Custom Substrates - Conductor Resistor Pattern and Overcoat

FEATURES
- Precision conductor and resistor patterns
- TaN and NiCr resistor films
- Resistor tolerance down to 0.1 %
- Silicon nitride, and polyimide overcoat coatings
- Metallization on 1 or 2 surfaces
- Various substrate materials
- Sputtered / plated metal systems
- Custom sizes from 0.020” x 0.020” to 4.000” x 4.000”
- Quick delivery available

APPLICATIONS
Vishay EFI conductor resistor patterned substrates with optional overcoat coatings are used in the hybrid circuit, microwave, and telecommunications industries. These conductor resistor patterns are precisely manufactured to be used for precision current flow, voltage division and RF / Microwave designs. Resistor overcoat options are used for resistor protection and can be applied and patterned to match the conductor and / or resistor pattern. The conductor resistor patterned substrates are manufactured using Vishay Electro-Films (EFI) sophisticated thin film equipment and manufacturing technology. The custom specialty film substrates are visually inspected to MIL-STD-883, method 2032 class H or K.

THIN FILM DESIGN GUIDELINES

SUBstrate MATERIALS

METAL SYSTEM AND CONDUCTOR PATTERNING

INTEGRATING THIN FILM RESISTORS
Vishay EFI offers two thin film resistor film choices of lithographically patterned Tantalum Nitride (TaN) or Nickel Chromium (NiCr). The resistive film should be selected based upon application-specific requirements such as performance, assembly packaging needs, and temperature exposure. The table below summarizes the key standard parameters of these resistor materials.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>TCR (ppm/°C)</th>
<th>STANDARD SHEET RESISTIVITY 99.6 % Al2O3 (Ω/sq)</th>
<th>STANDARD SHEET RESISTIVITY AIN, BeO (Ω/sq)</th>
<th>STABILITY (1)</th>
<th>TOLERANCE (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TaN</td>
<td>± 50</td>
<td>20 to 125</td>
<td>25 to 100</td>
<td>&lt; 0.1 %</td>
<td>0.1 % to 20 %</td>
</tr>
<tr>
<td>NiCr</td>
<td>± 25</td>
<td>25 to 225</td>
<td>50 to 150</td>
<td>&lt; 0.1 %</td>
<td>0.1 % to 20 %</td>
</tr>
</tbody>
</table>

Notes
(1) 1000 h at 125 ºC in air
(2) Special tolerances available
CURRENT DENSITY

To ensure optimal Resistor performance, the design engineer must consider the self-heating effects of the operating resistor and understand the power dissipation characteristics of the environment. A complete thermal analysis should be performed by the design engineer to ensure proper thin film resistor design. The following table lists current density standards for common materials.

<table>
<thead>
<tr>
<th>SHEET RESISTANCE</th>
<th>Al₂O₃</th>
<th>SILICON</th>
<th>QUARTZ</th>
<th>AIN</th>
<th>BeO</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 Ω/sq</td>
<td>4 mA/mil</td>
<td>20 mA/mil</td>
<td>0.5 mA/mil</td>
<td>19 mA/mil</td>
<td>32 mA/mil</td>
</tr>
<tr>
<td>50 Ω/sq</td>
<td>2 mA/mil</td>
<td>10 mA/mil</td>
<td>0.25 mA/mil</td>
<td>9.5 mA/mil</td>
<td>16 mA/mil</td>
</tr>
<tr>
<td>100 Ω/sq</td>
<td>1 mA/mil</td>
<td>5 mA/mil</td>
<td>0.125 mA/mil</td>
<td>4.7 mA/mil</td>
<td>8 mA/mil</td>
</tr>
<tr>
<td>200 Ω/sq</td>
<td>0.5 mA/mil</td>
<td>2.5 mA/mil</td>
<td>0.062 mA/mil</td>
<td>2.3 mA/mil</td>
<td>4 mA/mil</td>
</tr>
</tbody>
</table>

