Determination of polarisation profiles in P(VDF-TrFE) films with LIMM and LITP

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Abstract

Vinylidenefluoride-trifluorethylene copolymer films were polarized under different conditions and then investigated with the laser intensity modulation method (LIMM) and the laser induced thermal pulse technique. (LITP). For thick films with thick electrodes the results derived from LIMM and LITP experiments are identical. For thin films experimental and methodical constraints influence the applicability and resolution achieved with LITP.

1. Introduction

Thermal methods are useful for the investigation of the polarization profiles in pyroelectric materials. The sample under investigation is heated on one surface by the absorption of laser light. The incident radiation intensity is varied with time and the pyroelectric current is recorded. The laser intensity modulation method (LIMM) [1] uses sinusoidally modulated light, the laser induced thermal pulse technique (LITP) [2, 3] a short laser pulse. The thermal excitation generates a thermal wave which penetrates into the sample. For LIMM the penetration depth varies with the modulation frequency, while for LITP it is a function of time. From a fundamental point of view both techniques are equivalent as the input-output relation of a linear system can be either determined from the response to a sinusoidal input as a function of frequency or from the response to a short input pulse as a function of time. We report on investigations of thick and thin films of polyvinylidenefluoride-trifluoroethylene (PVDF-TrFE) with both methods.

2. Experimental

Thick films (≈ 0.8 mm) and thin films ($\approx 25\ \mu$m) of PVDF-TrFE in the composition 75/25 mol% were prepared for investigations with LIMM and LITP. Thin layers of silver paint ($5 \ldots 10\mu$m thickness) were deposited on the two surfaces of the thick samples to serve as electrodes and also as absorbing layer for the laser radiation. Three thick films (samples A, B, C) were polarized under different conditions. Sample A was poled under 16 kV for 2 hours at 115 °C , sample B under 22 kV at 110 °C . Sample C was poled under 18 kV for 2 hours at 90 °C and then reversely poled under 20.5 kV for 3 hours at 110 kV. On the two surfaces of the thin film (sample D) 100 nm thick gold electrodes were evaporated. The thin film was polarized at room temperature by the application of a half cycle of a sinusoidal voltage with an amplitude of 2.9 kV and a duration of 50 s.

In the LIMM experiments the output power of a laser diode with the wavelength 750 nm was modulated sinusoidally with an amplitude of 10 mW. The laser light was directed to one electrode of the sample. Pyroelectric current spectra were measured with a fast current-to-voltage converter (risetime 10^{-7}s) and a Lock-In amplifier as a function of modulation frequency. The frequency range was 0.1 Hz to 10 kHz for the thick samples and 1 Hz to 100 kHz for the thin sample. Ten data points were measured per frequency decade. With an integration time of 30 s, the total time required for the recording of a pyroelectric spectrum was about half an hour. The response

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