric (PPE) method [2] has been recognized as a reliable and useful tool to obtain thermal parameters of condensed matter, including liquid samples. The experimental PPE setups more frequently used are the back [3] and front [4] detection configurations. In the former setup the modulated excitation light impinges onto the surface of an optically opaque sample and the generated temperature oscillations are detected with a pyroelectric (PE) sensor attached at its rear side. The sample's thermal diffusivity, α, can be obtained from both the amplitude and the phase of the measured signal in a straightforward manner. In the front configuration the light beam is focused onto an opaque PE sensor whose opposite side has a good thermal contact with the sample. Due to the almost perfect thermal contact that can be achieved when liquid samples are analysed, it has been widely used in the last few years for thermal characterization of liquids. The front PE signal amplitude depends mainly on the sample's thermal effusivity, ε, a parameter that can be determined in a direct way [5] or using normalization procedures that involve a reference sample of known thermal properties [6]. Due to the fact that direct configuration experiments do not have the required resolution and accuracy to detect small changes in thermal effusivity, differential variants have been proposed. In a previous paper in this journal [7] the theory of the so-called differential front photopyroelectric technique (D-FPPE) has been developed, a method where the sample and reference signals are subtracted directly at the output of two PE sensors connected in parallel in order to assess minor variations in this thermal parameter. In this paper we describe the experimental details inherent to the proposed technique as well as the results of both direct and differential measurements performed in test samples consisting of binary mixtures of ethanol and glycerol with water. The good agreement between our results for the maximum

