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ELECTROSTATIC CHARGING AND SURFACE RESISTIVITY MEASUREMENTS: A CASE STUDY FOR PREVENTING AND CONTROL OF ELECTROSTATIC DISCHARGE EVENTS

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Abstract. The paper is focused on software tests and measurements of electrostatic charges and surface resistivity of materials for preventing and predicting issues of electrostatic discharge events. The computational program used was 6517 Hi-R Test, based on Alternating Polarity Test Method, in connection with 6517A High Resistance Meter and 8009 Resistivity Test Fixture. The conclusions were extracted concerning the importance of these measurements for avoiding and control of electrostatic discharges.

Key words: electrostatic charge; electrostatic discharge.

1. Introduction

Defined as a transient current flow compensating the charge imbalance or the transfer of electrical charge between two bodies at different potentials, electrostatic discharge (ESD) phenomenon arises due to electrostatic charge accumulations. The two main sources of electrostatic discharge events come from people and equipment (Esmark *et al.*, 2003; ESD, 2001).

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This phenomenon can modify the electrical properties and characteristics of a semiconductor device, degrading or destroying it or may upset the normal operation of an electronic system. Hereby, ESD represents an important threat in electronical industry but also, for many others industries (ESD, 2001).

For avoiding, predicting and control of these electrostatic disturbances, it is important to evaluate, control and measure the electrostatic charges accumulated and to evaluate the materials through surface resistivity characteristic.

Surface resistivity represents an important parameter of any dissipative, semi-insulating or insulating material. The literature indicates the surface resistivity as the ratio of DC voltage per unit of length to the surface current per unit of width (Esmark *et al.*, 2003). A basic method for resistivity measurement issues uses a digital electrometer or high resistance meter in connection with the model 8009 Resistivity Test Fixture for material samples. The measurement results obtained with this method can be compared with those obtained by using a computational program based on alternating polarity resistivity tests for high software measurements and simulations.

In this paper has been studied the influence of electrostatic charge and surface resistivity measurements of materials for ESD protective considerations.

2. Method and Measurement Instrumentation

For surface resistivity software developments was used the 6517 Hi-R Test program from the Keithley 6524 High Resistance Measurement package. This program is used for electrical resistivity measurements and tests using the Alternating Polarity method, in direct connection with some proper equipments, such as Electrometer/High Resistance Meter model Keithley 6517A, with resistance and resistivity range measurements from 10 Ω to 210 T Ω , DC voltage measurements, DC current measurements and charge measurements and 8009 Resistivity Test Fixture. This sample's chamber can support a maximum working voltage of 1,000 V and a test current of 0.1 A, with good and complete electrostatic shielding. The 8009 model can accommodate samples from 64 to 102 mm in diameter and with a thickness of max. 3.2 mm.

The measurement systems used for these measurements are presented in Fig. 1 namely: a) software measurement set-up for surface resistivity, b) electrostatic charge measurement set-up. The interconnection between computer PC and High Resistance Meter was made with an IEEE-488 Interface Board (GPIB board) model KeithleyPCI-488A (Fig. 1 a). All the sample's fabrics used for these measurements were electrified by rubbing actions (triboelectric charging) and were prepared according with the requirements of the 8009 model, in proper and normal temperature and relative humidity conditions: insulating polyethylene, textile fabric with wool, insulating polytetrafluoroethylene (PTFE) and electrical cardboard.

For electrostatic charge investigations, the measurement system contains a Coulombmeter, C (Electrometer) and the Faraday Pail, FP, (an electrostatic device represented by two cylinders, for measurement and for shielding issues, separated through an insulator (Chubb, 2007; Antoniu & Antoniu, 2004). The test method used presumes the charging of the fabrics/materials by rubbing procedures (triboelectric effect) and after this action, placing into the FP.

