

# Rogers High Frequency Circuit Materials

Property	RT/duroid® 5880	RT/duroid® 5870	ULTRALAM® 2000	RT/duroid® 6002	RT/duroid® 6006	RT/duroid® 6010LM	TMM® 3	TMM® 4	TMM® 6	TMM® 10	TMM® 10i	
<b>Composition</b>	PTFE Glass Fiber	PTFE Glass Fiber	PTFE Woven Glass	PTFE Ceramic	PTFE Ceramic	PTFE Ceramic	Hydro- Carbon Ceramic	Hydro- Carbon Ceramic	Hydro- Carbon Ceramic	Hydro- Carbon Ceramic	Hydro- Carbon Ceramic	
<b><math>\epsilon_r</math><sup>(1)</sup> Tolerance</b>	2.20 ±0.020	2.33 ±0.020	2.40-2.60 ±0.040	2.94 ±0.040	6.15 ±0.150	10.2 ±0.250	3.27 ±0.032	4.50 ±0.045	6.00 ±0.080	9.20 ±0.230	9.80 ±0.245	
<b>Tan <math>\delta</math><sup>(1)</sup></b>	0.0009	0.0012	0.0019	0.0012	0.0019	0.0023	0.0020	0.0020	0.0023	0.0023	0.0020	
<b>Thermal coeff. of <math>\epsilon_r</math><sup>(2)</sup> -50° to 150°C ppm/°C</b>	-125	-115	-100	+12	-410	-425	<sup>(4)</sup> +39	—	<sup>(4)</sup> -10	<sup>(4)</sup> -38	<sup>(4)</sup> -43	
<b>Volume resistivity Mohm-cm (Typical)</b>	2x10 <sup>7</sup>	2x10 <sup>7</sup>	2x10 <sup>7</sup>	10 <sup>6</sup>	2x10 <sup>7</sup>	5x10 <sup>5</sup>	3x10 <sup>9</sup>	6x10 <sup>8</sup>	1x10 <sup>8</sup>	2x10 <sup>7</sup>	—	
<b>Surface resistivity Mohm (Typical)</b>	3x10 <sup>8</sup>	2x10 <sup>8</sup>	4x10 <sup>7</sup>	10 <sup>7</sup>	7x10 <sup>7</sup>	5x10 <sup>6</sup>	>9x10 <sup>9</sup>	1x10 <sup>9</sup>	1x10 <sup>9</sup>	4x10 <sup>7</sup>	—	
<b>Young's Modulus<sup>(3)</sup></b>	X - kpsi (MPa)	156 (1,076)	189 (1,340)	1700 (11,730)	120 (828)	74 (511)	135 (932)	1916 (13,210)	2000* (13,790)	2200 (15,168)	2400 (16,547)	
	Y - kpsi (MPa)	125 (863)	185 (1,277)	1300 (8,970)	120 (828)	91 (628)	81 (559)	1916 (13,210)	2000* (13,790)	2200* (15,168)	2400 (16,547)	—
	Z - kpsi (MPa)	136 (938)	120 (828)	—	360* (2,482)	155 (1,070)	311 (2,146)	742 (5,116)	752 (5,185)	736 (5,075)	575 (3,964)	—
<b>Moisture<sup>(4)</sup> absorption D24/23 % (Typical)</b>	0.015	0.015	0.03	0.1	0.05	0.05	<sup>(4)</sup> 0.04	<sup>(4)</sup> 0.010	<sup>(4)</sup> 0.06	<sup>(4)</sup> 0.09	<sup>(4)</sup> 0.16	
<b>Thermal <sup>(5)</sup> conductivity W/m<sup>2</sup>K (Typical)</b>	0.20	0.22	0.24	0.60	0.49	0.78	0.70	0.70	0.72	0.76	0.76	
<b>Coefficient of Thermal Expansion ppm/°C<sup>(6)</sup> 0° to 100°C (typ)</b>	X	31	22	15	16	47	24	16	14	16	16	16*
	Y	48	28	15	16	34	24	16	14	16	16	16*
	Z	237	173	200	24	117	24	20	20	20	20	20*
<b>Density gm/cm<sup>3</sup> (typical)</b>	2.2	2.2	2.2	2.1	2.7	3.1	1.78	2.07	2.37	2.77	2.77	

