Requirements and measurement method for ESD packaging material - shielding properties

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***Abstract* – This report is about the experiences at the measurement of special ESD packaging material. In the first part the problems of the different probes and measurement arrangements are described. Two small probes are used for the measurement of several packaging materials. In the second part the additional properties "shielding" will be describe. Expendable measurement methods are necessary to characterize the full packaging properties. There are special requirements for packaging materials in the EPA. They have to protect ESDS from electrostatic discharges. Simple measurement methods will be tried and described for Static decay time and shielding properties. Are these measurements arrangements are compare?**

***Index Terms* – packaging material, shielding properties, ESD, IEC 61340-5-1**

I. INTRODUCTION

The report describes the shown problems and experiences during the realization and evaluation of measurements. Once more it deals with the problem pressure / tightness resistance between probe and material at planar grounds.

Additional to the measurement methods of surface resistance and resistance to ground with „normal“ probes, a new measurement method with small special probes for packaging materials will be introduced. In the following table the technical requirements on the ESD material are defined. Table 1 shows the resistance parameters and the shielding requirements of selected materials.

Table 1: Requirements on ESD packaging materials after IEC 61340-5-1 and ANSI/ESD S541

Material	**Parameter**
Low charging	reducing of a minimum of charge generation
Conductive	$> 1 * 10^{2} \ldots < 1 * 10^{5}\ \Omega$
Dissipative	$> 1 * 10^{5} \ldots < 1 * 10^{11}\ \Omega$
Shielding	max. energy: 50 nJ at a HBM-discharge of 1000 V

II. MEASUREMENT METHODS – SURFACE RESISTANCE AND VOLUME RESISTANCE

The resistance to ground is the resistance, which is measured between the probe on the surface of a sample and for example with the ground connection or the copper band of a conductive floor covering. The resistance, which is measured between the surface and the earth potential, could also be called as earth resistance to ground. This resistance is not suitable for the measurement of packaging material. For packaging material we don't use this measurement method, we use an analogically method, between one probe on the surface and the other of the back side.

III. CALCULATION OF THE SHIELDING BEHAVIOR OF ESD PACKING MATERIALS

ESD packing materials must shield ESDS from electrostatic discharges and fields out of an EPA. Thus, they must feature a special and defined shielding behavior. The behavior's test follows a method described in the standard IEC 61340-5-1, enclosure B (2001). A defined sensor is placed into the tested packing material. The dimensions, described in the standard, must be kept exactly.

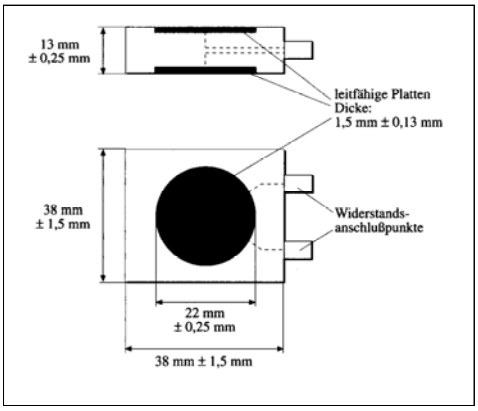

Fig. 1 Sensor for the calculation of the shielding behavior of ESD packaging materials

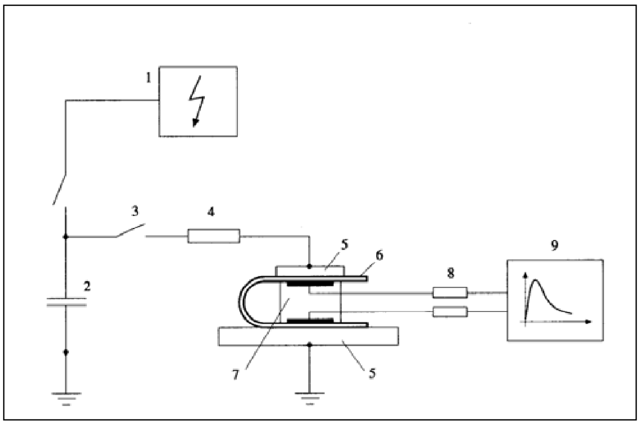

Fig. 2 Measuring system for the behavior's test

1 DC – HV source, single pulse (discharge parameter: R = 1.5 kΩ, C = 100 pF)
2 capacitance (200 pF)
3 switcher
4 resistances (400 kΩ)
5 upper discharge electrode upon (∅ > 38 mm), electrode, down (200 mm x 250 mm)
6 bag under test
7 capacitive probe, fig. 2
8 current probe
9 sampling oscilloscope, band width greater 200 MHz, single pulse, sampling rate > 500 x 10^6 points per second

The capacitive sensor is placed into the ESD packing material. According to the complete measuring system, the upper probe is charged with an impulse voltage of about 1000 volts. The discharge happens according to the Human Body Model (HBM). The classification of the ESD packing materials depends on the measured voltage of the capacitive sensor. The maximum voltage of a functional packing may not exceed 100 volts inside, see IEC 61340-5-1: max. 50 nJ.

