Design and Properties of a Microcalorimeter

Siegfried Bauer and Bernd Ploss

Institut für angewandte Physik, Karlsruhe, Germany

ABSTRACT

A pyroelectric microcalorimeter is introduced for the measurement of the specific heat of films. The pyroelectric calorimeter consists of a pyroelectric sensor with the sample directly deposited onto one of the electrodes of the sensor. The arrangement is heated by the absorption of intensity-modulated radiation at the other electrode of the pyroelectric sensor. In the case of a homogeneously poled pyroelectric sensor, the quotient of the pyroelectric current, obtained at modulation frequencies ω below and above $\omega = 2D/d^2$, with D the thermal diffusivity and d the thickness of the pyroelectric sensor material, directly yields the quotient of the heat capacity of the pyroelectric material and the sample. Experimental results are shown with a 30 μm thick $LiTaO_3$ crystal, 25 and 9 μm thick PVDF films as sensor materials and with 25 μm thick Ag foils and with 0.25 to 1.25 μm thick polyglutamate Langmuir-Blodgett films. The measurements showed that with the pyroelectric microcalorimeter it is possible, to measure the specific heat of film samples with a thickness in the submicron range and with a sample mass of several μg.

1. INTRODUCTION

PYROELECTRIC materials, especially the pyroelectric polymer polyvinylidenefluoride (PVDF) and the copolymers of vinylidenefluoride (VDF) with trifluoroethylene (TrFE) are very interesting for a variety of applications. The most important include piezoelectric and pyroelectric devices as IR sensors [1], especially hybrid sensor arrays on silicon [2,3]. Pyroelectric sensors can be used not only as detectors for radiation but also as measurement devices for the thermal properties of other materials. Pyroelectric sensors have been used for the measurement of the thermal diffusivity of various materials [4–7].

In this paper a pyroelectric microcalorimeter is presented and discussed, which allows specific heat measurements of films in the submicron thickness region and with a minimal sample mass of ~ 3 μg.

2. PRINCIPLE OF OPERATION

IN this Section the operation principle of the pyroelectric calorimeter is presented, a more formal consideration follows in Section 3.

The pyroelectric microcalorimeter is a two-layer system of a pyroelectric material and of a second material, which is under investigation, or which serves as a reference material, if the heat capacity of the pyroelectric material itself shall be measured. Metal contacts are deposited on the pyroelectric layer. The calorimeter is heated by the absorption of light within the opaque front electrode. The

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