Introduction

Conformal coating is a material applied to circuit boards to protect the electronics from moisture, solvents, contamination, dust, fungus, metallic debris particles, etc. These molecules or particles could otherwise degrade the electrical performance or cause outright failure.

In addition, the conformal coat provides:
1. Protection against corrosion, short circuiting, and abrasion
2. Electrical insulation for high-voltages components, particularly at high altitudes
3. Insulation against temperature extremes
4. Shock and vibration attenuation

Materials

The conformal coating is typically transparent. Common coating materials are:

<table>
<thead>
<tr>
<th>Type</th>
<th>Material</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR</td>
<td>Acrylic</td>
<td>Easy to apply and remove</td>
</tr>
<tr>
<td>ER</td>
<td>Epoxy</td>
<td>Tough, durable, and very chemically-resistant</td>
</tr>
<tr>
<td>SR</td>
<td>Silicone</td>
<td>Soft, useful over a wide temperature</td>
</tr>
<tr>
<td>UR</td>
<td>Polyurethane or</td>
<td>Good moisture and chemical resistance, good electrical insulation</td>
</tr>
<tr>
<td>UR</td>
<td>urethane</td>
<td></td>
</tr>
<tr>
<td>XY</td>
<td>Paraxylylene</td>
<td>Very thin coating</td>
</tr>
</tbody>
</table>

The material conforms to the shape of the circuit board and its piece parts.

Another concern is the likelihood of repair or rework. Some materials are difficult to remove.
Application

The coating is more effective if all surface contamination is removed first, using a highly repeatable industrial process such as vapor degreasing. Cleanliness is necessary for surface adhesion.

The material is applied by brushing, spraying or dipping. It is then dried, or cured. Ultraviolet (UV) curing is used in some cases.

Thickness

The coating thickness is typically a few mils, or a fraction of a millimeter.

Thicker coats may be used in some cases. For example, a 14-mil thickness may be used if the circuit board will be exposed to corrosive gases and salt-spray atmospheres. Hydrogen sulfide is an example of a corrosive gas.

Vibration Attenuation

The following factors affect the vibration attenuation of the conformal coat:

1. Material Type and Properties
2. Thickness
3. Surface Adhesion
4. Quality of cleaning and curing

Conformal coating adds both mass and stiffness to a circuit board. Mass is the dominant parameter such that the coating causes the circuit board’s natural frequency to decrease.

The conformal coat also provides damping. The amount of damping varies significantly depending on the four factors given above.

Test Results

The author participated in some testing of circuit boards with conformal coating in 1993 to 1995.

Note that the circuit boards did not have any wiring or electrical piece parts, which would have altered the response.

The same circuit board part number was used in each test.

Each circuit board was excited via a shaker table to a common base input level, which was 5.7 GRMS overall.
A summary of the response results is given in the following tables. Note that power transmissibility is the ratio of the response to the input at a given frequency, with units of \((G^2/G^2)\).

**Table 2. Test Series I**

<table>
<thead>
<tr>
<th>Board Configuration</th>
<th>Overall Response (GRMS)</th>
<th>Power Transmissibility at First Mode</th>
<th>Power Transmissibility at Second Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>2B74</td>
<td>6.5</td>
<td>102 at 110 Hz</td>
<td>8 at 665 Hz</td>
</tr>
<tr>
<td>UV986</td>
<td>9.7</td>
<td>234 at 125 Hz</td>
<td>15 at 840 Hz</td>
</tr>
<tr>
<td>Solithane 113</td>
<td>13.8</td>
<td>2186 at 95 Hz</td>
<td>74 at 545 Hz</td>
</tr>
<tr>
<td>No Coat</td>
<td>32.7</td>
<td>4399 at 150 Hz</td>
<td>1837 at 790 Hz</td>
</tr>
</tbody>
</table>

**Table 3. Test Series II**

<table>
<thead>
<tr>
<th>Board Configuration</th>
<th>Overall Response (GRMS)</th>
<th>Power Transmissibility at First Mode</th>
<th>Power Transmissibility at Second Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE615</td>
<td>23.6</td>
<td>3792 at 100 Hz</td>
<td>1472 at 595 Hz</td>
</tr>
<tr>
<td>BIWAX 82.878</td>
<td>23.3</td>
<td>4777 at 100 Hz</td>
<td>829 at 565 Hz</td>
</tr>
<tr>
<td>GE RTV655</td>
<td>18.8</td>
<td>996 at 95 Hz</td>
<td>997 at 570 Hz</td>
</tr>
<tr>
<td>Solithane 113</td>
<td>8.8</td>
<td>502 at 95 Hz</td>
<td>32 at 590 Hz</td>
</tr>
<tr>
<td>No Coat</td>
<td>30.0</td>
<td>2589 at 140 Hz</td>
<td>998 at 790 Hz</td>
</tr>
</tbody>
</table>

**Table 4. Test Series III**

<table>
<thead>
<tr>
<th>Board Configuration</th>
<th>Board Number</th>
<th>Overall Response (GRMS)</th>
<th>Power Transmissibility at First Mode</th>
<th>Power Transmissibility at Second Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>2B74</td>
<td>1</td>
<td>9.0</td>
<td>310 at 100 Hz</td>
<td>11 at 620 Hz</td>
</tr>
<tr>
<td>BIWAX 628</td>
<td>2</td>
<td>7.0</td>
<td>120 at 95 Hz</td>
<td>10 at 600 Hz</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>7.0</td>
<td>180 at 100 Hz</td>
<td>7 at 650 Hz</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>7.4</td>
<td>90 at 110 Hz</td>
<td>15 at 720 Hz</td>
</tr>
<tr>
<td>SOLITHANE 113</td>
<td>4</td>
<td>18.9</td>
<td>3100 at 95 Hz</td>
<td>400 at 580 Hz</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>9.3</td>
<td>750 at 85 Hz</td>
<td>90 at 540 Hz</td>
</tr>
<tr>
<td>BIWAX 82.878</td>
<td>6</td>
<td>25.9</td>
<td>6000 at 100 Hz</td>
<td>1800 at 550 Hz</td>
</tr>
<tr>
<td>GE RTV 615</td>
<td>7</td>
<td>15.2</td>
<td>2000 at 100 Hz</td>
<td>70 at 600 Hz</td>
</tr>
<tr>
<td>GE RTV 655</td>
<td>8</td>
<td>21.3</td>
<td>6000 at 95 Hz</td>
<td>30 at 560 Hz</td>
</tr>
</tbody>
</table>
Recommendation

Alas, the 2B74 and the UV986 materials appear to be no longer commercially available.

Solithane 113 appears to be the best, remaining material. On average, it provided an overall response that was about 8 dB lower than the board with no coating.

Solithane 113 is a urethane material. It is a resin which requires a curing agent. The type and amount of curing agent affects the resulting hardness.¹

Further information is given at:


Reference Documents

1. MIL-I-46058
2. ASTM-D-1005
3. IPC-HDBK-830
4. NASA-STD-8739.1

¹ The curing agent was not documented in the previously described testing, however.