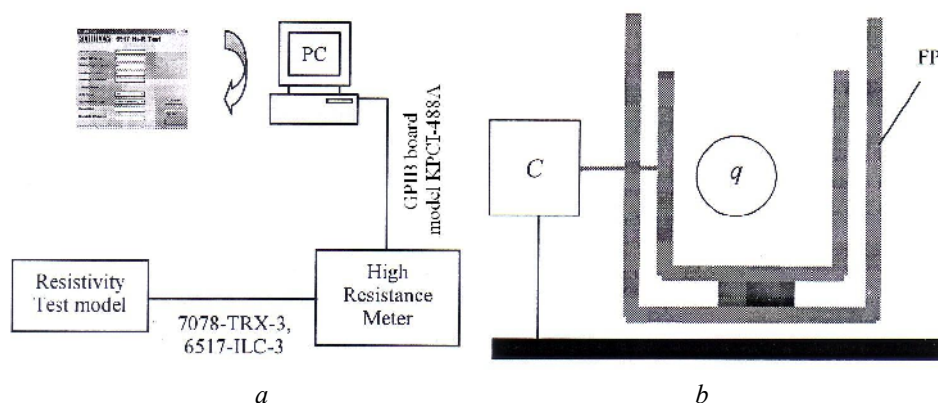


Fig. 1 – Measurement set-up: surface resistivity (a), electrostatic charges (b).

3. Measurements Results

The environment conditions were 23°C temperature and 45% relative humidity and the electrostatic charge measurements for each fabric were performed five times, the result being the average of these recordings. In Fig. 2 are illustrated the measurement results for surface resistivity of materials.

In the Fig 2 a are presented the resistivity test current trace for textile fabric with wool, obtained with the 6517 Hi-R Test software and the last surface resistivity values recorded for the selected material.

The technique of this computational tool is based on current measurements at normal speed by the dedicated equipments (6517A electrometer). In this case, the alternating voltage is set on 150 V and the offset voltage for 10 V, with an autorange current of 200 nA. The measure time used in this software measurement has been of 40 s. The last current measurement, I_M , is displayed for the end of any alternation cycle of the voltage applied, which is symbolised on the resistivity test current trace from the diagram through a little black square. The value of the calculated current, I_C , will be displayed after two positive and two negative values (four alternations). This current is symbolised on the current trace diagram with x and represents the weighted average of the last four values obtained. The recorded result illustrates the surface resistivity values derived from the current measurements values

