

## TMM<sup>®</sup> Thermoset Microwave Materials



TMM<sup>®</sup> thermoset microwave materials are ceramic, hydrocarbon, thermoset polymer composites designed for high plated-thru-hole reliability stripline and microstrip applications. TMM laminates are available in a wide range of dielectric constants and claddings.

The electrical and mechanical properties of TMM laminates combine many of the benefits of both ceramic and traditional PTFE microwave circuit laminates, without requiring the specialized production techniques common to these materials. TMM laminates do not require a sodium naphthanate treatment prior to electroless plating.

TMM laminates have an exceptionally low thermal coefficient of dielectric constant, typically less than 30 ppm/°C. The material's isotropic coefficients of thermal expansion, very closely matched to copper, allow for production of high reliability plated through holes, and low etch shrinkage values. Furthermore, the thermal conductivity of TMM laminates is approximately twice that of traditional PTFE/ceramic laminates, facilitating heat removal.

TMM laminates are based on thermoset resins, and do not soften when heated. As a result, wire bonding of component leads to circuit traces can be performed without concerns of pad lifting or substrate deformation.

TMM laminates combine many of the desirable features of ceramic substrates with the ease of soft substrate processing techniques. TMM laminates are available clad with 1/2 oz/ft<sup>2</sup> to 2 oz/ft<sup>2</sup> electrodeposited copper foil, or bonded directly to brass or aluminum plates. Substrate thicknesses of 0.015" to 0.500" are available. The base substrate is resistant to etchants and solvents used in printed circuit production. Consequently, all common PWB processes can be used to produce TMM thermoset microwave materials.

### *Data Sheet*



#### **Features and benefits:**

Wide range of dielectric constants

- Ideal for single material systems on a wide variety of applications

Exceptional mechanical properties

- Resist creep and cold flow

Coefficient of thermal expansion matched to copper

- High reliability of plated through holes

Resistant to process chemicals

- Reduces damage to material during fabrication and assembly processes

Thermoset resin

- Reliable wirebonding
- No specialized production techniques required
- TMM10 and 10i laminates can replace alumina substrates

#### **Some Typical Applications:**

- RF and microwave circuitry
- Power amplifiers and combiners
- Filters and coupler
- Satellite communication systems
- Global Positioning Systems Antennas
- Patch Antennas
- Dielectric polarizers and lenses
- Chip testers

