Electrical conduction in fluorocarbon thin films

A.Sylvestre and P.Gonon
Laboratory for Electrostatics and Dielectric Materials (LEMD –CNRS)
25 Avenue des Martyrs, BP166, 38042 Grenoble Cedex 9, France
sylva@grenoble.cnrs.fr – gonon@grenoble.cnrs.fr

Recently, there was a renewed interest in fluorocarbon thin films for electronic applications. Schwödiauer [1] studied these films for electret applications, Seyrat (Philips) investigated fluorocarbon thin films for electrowetting devices [2], Hung (Eastman Kodak) used these films for organic light emitting diodes [3], and Theil (Hewlett-Packard) studied these films for microelectronic interconnects [4], etc. Most of past works on fluorocarbon films were focused on physico-chemical properties and their relation to deposition conditions.
In a previous work [5], we have investigated the dielectric properties (dielectric constant and loss factor) for these materials as a function of frequency (10^{-1} – 10^{6} Hz) and temperature (25°C – 100°C). An optical dielectric constant of 1.8 was obtained. The dielectric constant rises to around 2.3 at rf frequencies. We identified at least two different relaxations mechanisms (β and γ relaxations) responsible for the dielectric constant and loss factor fluctuations.

In this new study, we interest in the electrical conduction mechanisms involved in these materials. To realize the measurements, we use a surface potential decay (SPD) method. The SPD principle is described in figure 1. Samples are placed under a metal needle. The output of a negative dc high-voltage supply is connected to the needle that induces a corona discharge in air. In this point-to-surface configuration, discharges take place between the tip and the insulator. Negative ions are created and deposited on the surface of samples.
A grounded metallic grid is inserted between the tip and the sample surface to produce a uniform distribution of ions on the surface. In our experiment the corona discharge has a short duration (1 second) so the samples are not physically degraded. The value of the surface charge can be adjusted by adjusting the needle voltage. The sample-needle distance is 3 mm.
Once the sample has been charged, it is transferred under a non-contacting probe (Monroe type). The measuring probe is set to the potential of the charged surface according to the vibrating capacitance principle. This probe is connected to an electrostatic voltmeter, which measures the surface potential in the ± 100V range. The maximal temperature usable with this probe is 100°C. Measurements were, also, performed for negative temperature (up to –80°C).
The sample placed on a turntable is initially positioned under the corona needle, and then rotated to under the measurement probe. The first surface potential measurement "V_0" is recorded 3 seconds after the corona discharge.
The measurements were carried out, *in situ*, in a commercial climatic chamber (relative humidity in the range 10-95% for temperature range 10-90°C). All operations are computer-controlled.
The time dependence of the surface potential decay and the treatment signal of this time dependence give us information on the conduction mechanisms.
Results obtained have shown a strong dependence of these 2 parameters (temperature and relative humidity) after corona discharges. Different conduction mechanism have been identified. A correlation between the conduction mechanisms and dielectric responses for these fluorocarbon films will be also discussed.

As a conclusion, new results about conduction mechanisms in fluorocarbon films for electronic applications will be presented and discussed as a function of climatic conditions (temperature and relative humidity).

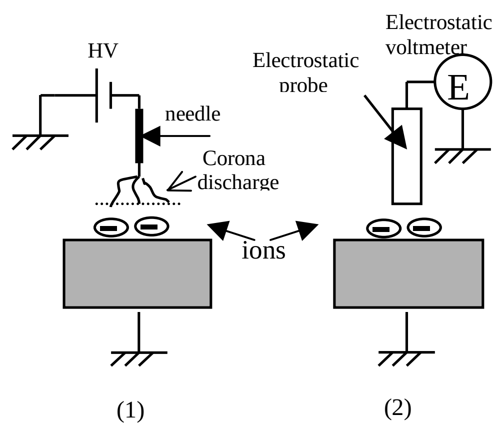

Figure 1. Surface potential decay principle. Corona discharge (1) and surface potential measurements (2).

References

[1] R.Schwödiauer et al : Appl. Phys. Lett. 43, 2941, 1998

[2] E.Seyrat et al, J.Appl. Phys., 90, 1383, 2001

[3] L.S.Hung et al, Appl. Phys Lett., 78, 673, 2001

[4] A.Theil, J.Vac Sci. Tech., B17, 2397, 1999

[5] P.Gonon et al, J.Appl. Phys., 92, 4584, 2002