Ferroelectrics, 1991, Vol. 118, pp. 435–450
Reprints available directly from the publisher
Photocopying permitted by license only

MEASUREMENT OF THE THERMAL DIFFUSIVITY OF THIN FILMS WITH BOLOMETERS AND WITH PYROELECTRIC TEMPERATURE SENSORS

B. PLOSS and S. BAUER
Institut für angewandte Physik der Universität Karlsruhe, Kaiserstr. 12, 7500 Karlsruhe, Germany

and

C. BON
Université Joseph Fourier, Grenoble, France

(Received April 18, 1990; in final form August 5, 1990)

Several methods for the measurement of the thermal diffusivity of thin films are developed. Common to all methods is the generation of a thermal wave via the absorption of intensity-modulated light on one surface of the film; resistive thin film bolometers and pyroelectric sensors are used for the temperature recording. For free-bearing films the thermal diffusivity is determined from front and rear side temperature spectra as a function of the modulation frequency, measured with resistive bolometers. If a pyroelectric material is mounted on a heat sink, the thermal diffusivity is obtained from the spectrum of the pyroelectric current. For very thin films pyroelectric substrates are recommended as temperature sensors. A novel method is also proposed, in which the thermal diffusivity is obtained without the influence of any other material properties and any sensor characteristics. Experimental results are presented with a 25 μm thick PVDF film and with a 1.25 μm thick Polyglutamate Langmuir-Blodgett film on a 9 μm thick PVDF substrate. The thermal diffusivity for the PVDF films is $D = 6.2 \times 10^{-8}$ m²/s and for the Polyglutamate Langmuir-Blodgett film $D = 5.5 \times 10^{-8}$ m²/s at room temperature. The techniques are theoretically discussed and various methods for the analysis of measured data are introduced.

1. INTRODUCTION

The growing interest in thin films in recent years has stimulated work to develop methods for the measurement of the specific heat, the thermal conductivity and the thermal diffusivity of thin films. As an example, a knowledge of the thermal diffusivity of pyroelectric materials is essential for the characterization of linear and two-dimensional infrared sensor arrays.[1,2] In these measurements the thermal excitation is performed using light pulses or intensity-modulated light and the resulting thermal response measured by a variety of methods. Some promising methods for the measurement of the time development of the sample temperatures include thin evaporated resistive bolometers[3,4] and pyroelectric detectors.[5–10] For the extraction of the thermal diffusivity, in the latter method the time development of the temperature rise on the rear side of the film after the absorption of a short light pulse is analysed. The data analysis with pyroelectric substrates as thermal detectors is complicated because the thermal properties of the sample and the substrate are involved.[5,7,10]

The intention of this paper is to consider arrangements, for which the thermal