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Property	RO3003™	RO3203™	RO3006™	RO3010™	RO3210™	RO4003®	RO4350®
Composition	PTFE Ceramic	PTFE Ceramic Reinforced Woven Glass	PTFE Ceramic	PTFE Ceramic	PTFE Ceramic Reinforced Woven Glass	Hydrocarbon Ceramic Woven Glass	Hydrocarbon Ceramic Woven Glass
$\epsilon_r$ <sup>(1)</sup> Tolerance	3.00 – 0.04	3.02 – 0.04	6.15– 0.15	10.2 – 0.30	10.2– 0.5	3.38– 0.05	3.48– 0.05
Tan $\delta$ <sup>(1)</sup>	0.0013	0.0016	0.0025	0.0035	0.003	0.0027	0.004
Thermal coefficient of $\epsilon_r$ <sup>(2)</sup> ppm/ C (-50 to 150 C)	13	13	-160	-280	13	+40	+50
Volume resistivity (Mohm cm) (typical)	10 <sup>6</sup>	10 <sup>7</sup>	10 <sup>3</sup>	10 <sup>3</sup>	10 <sup>4</sup>	1.7 x 10 <sup>10</sup>	1.2 x10 <sup>10</sup>
Surface resistivity (Mohm)	10 <sup>7</sup>	10 <sup>7</sup>	10 <sup>3</sup>	10 <sup>3</sup>	10 <sup>4</sup>	4.2 x 10 <sup>9</sup>	5.7 x 10 <sup>9</sup>
Youngs modulus <sup>(3)</sup>	X-kpsi (MPa)	300 (2068)	300 (2068)	300 (2068)	300 (2068)	3700 (25,510)	
	Y-kpsi (MPa)	300 (2068)	300 (2068)	300 (2068)	300 (2068)	3900 (26,889)	1664 (11,473)
Moisture absorption <sup>(4)</sup> D24/23 (%) (typical)	<0.1	<0.1	<0.1	<0.1	<0.1	0.06	0.06
Copper peel strength lbs/in (N/mm)	17.6 (3.1)	10 (1.7)	12.2 (2.1)	13.4 (2.4)	10 (1.7)	6.4 (1.1)	5.3 (0.9)
Thermal conductivity <sup>(5)</sup> (W/m/ K)	0.50	0.50	0.61	0.66	0.81	0.64	0.62
Coefficient of thermal expansion <sup>(6)</sup> 0 to 100 C (ppm/ C)	X	17	13	17	17	13	11
	Y	17	13	17	17	13	14
	Z	24	58	24	24	34	46
Density gm/cm <sup>3</sup> (typical)	2.1	2.1	2.6	3.0	3.0	1.8	1.9
Flammability rating, UL 94V-0	Yes	Yes	Yes	Yes	Yes	No	Yes

\*estimated

1) Measured by IPC-TM-650 method 2.5.5.5 at -10 GHz, 23°C. RT/duroid 6010 materials were based on testing a 0.025" thick sheet clad with 1 oz. electrodeposited copper.  $\epsilon_r$  values and tolerances reported by IPC-TM-650 method 2.5.5.5 are the basis for quality acceptance, but for some products these values may be incorrect for design engineering applications, especially those in microstrip. We recommend that prototype boards of a new design be verified for electrical performance.

2) Measured by IPC-TM-650 method 2.5.5.5 at -10 GHz modified. Data are typical only.

3) Young's modulus (elastic modulus), steepest region of the stress/strain curve is in tension for X and Y axes by ASTM D 638; in compression for Z axis by ASTM D 695 on 12.7 x 12.7 x 25.4 mm stacked specimen. Data are typical only.

4) Testing conditions: 24 hours @ 23°C, specimens etched free of copper.

5) Tested by ASTM C 518

6) Tested by ASTM D3386-94. Values are average over temperature range but not necessarily linear. However, for RT/duroid 6002 and TMM grades the response is essentially linear.

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These products may require a validated export license issued by the U.S. Department of Commerce for export of these materials from the United States or Canada.

## Cladding Metals

<b>Copper Foil</b>	<b>Surface Roughness</b>		<b>Tensile Strength kpsi (MPa)</b>	<b>Elongation %</b>	<b>Volume Resistivity Microhm·cm</b>	<b>Stress Crack Resistance</b>	<b>Thickness mil</b>	<b>Peel Strength RT/duroid®5000 Series lbs/in (kN/m)</b>
	<b>Treated Side</b>	<b>Untreated Side</b>						
1/4 oz (9µm) ED	70 (1.8)	15 (0.4)	—	—	1.87	Fair	0.4	11 (1.93)
1/2 oz (17.5µm) ED	75 (1.9)	15 (0.4)	33.0 (228)	20.0	1.82	Fair	0.7	12 (2.10)
1 oz (35µm) ED	95 (2.4)	15 (0.4)	30.0 (207)	28.0	1.78	Fair	1.4	16 (2.80)
2 oz (70µm) ED	115 (2.9)	15 (0.4)	32.0 (221)	42.0	1.78	Fair	2.8	18 (3.15)
1/2 oz (17.5µm) Rolled	55 (1.4)	12 (0.3)	20.0 (138)	8.0	1.78	Excellent	0.7	9 (1.58)
1 oz (35µm) Rolled	55 (1.4)	12 (0.3)	22.0 (152)	13.0	1.74	Excellent	1.4	10 (1.75)
2 oz (70µm) Rolled	55 (1.4)	12 (0.3)	28.0 (193)	27.0	1.74	Excellent	2.8	11 (1.93)

