Electrostatics Society of America 2011 Annual Meeting
Case Western Reserve University, Cleveland, OH
June 14-16, 2011

Improved Measurement of the Apparent and Steady-State DC Surface Resistivity of Sheets and Films

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Abstract

The DC surface resistivity is an important parameter for assessing the static performance of flexible sheets and continuous films. Measuring the DC surface resistivity of a material is accomplished by applying a known voltage to an electrode structure in contact with the material under test and measuring the resultant current[1]. However, obtaining accurate measurements on semi-insulating and insulating surfaces can be challenging because the current varies with time. The variation in current can have several root causes including instrument drift, dielectric absorption (interfacial polarization, volume charge) and the sweep of mobile ions to the electrodes[1,2]. The alternating polarity method by Keithley improves the precision of DC resistivity measurements[2]. ASTM D-257 requires that the current reach steady state to obtain the resistivity. And, it identifies the apparent resistivity as a value obtain at a specified electrification time that may be shorter than required for the current to reach steady state.

One primary source of current variation is the sweep of mobile ions to the electrodes[1]. While these mobile ions contribute to the electrostatic performance of the material, their contribution to the DC measured resistivity is systematically eliminated by requiring that the current reach steady state. Both the steady state resistivity and the apparent resistivity should be given when reporting DC resistivity measurements.

Accurate measurements of both the steady state resistivity and the apparent resistivity may be obtained using the Keithley alternating polarity method. Using a separation of variables analysis, the current variation due to the finite mobility of one ionic species is found to vary according to (1)[3].

$$I = I_{SS} + \frac{I_1}{\left(1 + \frac{t}{\tau_1}\right)^2} \qquad (1)$$

The steady state current I_{SS}, the time varying current I_1 , and the time constant τ_1 governing the transient current can be estimated by fitting the measured current as a function of time using (1). Knowing the steady state current I_{SS} and the transient current I_1, the resistivity and the apparent resistivity may be obtained. In addition, measurement productivity is improved because the measured current need not

reach steady state to obtain reliable measurements. The time constant τ_1 can very long (hours), which would require a measurement time of many hours to obtain a steady state measurement.

[1] ASTM Standard D257-07 (2007), "Standard Test Methods for DC Resistance or Conductance of Insulating Materials," ASTM International, West Conshohocken, PA, 2007, DOI: 10.1520/D0257-07, www.astm.org.

[2] Adam Daire, "Improving the Repeatability of Ultra-High Resistance and Resistivity Measurements," Keithley White Paper No. 1808, Keithley Instruments, Inc., 2001, http://www.keithley.com/.

[3] K. Robinson and Ravi Sharma, "Electrophoretic Mobility Estimated from the Transient Current in a Parallel Plate Cell," Proceedings of the ESA Annual Meeting on Electrostatics, Laplacian Press, Cambria, CA, 2007, pg. 194 – 197.