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Photo-stimulated discharge current and charge distribution measurements on biaxially oriented polypropylene thin films

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Introduction

The development of the market of polymer film capacitors (mainly bi-oriented polypropylene-BOPP) is led by many applications in different fields such as electronics, energy storage or electrical vehicle. The study of generation, transport and trapping of charges in relatively thin dielectrics is of specific interest here. Volume trapping is a weakness that introduces a local intensification of the local electric field. On the other hand, the experimental methods to study dielectric phenomena as charge trapping are not numerous. One expects notably methods giving access to the distribution of trap energy levels. Photo-stimulated discharge method (PSD) is among the most used. It consists in measuring the discharge current under light irradiation, making it possible to obtain spectra with wavelengths in the UV-visible range, giving theoretically access to the energy depth of occupied traps [1]. Our objective is to analyse the PSD spectra on BOPP films, for the first time in conjunction with the density and position of the charges in the material. The later is achieved by Light Intensity Modulation Method (LIMM), suited for films of a few μm thickness.

Results and Discussion

The experimental work was realized with the following procedure: The $18\mu\text{m}$ thick BOPP films were provided with segmented electrodes [1]. After applying a voltage of 1 kV for 30 min, a first measurement of the charge distribution is realized by LIMM. Then, the PSD spectrum is recorded while scanning the light from low (590 nm) to high energy (200 nm) at a scanning rate of 24 nm/min. Finally, a second LIMM measurement is achieved. This protocol is repeated for voltages of 2kV and 3kV.

The PSD spectra shown in Fig. 1, present two current peaks, located at approximately 400 nm and 220 nm. The PSD intensity increases with the voltage applied during the polarization step; the intensity of the peak located at 220 nm rises when compared to the peak at 400 nm. One notices that the intensity is very weak for 1 kV polarization; it increases substantially for 2 and 3 kV, revealing that the threshold for massive charge injection has been reached. Figs. 2a)-b) show the LIMM current and the space charge distribution recorded after polarization under 3 kV. We note the presence of charges trapped in the sample.

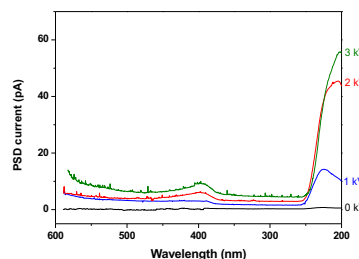


Figure 1: PSD spectra of $18\mu\text{m}$ -thick BOPP recorded after LIMM measurements with polarization voltage of 1 kV, 2 kV and 3 kV.

The LIMM results obtained after the PSD measurement (see Fig. 2c)-d) reveal that charges have been partially released from the sample due to optical detrapping, particularly near the surface.

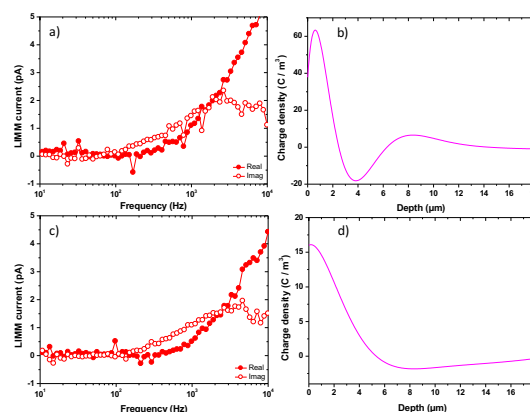


Figure 2: Real and imaginary part of LIMM current: a) after 3kV, c) after PSD. Space charge profiles: b) after 3kV, d) after PSD.

Conclusions

This paper presents a coupling between the PSD measurements with LIMM measurements in BOPP films. The methods will be used to probe the actual changes in charge distribution induced by the optical detrapping in order to better understand the related processes and to propose a quantitative analysis of charge trapping phenomena.

References

- [1] L. Boudou, F. Zheng and G. Teyssedre "Photo-stimulated discharge current measurements on biaxially oriented polypropylene thin films (BOPP)", Proc. 12th ICPADM Conference, pp. 722-725, 2018.

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