Photo-stimulated Discharge Current Measurements on Biaxially Oriented Polypropylene Thin Films (BOPP)

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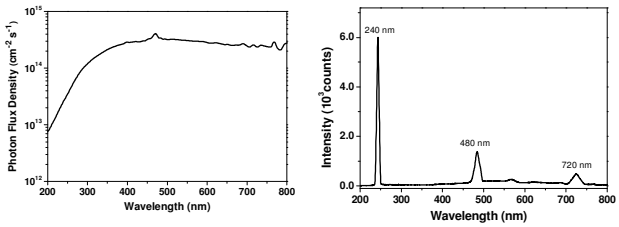
Abstract

The PSD method, consisting in recording a discharge current while scanning with light excitation, is a tool to estimate in principle charge trap energy levels in transparent or semi-transparent materials. A test bench is described, including irradiation source characterization, electrode structure and experimental protocol. PSD measurements performed on 18 µm thick biaxially oriented polypropylene films used in capacitors are presented. The PSD spectrum shows two peaks located at 400 nm and 240 nm scanning light wavelength. The effect of the electrode structure (fingered vs. continuous electrodes) and the effect of applied field intensity are investigated.

Methodology

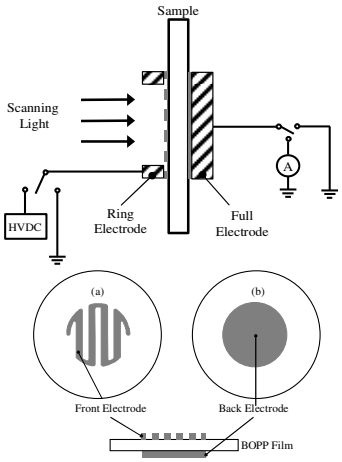
Illuminating light characteristic



	Fundamental	Harmonic n=2	Harmonic n=3
Peak w.l. (nm)	240	480	720
Imax (counts)	6638	2001	1112
FWHM (nm)*	7	14	21

+ 150W Xe arc lamp
+ Monochromator with a 300nm-blaze grating (1200g/mm)
+ Input and output slits (2 mm)
+ Measurements in ambient air and at room temperature

PSD apparatus

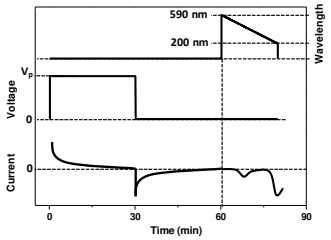


+ Fingered electrode allows to increase the current intensity without loss of wavelength resolution [2]

Sample

- 18 µm-BOPP provided by Kopafilm, Germany
- Rough surfaces

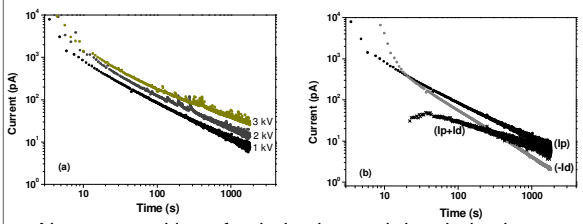
Experimental protocol



+ Pre-Polarization at constant voltage (1 kV, 2 kV or 3 kV), for 30 min
+ Scanning from low energy (590 nm) to high energy (200 nm) with a scanning rate of 24 nm/min.

Results and discussion

Polarization and depolarization current



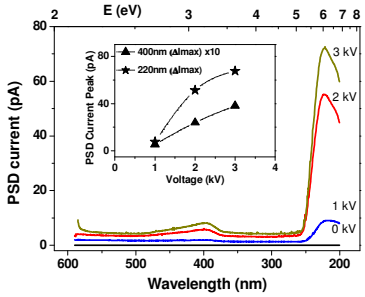
+ No superposition of polarization and depolarization current ⇒ Contribution from dipolar mechanisms is negligible

+ Threshold field for nonlinear behavior at about 40 kV/mm [1] ⇒ For 50<E<150 kV/mm, charge injection and trapping are the main mechanisms at play

+ Fingered electrode : electric field is enhanced locally due to edge effects, and charge injection and trapping at these "hot points" can be increased [2].

PSD spectra

+ Flat blank PSD spectrum
+ Well defined spectra for 110 and 165 kV/mm
+ Two asymmetric current peaks located at 400 nm (broad) and 220 nm (narrow)
+ ΔImax does not increase linearly with the applied voltage



- ➢ **220 nm-peak** is located in a wavelength range wealthy in optical signature when considering the UV-absorption spectrum of BOPP [3]
- ➢ **400 nm-peak** does not correspond to known absorption band in polyolefins

  It can correspond to : - some additives that could efficiently trap charges
  - localized states formed under the effect of space charge.

+ Possibility of photo-generation of electrons from the illuminated electrode…

Conclusion

+ Blank PSD being flat, the PSD current recorded is most probably linked to charge detrapping phenomena.
+ PSD spectrum of 18 µm thick BOPP film shows two peaks located at 400 nm and 240 nm
+ Interpretation of the peak wavelength positions is not trivial and further work is needed

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References:

[1] H. Li et al, "*Electrical conduction of metallized BOPP films based on revised Poole-Frenkel effect*", J. Electrostatics, vol. 71, p.958, 2013.

[2] P. Ma et al, "*Analysis and interpretation of photo-stimulated discharge spectrum for polypropylene films under different electric and geometrical conditions*", *J. Electrostatics*, vol. 84, p.128, 2016.

[3] B. Qiao et al, "*Field- and electron beam- induced luminescence phenomena in polypropylene thin films*", Proc. ICPADM, Sydney, p. 196, 2015.

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