RESISTOR DESIGN

After the thin film resistor values have been determined and a metallization film selected per SPF1 and SPF2 datasheets, the thin film resistor layout can be designed. There are two typical approaches for accomplishing this: the block-style resistor (see Fig. 1) or serpentine-style resistor (see Fig. 2). With both design approaches, it is standard to employ a laser trim process to trim the resistor to the desired value and tolerance. Vishay EFI employs both scrub (edge) trimming and plunge trimming techniques to achieve the desired resistor value.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>VALUES</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min. resistor dimension</td>
<td>0.002&quot; x 0.002&quot; (50 μm x 50 μm)</td>
<td>For resistors &lt; 1000 Ω, use probe pad size of 0.006&quot; (152 μm) x 0.008&quot; (203 μm)</td>
</tr>
<tr>
<td>Min. probe pad dimension</td>
<td>0.003&quot; x 0.003&quot; (75 μm x 127 μm)</td>
<td></td>
</tr>
<tr>
<td>Min. conductor/resistor design overlap</td>
<td>0.002&quot; (50 μm)</td>
<td>See Fig. 1</td>
</tr>
<tr>
<td>Resistor layout dimensions (block resistor/serpentine resistor)</td>
<td>100 % of nominal value / 100 % of nominal resistor value plus laser kerfs of 0.5 mil²/sq</td>
<td></td>
</tr>
<tr>
<td>Resistor trim</td>
<td>Scrub, plunge, or bake to value</td>
<td>Bake to value ± 10 % or 20 %</td>
</tr>
</tbody>
</table>

All high frequency resistors should be Edge trimmed to value to preserve frequency response. VEFI can also supply resistors of 20 % tolerance (10 % special) or looser tolerances which are designed to 100 % of bake to value with no laser trimming.
PROTECTIVE COATING

Vishay Electro-Films (EFI) has developed several patternable overcoat options to protect the resistors and other critical areas from mechanical damage during handling. It is essential to overcoat resistors of 0.1 % or tighter tolerances to maintain tolerance during assembly and test of the hybrid, and it is beneficial to overcoat all resistors.

### PROTECTIVE COATING APPLICATIONS

<table>
<thead>
<tr>
<th>OVERCOAT</th>
<th>TYPICAL THICKNESS (Å)</th>
<th>APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicone nitride</td>
<td>4000 to 6000</td>
<td>Resistor overcoat with fine trim capability and integrated capacitor</td>
</tr>
<tr>
<td>Polyimide</td>
<td>50 000 to 80 000</td>
<td>Resistor overcoat and solder dam</td>
</tr>
</tbody>
</table>

### PROTECTIVE COATING GUIDELINES

<table>
<thead>
<tr>
<th>OVERCOAT</th>
<th>TYPICAL THICKNESS (Å)</th>
<th>MIN. FEATURE SIZE</th>
<th>MIN. METAL OVERLAP</th>
<th>PATTERN TOLERANCE (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicone nitride</td>
<td>4000 to 6000</td>
<td>0.004&quot; x 0.004&quot;</td>
<td>0.002&quot;</td>
<td>± 0.002&quot;</td>
</tr>
<tr>
<td>Polyimide</td>
<td>50 000 to 80 000</td>
<td>0.004&quot; x 0.004&quot;</td>
<td>0.001&quot;</td>
<td>± 0.002&quot;</td>
</tr>
</tbody>
</table>

**Notes**

1. Special tolerance of ± 0.001" available
2. Minimum gap in polyimide pattern is 0.0015" x 0.003"

In summary NiCr will perform at higher sheet resistance with lower TCR than TaN giving higher resistance values in less area. TaN will continue to perform in a moisture environment but NiCr will require a hermetic package to maintain resistance values. Both resistive films will work in highly demanding environments for a wide range of applications with VEFl thin film technology.

### GLOBAL PART NUMBER INFORMATION

**Custom Global Part Number:** PSS205687-00N

**Custom Global Part Number Description:** Specialty Films Custom 205687-00N

<table>
<thead>
<tr>
<th>MODEL</th>
<th>CUSTOM PART NUMBER</th>
<th>INTERNAL REVISION</th>
<th>VARIANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>S</td>
<td>S</td>
<td>2 0 5 6 8 7 - 0 0 N</td>
</tr>
</tbody>
</table>

A = AlN  
B = BeO  
F = ferrite/garnet  
K = zirconia  
N = resistor conductor

### CONTACT INFORMATION

For design assistance, contact: efi@vishay.com
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