

# In-plane homogeneity of polarization in thin VDF-TrFE copolymer films

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## I. INTRODUCTION

Annealing of thin copolymer films of vinylidene fluoride (VDF) and trifluoroethylene (TrFE) causes a strong increase in grain size as well as in crystallinity [1]. It is known from AFM topographic images that flat-on lamella with diameters of up to 100  $\mu\text{m}$  grow when thin films are annealed at temperatures around 140  $^{\circ}\text{C}$  for several hours. To examine the orientation and the polarization state of the lamella, two dimensional images of the pyroelectric activity have been recorded.

## II. EXPERIMENTAL

VDF/TrFE copolymer with composition 75/25 mol% was dissolved in diethyl carbonate (2 %), filtered, and spin coated onto an aluminum coated glass substrate. The film with thickness of about 70 nm was melt-crystallized at 140  $^{\circ}\text{C}$  for five hours. The film was corona poled for 10 s by applying a voltage of -5 kV to a needle placed 5mm above the sample surface. After poling an aluminum electrode was evaporated on the top surface of the film.

A two dimensional image of the pyroelectric activity of the film has been recorded with a laser-scanning microscope [2]. The beam of a laser diode with wavelength 830 nm was focused onto a spot on the top electrode. The laser intensity was modulated with a frequency of 100 kHz and the resulting pyroelectric current measured with a lock-in amplifier. The heated area on the film has a diameter of about 2  $\mu\text{m}$  as determined by the size of the laser spot and the diffusion length of the generated thermal wave. The surface of the sample was scanned line by line with the laser spot, and the pyroelectric current was recorded producing 2D images of the polarization.

## III. RESULTS AND DISCUSSION

Fig. 1 shows the pyroelectric image of a VDF/TrFE copolymer thin film. The pyroelectric activity is indicated by the brightness. Various characteristic structures can be identified. Dark spots with diameters of 50  $\mu\text{m}$  to 150  $\mu\text{m}$  indicate flat-on lamella with very low pyroelectric activity, i.e., with polarization oriented preferentially in parallel to the

substrate. Some thin needle-shaped lamella with typical length 100  $\mu\text{m}$  and width below 5  $\mu\text{m}$  are seen which appear to have grown out from the centers of the dark spots. These needle-shaped structures can be identified either as edge-on lamella with molecular chains in parallel to the substrate showing large pyroelectric activity (marked by letter "e") or as flat-on lamella showing only little pyroelectric activity ("f").

## REFERENCES

- [1] T. Furukawa, T. Nakajima, Y. Takahashi, "Factors Governing Ferroelectric Switching Characteristics of Thin FDF/TrFE Copolymer Films", *IEEE Trans. Dielect. Electr. Insul.*, vol. 13, pp.1120-1131, 2006.
- [2] B. Ploss and C. Albrecht, "Anisotropic thermal diffusivity of thin polymer films: Determination with a laser scanning microscope", *Ferroelectrics*, vol. 165, pp. 171-185, 1995.

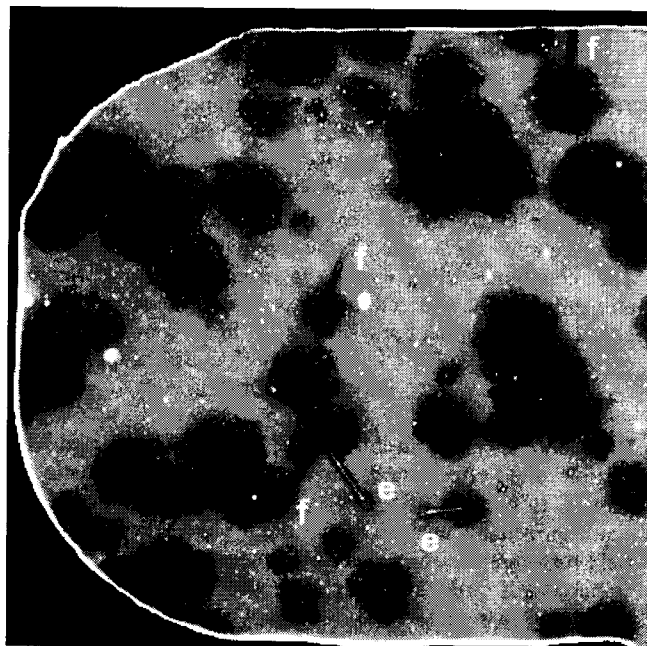


Fig. 1. Pyroelectric image of a VDF/TrFE copolymer thin film (size 1 mm x 1 mm). Dark colour indicates low and white colour high pyroelectric activity.