Electrostatic discharge attenuation test for the characterization of ESD protective materials

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Purpose

- To develop a test method for that can be used to evaluate materials and objects (including tools, equipment, packaging) used in the electronics manufacturing environment under CDM type of transients
Outline

- Motivation
- Measurement method and set-up
- Experimental tests
- Conclusion
Motivation

- To avoid CDM types of ESD failures to devices due to an abrupt discharge of charged device or board assembly, all contacts to charged electronics during manufacturing and testing should be done by materials having carefully controlled charge dissipation properties.
Motivation

- Material requirements given in ESD control standards rely on quasi-static measures.
- Static measures do not always correctly predict the material response under dynamic ESD events.
Motivation

- Need for a test method to characterize the ability of material or object to attenuate discharge energy and peak discharge current when a charged device is discharged into the material under test.
Measurement method and set-up

Simplified CDM kind of circuit for the ESD attenuation test of materials

We have used C=20 pF, R=35 Ω, L=70 nH
Measurement method and set-up

- The method simulates a real world CDM/CBM discharge in the sense that
  - The energy measured simulates the ESD energy which may lead to device damage
  - The measured peak current is related to an internal voltage transient which may lead to device damage
- In a material with high level of attenuation, majority of energy dissipation will safely happen in a material – not in the victim charged device
Experimental tests

- Examples include measurements done for electrostatically challenging materials and objects as well as form simple reference materials for verification purposes.
- Examples of ESD discharge attenuation test waveforms for the discharge current and energy dissipated in the charged (simulated) device are given for 1000 V, 20 nC discharges.
Experimental tests

Discharge to 100 µm thick soldering paste having $R_{pp} = 1 \, \text{M}\Omega$

- $I_{\text{max}} = 9.2 \, \text{A}$
- $E = 4.6 \, \mu\text{J}$
Experimental tests

Discharge to a metallic and isolated pin of insulating tester jig

\[ I_{\text{max}} = 2.7 \text{ A} \]
\[ E = 0.17 \mu\text{J} \]
## Experimental tests

Example of ESD attenuation test results for a variety of materials and objects

<table>
<thead>
<tr>
<th>Sample</th>
<th>$R_{pp}$ [kΩ]</th>
<th>$I_p$ [A]</th>
<th>$E$ [nJ]</th>
<th>$I_p/I_{ref}$ [dB]</th>
<th>$E/E_{ref}$ [dB]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soldering paste (100 µm)</td>
<td>1000</td>
<td>9.2</td>
<td>4600</td>
<td>-2</td>
<td>-2</td>
</tr>
<tr>
<td>Pin of dissipative tester jig</td>
<td>&lt;10</td>
<td>7.3</td>
<td>2300</td>
<td>-4</td>
<td>-5</td>
</tr>
<tr>
<td>Pin of insulating tester jig</td>
<td>&gt; 10 G</td>
<td>2.7</td>
<td>170</td>
<td>-14</td>
<td>-17</td>
</tr>
<tr>
<td>Dissipative rubber</td>
<td>100</td>
<td>0.13</td>
<td>0.62</td>
<td>-40</td>
<td>-41</td>
</tr>
<tr>
<td>Resistor 1 kΩ</td>
<td>1</td>
<td>1.2</td>
<td>350</td>
<td>-20</td>
<td>-13</td>
</tr>
<tr>
<td>Resistor 10 kΩ</td>
<td>10</td>
<td>0.6</td>
<td>25</td>
<td>-26</td>
<td>-25</td>
</tr>
<tr>
<td>Metal reference</td>
<td>0</td>
<td>12</td>
<td>7400</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Conclusions

- New dynamic test method has been developed to evaluate materials, tools, equipment and packaging which can be in contact with charged ESD sensitive components.
- The method is intended to characterize the ability of the material or object to attenuate ESD energy and peak discharge current when a charged device is discharged into the material under test.
Conclusions

- The test is supplementary for the quasi-static measurements (resistance, charge, potential, field) of ESD control programs in the cases where the standard measurements do not give sufficient information due to voltage non-linearity, complexity or shape of the material or object under test.