<b>Plates</b>	<b>Alloy</b>	<b>Surface Roughness µin (µm)</b>	<b>Machinability</b>	<b>Tensile Strength kpsi (MPa)</b>	<b>Specific Gravity</b>	<b>Thermal Conductivity W/m·K</b>	<b>Coefficient of Thermal Expansion ppm/°C</b>	<b>Resisitivity microhm cm</b>
Aluminum	6061	70 (1.8)	Poor	20 (138)	2.7	180	24	5
Brass	70/30 cartridge	70 (1.8)	Good	45 (311)	8.5	120	20	6
Copper	110	70 (1.8)	Fair to Poor	35 (242)	8.9	390	17	2

## Ordering Information

Rogers circuit laminates can be purchased by contacting your customer service representative at (602) 961-1382 or one of our overseas offices listed below.

To ensure you receive the right material for your application, please include order information for each of the categories listed below. For more detailed product information, refer to the charts in this product selector guide.

### GRADE:

TMM 3,4,6,10, and 10i Ceramic Thermoset Polymer Composite Circuit Board Materials, RT/duroid 5870 and 5880 Glass Microfiber Reinforced Polytetrafluoroethylene Composite Materials, ULTRALAM 2000 Woven Glass Reinforced Polytetrafluoroethylene Material, RT/duroid 6002 Polytetrafluoroethylene Composite Material, RT/duroid 6006, 6010 and 6010LM Ceramic Polytetrafluoroethylene Composite Materials. RO3003, RO3203, RO3006, RO3010, RO3210, RO4003 and RO4350 High Frequency Circuit Materials.

### THICKNESS AND TOLERANCE:

Dielectric is the thickness without copper. Refer to the price list(s) for standard thicknesses and tolerances. Custom thicknesses and tolerances are available on RT/duroid laminates and TMM laminates upon request.

### TYPE OF FOIL AND CLADDING:

RT/duroid, laminates	-	¼, ½, 1, and 2 ounce electrodeposited copper, ½, 1, and 2 ounce rolled copper or unclad (unclad is not available in dielectric thicknesses less than 0.010).
ULTRALAM,	-	½, 1, and 2 ounce electrodeposited copper, ½, 1, and 2 ounce rolled copper.
TMM laminates	-	¼, ½, 1, and 2 ounce electrodeposited copper foil two sides. TMM may also be supplied unclad.
*RO3003, *RO3203, *RO3006,		
*RO3210, *RO3010 laminates	-	½ and 1 ounce electrodeposited copper two sides.
*RO4003 laminates	-	½ and 1 ounce electrodeposited copper two sides.
*RO4350 laminates	-	½ and 1 ounce electrodeposited copper two sides.

Thick aluminum, copper and brass claddings are also available in a range of thicknesses and thickness tolerances. Other thick metal backings are available upon request.

*\*Thick metal backing is not available on RO3000 series and RO4000 series laminates.*

### PANEL SIZE:

See price list for standard panel sizes. Custom panel sizes are available upon request.

### SPECIFICATION REQUIREMENTS:

Standard specifications are Rogers material specification. Certificates of conformance are available.

All other specification requirements must be identified at the time the order is placed. If special testing or data generation is required, additional costs may be incurred.

# ROGERS

SINCE 1832

Rogers Corporation  
Microwave Materials Division  
100 S. Roosevelt Avenue  
Chandler, AZ 85226 U.S.A.

Tel: 602 961-1382

FAX: 602 961-4533

Toll Free: 877-643-7701

Website: <http://www.rogers-corp.com/mwu/>

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#### In Japan:

Rogers Japan Inc., Tokyo 116 Japan  
Tel: 03-3807-6430 FAX: 03-3807-6319

#### In Hong Kong:

Rogers Southeast Asia, Sheung Wan, Hong Kong  
Tel: 852-2549-7806 FAX: 852-2549-8615

#### In Europe:

Rogers N.V., Gent, Belgium  
Tel: 32-9-2353611 FAX: 32-9-2353658

#### In Taiwan:

Rogers Taiwan Inc, Taipei, Taiwan R.O.C.  
Tel: 886-2-86609056, FAX: 886-2-86609057

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