PYROELECTRIC EFFECTS IN PVDF AND P(VDF-TrFE)

Rudolf EMMERICH, Siegfried BAUER and Bernd PLOSS
Institut für angewandte Physik der Universität (TH) Karlsruhe
Kaiserstr. 12, 7500 Karlsruhe, Germany

ABSTRACT

The pyroelectric effect of PVDF and of the 50/50 P(VDF-TrFE) copolymers has been investigated. A new experimental method is described which enables the simultaneous measurement of the static and dynamic pyroelectric coefficient on the same sample within one single temperature scan. Static measurements with partially clamped samples showed a significant piezoelectric contribution to the pyroelectric coefficient.

1. INTRODUCTION

Pyroelectric materials, especially the pyroelectric polymer PVDF and the copolymers of VDF with TrFE are very interesting for applications in integrated ir-sensors on silicon [1,2]. For these applications a detailed knowledge of the pyroelectric properties of the polymers is necessary.

It had been observed, that the pyroelectric current is strongly depending on the measurement conditions. If the pyroelectric current is measured with the usual standard method by a constant heating rate [3], other pyroelectric coefficients are gained than with the modulated technique introduced by Chynoweth and Glass [4,5]. Furthermore, due to piezoelectric contributions, the pyroelectric coefficient is influenced by a mechanical clamping of the sample [6].

The aim of the present work is a study of the pyroelectric properties of PVDF and of the 50/50 P(VDF-TrFE) copolymer under various conditions. For this purpose a new experimental technique is developed, which enables the simultaneous measurement of the static and dynamic pyroelectric coefficient, as well as the difference of the pyroelectric coefficients between clamped and unclamped samples.

2. EXPERIMENTAL ARRANGEMENT

The sample consists of the pyroelectric film, covered by two metal electrodes. One of the metal electrodes is used as a resisitive bolometer for the measurement of the surface temperature of the sample. For dynamic measurements the sample is heated by the absorption of intensity modulated light. The sample is placed in a cryostat which allows a temperature scan between 100K and 400K with a heating rate of 0.05K/min. The static and the dynamic pyroelectric current is measured and simultanously the static and dynamic temperature of the sample is determined with the bolometer. Fig. 1 shows schematically the experimental arrangement, which is an extension of that described by Bauer and Ploss [7], and which will be presented in detail elsewhere [8].

3. EXPERIMENTAL RESULTS

To be sure, that the samples show a nearly uniform distribution of the polarization LIMM experiments [9] are performed. The experimental procedure is reported in detail elsewhere [10]. Fig. 2 shows the pyroelectric current spectra for the PVDF sample together with a fit, which assumes a small depolarized layer of $0.5\mu m$ thickness at both sample surfaces. Fig. 3a shows the pyroelectric current spectra for the 50/50 copolymer together with a fit. The depolarized layer at the heated surface is $0.5\mu m$ and $2\mu m$ at the other surface. Fig. 3b shows the pyroelectric current spectra for the same sample, with the heating performed at the other surface. Again, the fit with the same depolarization layers is in good agreement with the measurements.

Fig. 4 shows the measurement of the static pyroelectric coefficient for a unclamped and for a partially clamped PVDF sample. The pyroelectric coefficient in the clamped sample is