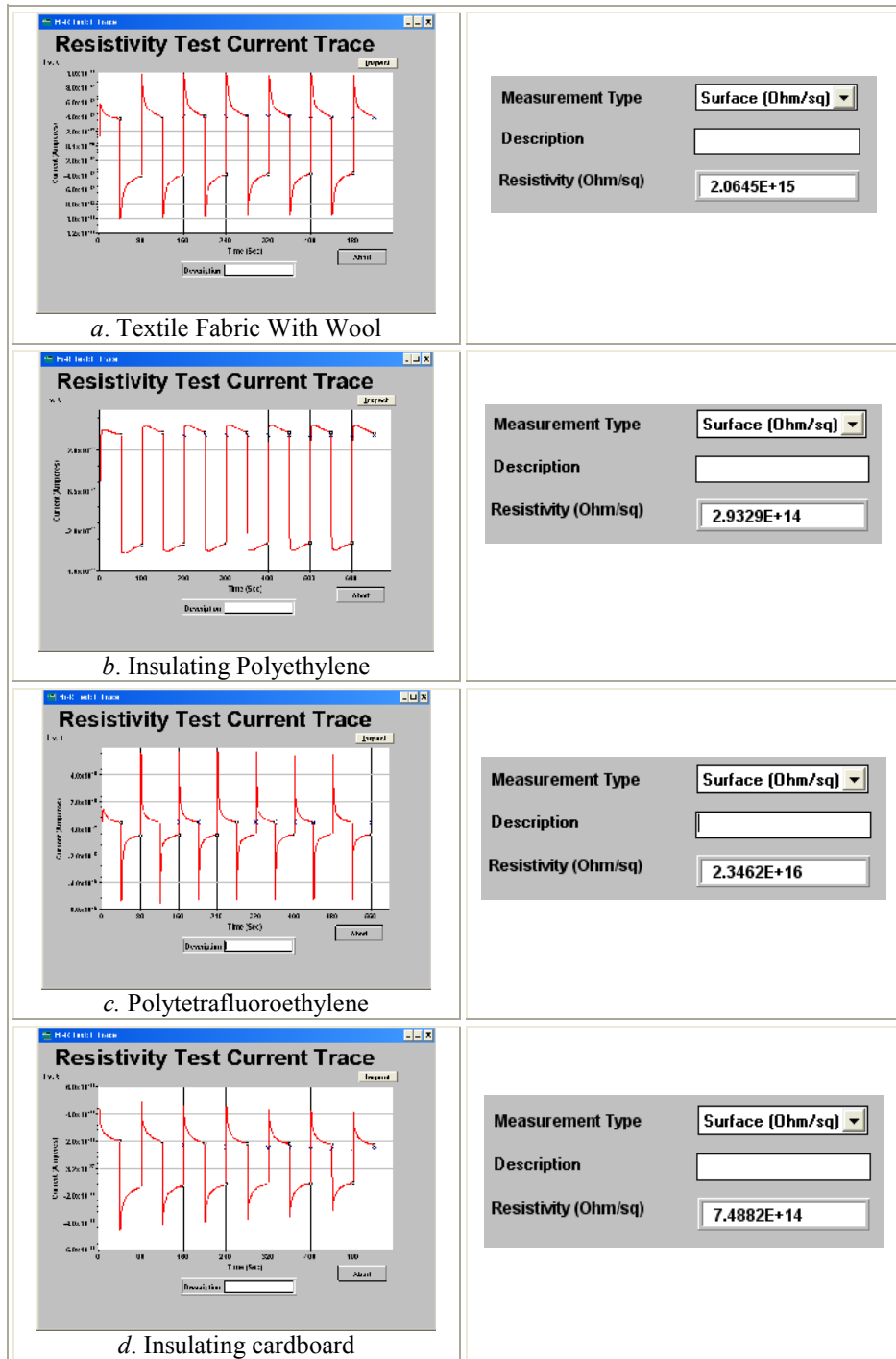


Fig. 2 – Surface resistivity measurement results.

obtained. The Fig 2 *b* illustrates the diagram obtained for insulating polyethylene, with +160/-140 V alternating voltages (the offset voltage was of 10 V and the alternating voltage was of 150 V) and a measure time of 50 s. Diagrams from the Fig. 2 *c* and 2 *d* present the resistivity test current traces obtained for PTFE and electrical cardboard samples. The measure time used has been of 40 s with an offset voltage of 20 V and an alternating voltage of 200 V.

In Table 1 are presented the electrostatic charge measurement results for the fabric choosed.

Table 1
Electrostatic Charge Measurement Results

	Fabric 1	Fabric 2	Fabric 3	Fabric 4
Electrostatic charge	1,258 μC	12,135 nC	3,402 nC	1,320 nC

The obtained electrostatic charge measurement results are influenced by some factors, like the environment conditions (humidity, pressure, temperature), materials conditions (the roughness and deformation of the surface, contamination factor), etc.

From the experimental results presented in Table 1 it can observe that the charge value recorded is different for all materials tested: the lowest electrostatic charges accumulated are for fabric 4 and the highest charge value is for fabric 1.

4. Conclusions

Electrostatic discharge events arise due to electrostatic charge accumulation. These phenomena can create important damages in electronic industry (mostly on semiconductor and integrated circuits and systems), leading up to the degradation and destruction of these devices. Thus, it is necessary to avoid, eliminate or diminish the accumulation of electrostatic charges to avoiding the occurrence of electrostatic discharge phenomena.

This work is focused on surface's resistivity of materials importance and also electrostatic charging measurements to evaluate, predicting or avoiding the charge accumulation and electrostatic discharge phenomena.

In many cases it is difficult to foretell the appearance of an electrostatic discharge event related to surface characteristics of material or due to electrostatic charge accumulated because these events depend, strongly, of some important external factors.

Because the electrostatic discharge phenomena represent important threats in many industrial processes which are based on modern systems and technologies, it is necessary to evaluate the electrical materials selected to work in sensitive environmental or conditions, from surface resistivity and

electrostatic charging points of view.

The basic method for protection and preventing against electrostatic discharge events is represented by the using of ESD materials, with good protective properties, such as anti-static materials or dissipative materials.

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MĂSURAREA SARCINILOR ELECTROSTATICE ȘI A REZISTIVITĂȚII DE SUPRAFAȚĂ A MATERIALELOR: STUDIU DE CAZ PENTRU PREVENIREA ȘI CONTROLUL FENOMENELOR DE DESCĂRCARE ELECTROSTATICĂ

(Rezumat)

Se studiază problematica măsurării sarcinilor electrostatice și a rezistivității de suprafață a materialelor pentru evaluarea, controlul și prevenirea apariției fenomenelor de descărcare electrostatică. Programul software utilizat la aceste aplicații a fost 6517 Hi-R Test, bazat pe metoda polarității alternante, în conexiune cu electrometrul 6517A și celula de măsură 8009. Rezultatele obținute arată importanța acestor măsurători pentru monitorizarea și controlul descărcărilor electrostatice.