Notwithstanding from the other measuring processes, two limit values for the relative humidity are tested: 12% ± 3% and 50 % ± 3 %. The samples are stored under the respective conditions for about 48 h and the measurement itself happens under the determined conditions, described before. The energy, which runs into the ESD packing, is calculated as follows, equation:

$$W_{el} = R * t * \sum_{i=1}^{n} I_i^2$$

The transfer of the storage oscilloscope's measuring results to a computer is meaningful. This measuring method is more complex than the previous method. Nevertheless, this method provides real measuring results, which are needed for a correct assessment of ESD packing materials. This system can be used for other packing materials, like corrugated card board boxes, either.

IV. THEORETICAL BASICS

Packaging materials are very thin materials in opposition to floor materials. The resistance to ground can be measured only, when an earth bonding point exists. There can be a current flow at the materials anymore, especially at shielding materials, which have a metal layer.

It is decisive that the conductive rubber builds up the contact between the probe area and the material surface. The resistance of an ideal contact is zero Ohm. In addition to the electrical resistance there is a tightness resistance on the real contact.

V. PRACTICAL MEASUREMENTS AND RESULTS

Measurements with typical packaging and packaging materials for electronic devices were done. Small and large packaging was measured with big and small probes for the proof of the problems. Fundamental only the standard probes are used in the practice. In Fig. 3 and 4 you can see which problems are caused by the measurements. Fig. 3 shows a typical procedure with a normal resistance probe. The probe surface only covers a small part of the measured material. So, only a small part of the resistance is measured. The magnitude of this resistance is unknown, it has to be calculated. The persistent measurement of different materials means, that you has to calculate the area permanently.

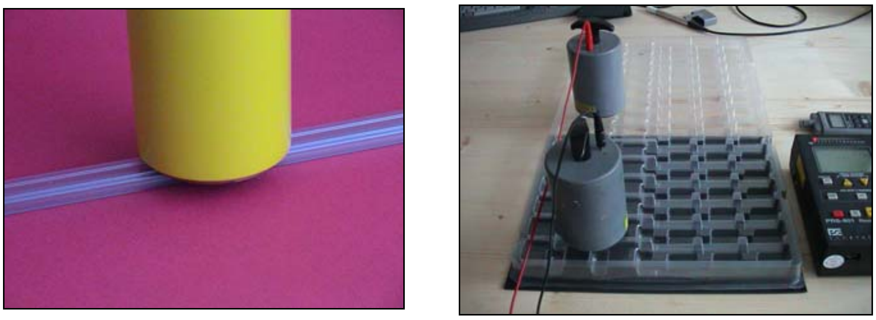

Fig. 3: Typical measurement methods with a normal probe, for example for IC tubes and trays

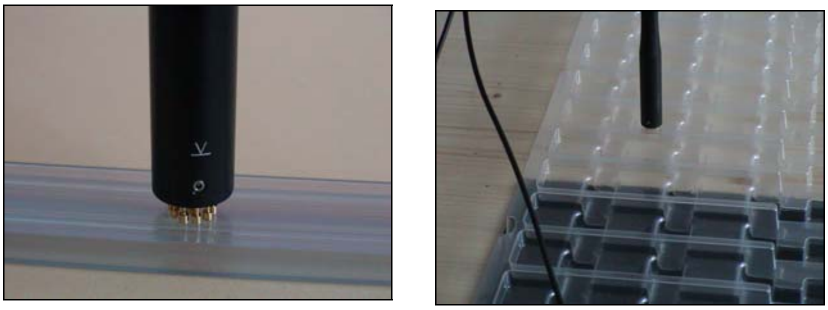

Fig. 4: Better methods with a small ring probe

The small probe with a diameter of 12 mm is more suitable for the measurement of small packaging and especially for electronic devices. So no more calculations of the areas are necessary.

The measurement serves to test the suitability of such probes for the practical use. The roughness could be offset with the feather contacts.

The table 2 shows the results with the new small ring probe and different materials. The environmental parameters were the same. The measurements were realized under controlled conditions.

Table 2: Measurement results at different packaging materials with the new small ring probe

Material	**1**	**2**	**3**	**4**
Antistatic IC – tube	$5.91 * 10^{12}\ \Omega$	$5.00 * 10^{12}\ \Omega$	$5.52 * 10^{12}\ \Omega$	$4.58 * 10^{12}\ \Omega$
Conductive IC – tubes	$1.03 * 10^{6}\ \Omega$	$1.03 * 10^{6}\ \Omega$	$1.34 * 10^{6}\ \Omega$	$1.17 * 10^{6}\ \Omega$
Window of a conductive IC – tubes (low charging)	$4.31 * 10^{12}\ \Omega$	$4.32 * 10^{12}\ \Omega$	$4.05 * 10^{12}\ \Omega$	$4.21 * 10^{12}\ \Omega$
Tray for IC's	$2.94 * 10^{12}\ \Omega$	$3.29 * 10^{12}\ \Omega$	$2.73 * 10^{12}\ \Omega$	$3.48 * 10^{12}\ \Omega$

The measurement results in table 2 show that the measurements with this very small probe can be done exactly. The measurement results also shows, that a small probe can be used for controlled measurements of packaging materials too. In comparison to this, of course, some other measurements with different materials were realized too.

