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Imprint enhanced polypropylene

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I. INTRODUCTION

Polypropylene is used as a model system for investigating the discharge mechanisms in polymer electret materials. The goal is to get an understanding of how to enhance the temperature and humidity stability for polypropylene and to be able to transfer this knowledge to other electret polymers. Polypropylene is chosen as a model system due to the limited charge lifetime compared to other much more stable electrets. This makes it possible to see improvements in the performance of polypropylene much faster than other more stable electret polymers.

II. SAMPLE PREPARATION AND MEASUREMENTS

All samples consist of a support structure and a spin coated layer of polypropylene, with an M_w of 250,000 g/mol and a M_n on 67,000 g/mol.

The support structures consist of a single side polished 4” highly doped silicon wafer with 20 nm/100 nm Ti/Au on the back side and 100 nm Ti of the front side. This is done to ensure good electrical conductivity throughout the support structure and to ensure polypropylene adherence to the front side. The silicon wafer has been chosen due to its flatness.

The polypropylene is spin coated on to the support structure, from a 10 wt.% polypropylene/cyclohexane solution. The spin coating is performed in two step both at 500 rpm, to reach a final thickness of around 30-40 µm.

Even though a spin coating technique is used to apply the polypropylene to the surface of the samples, the polypropylene is not as flat as expected. The samples are therefore flattened in a press at 180 °C. Some of the samples are later on imprinted with a custom made stamp at 120 °C. The cooling after flattering and imprint is done rapidly by placing the samples on an aluminium block at ambient conditions, unless otherwise stated.

The two stamps used in this abstract both consist of different areas with periodic structures of squares, circles and diamonds. The side lengths and diameter for the elements in the periodic structures are 1.5 µm and 21 µm respectively for the two stamps.

All samples are negative corona charged to approximately -500 V, and are left for minimum 12 hr. to settle. After this period the experiments start.

The objective of the experiments is to investigate the stability with respect to the temperature and humidity of imprinted vs. non-imprinted surfaces. The potential of the samples are measured five times over a period of 24 hr. In between the measurements the samples are placed in an oven at 90 °C or a climate chamber at 50 °C and 90 %RH, depending on the specific experiment.

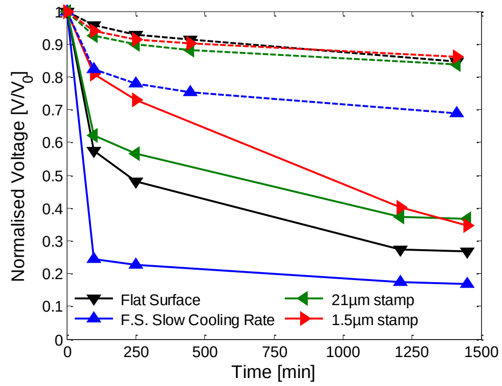

Fig. 1: The normalised average voltage decay, for polypropylene samples with and without surface imprint, at 50 °C and 90 %RH (solid lines) and at 90 °C and <2 %RH (dash lines) over a period of 24 hr.

III. RESULTS AND DISCUSSION

The values plotted in fig. 1 are average values from different samples of the same type, and different location on each sample. Some of the samples have been slowly cooled down from 180 °C before charging.

The dashed lines in fig. 1 show the normalised voltage decays for the samples that have been in an oven. It is seen that there is a pronounced stability difference between the samples that has been cooled rapidly and slowly, respectively. No difference in temperature stability is seen between the imprinted surfaces and the non-imprinted surfaces.

The solid lines in fig. 1 show the normalised voltage decays for the samples that have been in a climate chamber. It is seen that after 1450 min. the slowly cooled samples only have about 17% left of its initial voltage, while the non-imprinted samples have about 27% left, the samples with imprinted however, have about 36% of its initial voltage left. No pronounced difference is seen between the two different samples made with different stamps.

Using polypropylene as a model system is looking promising. The decay in the potential is happening relatively fast, making it possible to see any enhancement, as a result of mechanical manipulation one might introduce to the material, in a reasonable amount of time. The data in fig. 1 indicate that it is possible that an imprinted surface is more stable in high humidity than and non-imprinted surface, and that the cooling rate under the sample preparation is an important factor.

Future plans are to further investigate what the cooling rate and imprinted surface does to enhance both the humidity and temperature stability. The plan later on is also to introduce particles in the polypropylene model system. The goal is also to make a model that can explain the discharge mechanism for surface and bulk charges.