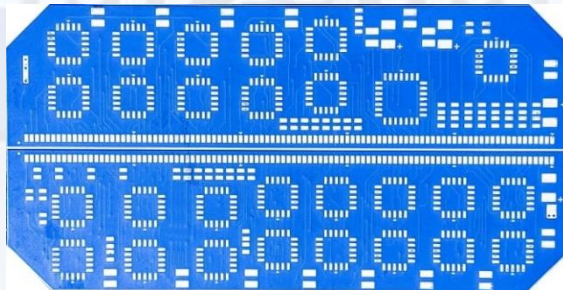
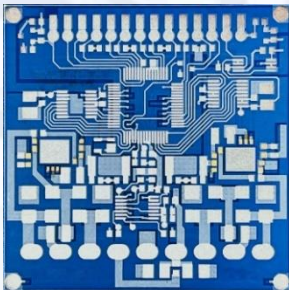




At Hybrid Sources, our **thick film experts** provide reliable, high-quality solutions for custom thick film substrate manufacturing. We use the best available technology for **precision screen printing** of conductive, resistive, and insulating pastes resulting in a cost-effective circuit that meets your requirements and specifications.

Standard substrates include **Alumina**, **Beryllium Oxide**, **Aluminum Nitride**, and exotic materials screen printed with various conductive, resistive, and insulating pastes to fabricate single, double-sided, and multilayer circuits. All shapes are possible with intricate patterns cut by laser. Sizes range from 10 mils square to 12 square inches (305mm) while substrate thickness ranges from 5-100 mils (0.005" - 0.100") with 25 mils typical.

Founded in 1985, the company adheres to applicable AS and MIL specs and takes pride in our outstanding on-time delivery record with products Made in the USA.





## Substrates

Material	Descriptions
Alumina (Al <sub>2</sub> O <sub>3</sub> )	90%, 96%, 99.6%, As fired, Lapped, Polished
Aluminum Nitride (AlN)	Lapped
Beryllium Oxide (BeO)	As fired, Lapped
Exotic Materials	Ferrite, Quartz, Pink Diamonite, Lithium Niobate, Sapphire

## Properties of Common Substrates (tested at 15GHz)

Properties	Units	Alumina 96%	AlN	BeO
Dielectric Constant (1MHz @ RT)		9.8	8.9	6.7
Dielectric loss (1MHz @ RT)		0.0001	0.0005	0.004
Electrical Resistivity	Ohm-cm	>10 <sup>14</sup>	>10 <sup>14</sup>	>10 <sup>14</sup>
Thermal conductivity @ T=.040 in.	W/m K	36	170 – 190	260
Coefficient of Thermal Expansion	ppm/°C	8.2	4.6	8.5
Density	g/cm <sup>3</sup>	2.89	3.3	3.85
Bending Strength	mPa	380	290	230
Hardness (knoop)	GPa	14.1	11.8	9.8
Youngs Modulus	GPa	372	331	345

*Nominal substrate thickness: 10, 15, 20, 25, 40, 60 mils ±10% as-fired. Other thicknesses and tolerances achieved by lapping or pre-sorting.*

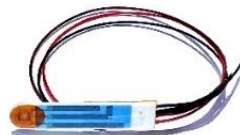
**Intricate patterns**



**Size: 10 mil<sup>2</sup> to 12" dia.**



**Assembly**



**Hermetically-sealed**





# Thick Film Design Guidelines

Conductor	Symbol	mΩ / □ resistivity	Notes
Gold	Au	4	Wire bondable and low resistance runs
Platinum Gold	PtAu	40	Wire bondable, Solderable (no migration)
Silver Palladium	AgPd	25	Wire bondable, Solderable (good aged adhesion)
Silver	Ag	3	Aluminum wire bondable; prone to oxidation

*Other conductors available: Platinum (Pt), Palladium Gold (PdAu), Platinum Palladium Gold (PtPdAu), Platinum Silver (PtAg), Platinum Palladium Silver (PtPdAg).*

Conductor Design Guidelines	Notes
Line & Space Width	5 mils (0.005") minimum
Thickness per layer, up to 8 layers	8-12 microns (gold 6-9 microns) typical
Offset / Pull back from diced edge	1-5 mils (0.001" to 0.005") ±2 mils
Offset / Pull back from scribed edge	5 mils (0.005") typical
Offset / Pull back from Dielectric	3-5 mils (0.003" to 0.005") typical
Alignment	5 mils (0.005") front to back

Resistors	TCR ppm/°C	Tolerance (no load)	Power dissipation mWatts/mm <sup>2</sup>
<20 ohms	±100	0.50%	900
20Ω-100k ohms	±50	0.25%	120-600
100k-10M ohms	±100	0.50%	120 max.