| ELECTRICAL PROPERTIES <sup>(1)</sup>         |                 | TYPICAL VALUES <sup>(2)</sup> |                   |                   |                   |                   |                             | DIRECTION | UNITS          | CONDITIONS                   | TEST METHOD                      |
|----------------------------------------------|-----------------|-------------------------------|-------------------|-------------------|-------------------|-------------------|-----------------------------|-----------|----------------|------------------------------|----------------------------------|
|                                              |                 | TMM3                          | TMM4              | TMM6              | TMM10             | TMM10i            | TMM13i                      |           |                |                              |                                  |
| <sup>(1)</sup> Dielectric Constant (process) |                 | 3.27 ± 0.032                  | 4.50 ± 0.045      | 6.00 ± 0.080      | 9.20 ± 0.230      | 9.80 ± 0.245      | <sup>(3)</sup> 12.85 ± 0.35 | Z         | -              | 10 GHz                       | IPC-TM-650 method 2.5.5.5        |
| <sup>(2)</sup> Dielectric Constant (design)  |                 | 3.45                          | 4.70              | 6.3               | 9.8               | 9.9               | 12.2                        | -         | -              | 8 GHz - 40 GHz               | Differential Phase Length Method |
| <sup>(1)</sup> Dissipation Factor (process)  |                 | 0.0020                        | 0.0020            | 0.0023            | 0.0022            | 0.0020            | 0.0019                      | Z         | -              | 10 GHz                       | IPC-TM-650 method 2.5.5.5        |
| Thermal Coefficient of Dielectric Constant   |                 | +37                           | +15               | -11               | -38               | -43*              | -70                         | -         | ppm/°K         | -55 to +125°C                | IPC-TM-650 method 2.5.5.5        |
| Insulation Resistance                        |                 | >2000                         | >2000             | >2000             | >2000             | >2000             | >2000                       | -         | Gohm           | C/96/60/95                   | ASTM D257                        |
| Volume Resistivity                           |                 | 3X10 <sup>9</sup>             | 6X10 <sup>8</sup> | 1X10 <sup>8</sup> | 2X10 <sup>8</sup> | 2X10 <sup>8</sup> | -                           | -         | Mohm cm        | -                            | ASTM D257                        |
| Surface Resistivity                          |                 | >9X10 <sup>9</sup>            | 1X10 <sup>9</sup> | 1X10 <sup>9</sup> | 4X10 <sup>7</sup> | 4X10 <sup>7</sup> | -                           | -         | Mohm           | -                            | ASTM D257                        |
| Electrical Strength (dielectric strength)    |                 | 441                           | 371               | 362               | 285               | 267               | 213                         | Z         | V/mil          | -                            | IPC-TM-650 method 2.5.6.2        |
| Thermal Properties <sup>(1)</sup>            |                 |                               |                   |                   |                   |                   |                             |           |                |                              |                                  |
| Decomposition Temperature (Td)               |                 | 425                           | 425               | 425               | 425               | 425               | 425                         | 425       | °C TGA         | -                            | ASTM D3850                       |
| Coefficient of Thermal Expansion - x         |                 | 15                            | 16                | 18                | 21                | 19                | 19                          | X         | ppm/K          | 0 to 140°C                   | ASTM E 831<br>IPC-TM-650, 2.4.41 |
| Coefficient of Thermal Expansion - y         |                 | 15                            | 16                | 18                | 21                | 19                | 19                          | Y         | ppm/K          | 0 to 140°C                   | ASTM E 831<br>IPC-TM-650, 2.4.41 |
| Coefficient of Thermal Expansion - z         |                 | 23                            | 21                | 26                | 20                | 20                | 20                          | Z         | ppm/K          | 0 to 140°C                   | ASTM E 831<br>IPC-TM-650, 2.4.41 |
| Thermal Conductivity                         |                 | 0.70                          | 0.70              | 0.72              | 0.76              | 0.76              | -                           | Z         | W/m/K          | 80°C                         | ASTM C518                        |
| Mechanical Properties <sup>(1)</sup>         |                 |                               |                   |                   |                   |                   |                             |           |                |                              |                                  |
| Copper Peel Strength after Thermal Stress    |                 | 5.7 (1.0)                     | 5.7 (1.0)         | 5.7 (1.0)         | 5.0 (0.9)         | 5.0 (0.9)         | 4.0 (0.7)                   | X,Y       | lb/inch (N/mm) | after solder float 1 oz. EDC | IPC-TM-650 Method 2.4.8          |
| Flexural Strength (MD/CMD)                   |                 | 16.53                         | 15.91             | 15.02             | 13.62             | -                 | -                           | X,Y       | kpsi           | A                            | ASTM D790                        |
| Flexural Modulus (MD/CMD)                    |                 | 1.72                          | 1.76              | 1.75              | 1.79              | 1.80*             | -                           | X,Y       | Mpsi           | A                            | ASTM D790                        |
| Physical Properties <sup>(1)</sup>           |                 |                               |                   |                   |                   |                   |                             |           |                |                              |                                  |
| Moisture Absorption (2X2)                    | 1.27mm (0.050") | 0.06                          | 0.07              | 0.06              | 0.09              | 0.16              | 0.16                        | -         | %              | D/24/23                      | ASTM D570                        |
|                                              | 3.18mm (0.125") | 0.12                          | 0.18              | 0.20              | 0.20              | 0.13              | 0.13                        |           |                |                              |                                  |
| Specific Gravity                             |                 | 1.78                          | 2.07              | 2.37              | 2.77              | 2.77              | 3.0                         | -         | -              | A                            | ASTM D792                        |
| Specific Heat Capacity                       |                 | 0.87                          | 0.83              | 0.78              | 0.74              | 0.72*             | -                           | -         | J/g/K          | A                            | Calculated                       |
| Lead-Free Process Compatible                 |                 | YES                           | YES               | YES               | YES               | YES               | YES                         | -         | -              | -                            | -                                |

Notes: ASTM E831 corresponds to IPC-TM-650, method 2.4.41 \* estimated

Typical values are a representation of an average value for the population of the property. For specification values contact Rogers Corporation.

- (1) Prolonged exposure in an oxidative environment may cause changes to the dielectric properties of hydrocarbon based materials. The rate of change increases at higher temperatures and is highly dependent on the circuit design. Although Rogers' high frequency materials have been used successfully in innumerable applications and reports of oxidation resulting in performance problems are extremely rare, Rogers recommends that the customer evaluate each material and design combination to determine fitness for use over the entire life of the end product.
- (2) The design Dk is an average number from several different tested lots of material and on the most common thickness/s. If more detailed information is required, please contact Rogers Corporation. Refer to Rogers Technical paper "Dielectric Properties of High Frequency Materials" available on [www.rogerscorp.com/acs](http://www.rogerscorp.com/acs).
- (3) Method 2.5.5.6.

| Standard Thickness                                                                                                                                                                                                                                                           | Standard Panel Size                                | Standard Copper Cladding                                                                                                                     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| 0.015" (0.381mm), 0.020" (0.508mm), 0.025" (0.635mm), 0.030" (0.762mm), 0.050" (1.270mm), 0.060" (1.524mm), 0.075" (1.905mm), 0.100" (2.540mm), 0.125" (3.175mm), 0.150" (3.810mm), 0.200" (5.080mm), 0.250" (6.350mm), 0.275" (6.985mm), 0.300" (7.620mm), 0.500" (12.70mm) | 18" X 12" (457 X 305mm)<br>18" X 24" (457 X 610mm) | ½ (18µm), 1 oz (35µm), 2 oz. (70µm)<br>electrodeposited copper foil.<br><br>Heavy metal cladding available. Contact Rogers customer service. |

The information in this data sheet is intended to assist you in designing with Rogers' circuit materials. It is not intended to and does not create any warranties express or implied, including any warranty of merchantability or fitness for a particular purpose or that the results shown on this data sheet will be achieved by a user for a particular purpose. The user should determine the suitability of Rogers' circuit materials for each application.

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