Fig. 5 Measurement of a blister belt with a normal probe

Fig. 6 Measurement of a blister belt with a small ring probe

The comparison problems of the different probes are shown in table 3. Here one material (blister belt for IC's) was measured with different probes.

Table 3: Measurement results with different probes at the same material

Probe	**1**	**2**	**3**	**4**
2.27 kg probe	$1.25 * 10^{7}\ \Omega$	$5.71 * 10^{6}\ \Omega$	$1.25 * 10^{7}\ \Omega$	$1.53 * 10^{7}\ \Omega$
Two point small probe	$1.68 * 10^{9}\ \Omega$	$1.31 * 10^{9}\ \Omega$	$8.01 * 10^{8}\ \Omega$	$2.58 * 10^{9}\ \Omega$
Small ring probe	$5.29 * 10^{8}\ \Omega$	$6.82 * 10^{8}\ \Omega$	$2.85 * 10^{9}\ \Omega$	$1.68 * 10^{9}\ \Omega$

Further measurement results can be used for the evaluation of packaging materials. The measurements of the shielding behavior and the discharge time or the static decay time are counted to it. Fundamental the goal must be, that only one simple measurement method has to be used for the evaluation of packaging material. The measurement of the shielding behavior or the static decay time is expandable. In this report two measurement methods are introduced, which are simple. The results are summarized in table 4 and 5.

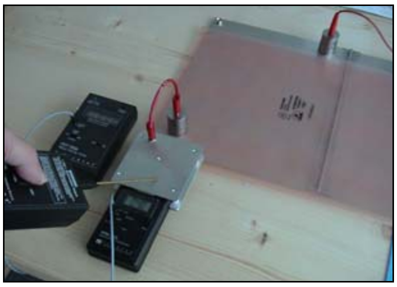

Fig. 7 Simple test method for static decay time

This simple method uses a digital field meter, a CPM, a timer and a charger. The defined capacity of the charge plate assembly is loaded up to 1000 V. After that the discharge to 100 V follows. The timer shows the discharge time. The measurements were realized with + 1000 V and – 1000 V to 10 % of the end value. The measurements were performed under normal conditions. The measurement method should be realized equitable to practice as possible. Differences at the polarities resulted in. Finally the surface resistance was measured with a defined ring probe.

Table 4: Measurement results – static decay time

Material	**Low charging**		**Shielding**	
	+ 1000 V ⇒ + 100 V	- 1000 V ⇒ - 100 V	+ 1000 V ⇒ + 100 V	- 1000 V ⇒ - 100 V
	2.9 sec	5.6 sec	0.6 sec	4.8 sec
	2.3 sec	7.8 sec	0.7 sec	11.5 sec
	5.3 sec	12.1 sec	0.9 sec	8.8 sec
	7.3 sec	15.5 sec	1.0 sec	11.2 sec
	7.0 sec	14.9 sec	1.2 sec	17.7 sec
Surface resistance	$5.78 * 10^{10}\ \Omega$		$2.07 * 10^{10}\ \Omega$	

Fig. 8 Simple test method for shielding property

Table 5: Measurement results for shielding property

Material	Low charging	Shielding
Outside: 1000 V	Inside	Inside
	860 V	20 V
	870 V	30 V
	950 V	80 V

The measurement results in table 4 and 5 show, that the way is correct: simple measurement methods for the fast and practical inspection of the properties. Differences obtain in comparison to measurements in laboratories. The "low charging" material is an „undefined“ material out of a practical environment, so some disagreements are achieved. The shielding property is just a simple method, which provides comparable values.

V. CONCLUSION

The usual measurement methods and two new measurement probes were used for testing the parameter von ESD packaging material. Comparing measurements were realized with traditional probes and micro probes for the resistance measurements. The limits of the traditional probes were shown. The contact area is not identical with the measurement area. So you get aggravating differences in the results.

The trials with the static decay time and the shielding property should contribute to find easier measurement methods for the practice. Until now only laboratory measurements were realized. A simple and, of course, a not expensive possibility for the inspection of packaging material hasn't found until now. Packaging materials ought to be reviewed during the daily work.

An initial entry for the measurement of the shielding properties with a simple test method will be shown. The complete test is described in part III. Further comparative measurements are necessary.

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