*Laser trimming, solder dipping, 1000 hour load life, stability >0.3% total*

## Dielectric:

- Low K dielectric allows up to 12 conductor layers
- High K dielectric allows capacitor formation (0.1 μF/in<sup>2</sup> max.)





# Thick Film Design Guidelines

Resistors	Description
Line & Space Width	5-10 mils (0.005" to 0.010") minimum
Minimum Value	0.1 $\Omega$
Maximum Value	10M $\Omega$ typical max., tolerance of $\pm 20\%$ . Can print to 2G $\Omega$ .
Minimum chip size	10 mils square (0.010")
Minimum Overlap	3 mils (0.003")

Vias (Plated or Solid-filled)	Description
Diameter	10 mils (0.010") typical. 5 mil min., 20 mil max.
Minimum metal overlap of pads	10 mils (0.010")

## Processing & Assembly

Processing & Assembly	Description
Laser Scribing	Single/Array
Laser Drilling	Vias/Holes
Laser Machining	Per requirement
Diamond Saw Cut	$\pm 2$ mils (0.002")
Hermetically-sealed	Per requirement

Wire Bonding	Description
Gold Ball	1 to 10 mil wire
Gold Wedge	$\frac{1}{2}$ to 3 mil wire
Aluminum Wedge	1 to 3 mil wire
Ribbon Bonding	1 to 10 mil wire







# Standards and Qualifications

AS & Military Standards	Description
AS-9100, Rev. D	Quality Management Systems
AS-9003, Rev. A	Inspection and Test Quality Systems
MIL-STD-883	Tests and procedures, microelectronics, High Reliability applications
MIL-I-45208	Quality
MIL-M-38510	General microcircuits
MIL-C-45662	Calibration
MIL-Q-9858	Quality Program
Hi Reliability (additional MIL-STD-883 screening)	Stabilization bake, Temperature cycling, Thermal shock, Constant acceleration, Fine and gross leak, Final electrical testing

Qualifications	Description
RoHS	EU Directive 2015/863 RoHS 3 Annex III 7c-I and 34 Category 9
REACH	Regulation (EC) No 1907/2006 of EU Parliament and Council
Conflict Minerals	Dodd-Frank Wall Street Reform & Consumer Protection Act of 2010
NIST SP 800-171	Certified to Cybersecurity standard for suppliers to the DoD
CMMC 2.0	Compliant with Level 2 Cybersecurity Maturity Model Certification
CAGE Code	07CB1
Made in USA	Manufactured and sourced in USA, unless specified by customer
Lockheed Martin	Sole-source qualified supplier for thick film





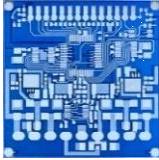
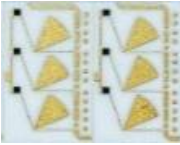
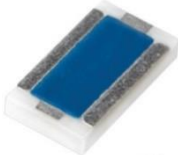
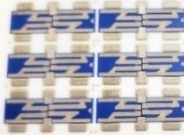
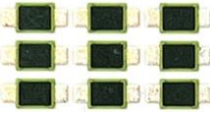

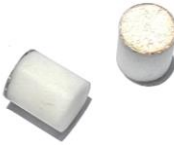

# Thermal Conductivity Chart

Material	Chemical	Watts cm • °C
<b>Metals:</b>		
Silver	Ag	4.08
Copper	Cu	3.94
Gold	Au	2.96
Aluminum	Al	2.18
Beryllium	Be	2.00
Tungsten	W	1.74
Rhodium	Rh	1.50
Molybdenum	Mo	1.46
Brass	66%Cu, 34% Zn	1.11
Chromium	Cr	0.937
Nickel	Ni	0.920
Platinum	Pt	0.716
Tin	Sn	0.666
Tantalum	Ta	0.575
Lead	Pb	0.353
Titanium	Ti	0.219
<b>PC Boards:</b>		
RT/Duroid® 5880		0.026
G10/FR4®		0.027
RT/Duroid® 60 (XX)		0.0041- .0048
TMM® (X)		0.0068- .0075

Material	Chemical	Watts cm • °C
<b>Insulators:</b>		
Diamond	CVD	10 – 16
Beryllium Oxide 99.5%	BeO	2.61
Aluminum Nitride	AlN	1.70
Sapphire		0.46
Alumina Oxide 99.6%	Al <sub>2</sub> O <sub>3</sub>	0.36
Alumina Oxide 96%	Al <sub>2</sub> O <sub>3</sub>	0.26
Alumina Oxide 91%	Al <sub>2</sub> O <sub>3</sub>	0.13
Glass		0.015
Mica		0.043- 0.0062
Air		0.00026
<b>Bonding:</b>		
Gold Germanium 88/12		0.8834
Gold Tin 80/20		0.6824
Tin Lead Solder	Sn62	0.4921
Indium 100%		0.2386
Silver Filled Epoxy		0.0156
Epoxy		0.0099



# Common Products

Product	Description	Example	Specifications
<b>Custom</b>	Single- or multi-layer custom designs built economically up to 8 layers.		Designed to customer requirements
<b>Antennas</b>	Converts voltage from transmitter to radio signal or captures signal for a receiver.		Built to spec for Frequency, Power, Gain, Return Loss and VSWR.
<b>Attenuators</b>	Reduces signal power without distorting waveform; opposite of amplifier.		<b>Frequency:</b> DC-6 GHz <b>Power:</b> 10-100 Watts <b>Attenuation:</b> 1-20 dB <b>Size:</b> 10 x 20 mils to 0.375" sq.
<b>Bonding pads</b>	SMT pad used to connect output pins of an IC or device on a PC board.		Bondable with Gold or Aluminum wire. Solderable for lead-free or leaded solder materials.
<b>Chip Resistors</b>	Passive 2 terminal device that resists flow of current. Available in Tab & Cover, Flange.		<b>Value:</b> 100mΩ to 10MΩ <b>Power:</b> 30-800W <b>Freq:</b> DC-6GHz <b>Size:</b> 0402 (20x40 mils) to 1" sq
<b>Crossovers</b>	SMT bridge replaces the need for a multilayer board or a coaxial jumper.		<b>Jumper:</b> RF to DC -or- RF to AC <b>Impedance:</b> 50Ω <b>Freq:</b> DC-4GHz, <b>Isolation:</b> 20dB <b>Power Max:</b> 30W
<b>Heat Sinks</b>	Passive heat exchanger dissipates heat from a device attached to PC board.		<b>Thermal conductivity:</b> 30 to 330 W/mK on ALN, Alumina, or BeO
<b>Heaters</b>	Heating element assures uniform and directional heat for accurate readings.		Printed on ceramic substrates in custom shapes and sizes.



## Common Products (cont'd)

Product	Description	Picture	Specifications
Sensors	<p><b>Hall Effect Sensor:</b> detects presence &amp; magnitude of magnetic field.</p> <p><b>Oxygen Sensor:</b> measures proportion of oxygen (O<sub>2</sub>) in gas or liquid.</p> <p><b>pH Sensor:</b> measures alkalinity &amp; acidity in water liquid.</p> <p><b>Pressure Sensor:</b> measures strain or pressure.</p> <p><b>Proximity Sensor:</b> detects presence of objects as near as 5 mils without physical contact.</p> <p><b>Temperature Sensor:</b> measures temperature using thermistors.</p>		<p><b>Specifications:</b> Built to customer specifications.</p> <p><b>Substrates:</b> Generally Alumina; all ceramic substrates available.</p> <p><b>Operating Range:</b> Broad temperature range, typically -55°C to 150 or 200°C.</p> <p><b>Sensing Distance:</b> Min. 5 mils to detect RPMs by measuring dot on rotating shaft.</p> <p><b>Output:</b> Voltage or current if needed.</p>
Static Transfer Plate	Moves Semiconductor wafers with static electricity		<b>Peak Voltage:</b> 3,000V
Terminations	Resistor grounded at end of transmission line prevents reflected signal from causing distortion.		<p><b>Power:</b> 30-800W</p> <p><b>Freq:</b> DC-8.5GHz</p> <p><b>Size:</b> 0402 (20x40 mils) to 1" sq</p> <p><b>Mounting:</b> Chip, Tab &amp; Cover, Flange mount.</p>
Thermistors	<u>Thermal Resistor</u> is a component with resistance dependent on temperature.		<p><b>Type:</b> NTC or PTC</p> <p><b>Size:</b> 0402 (20x40 mils) to 1" sq</p> <p><b>Op. Temperature:</b> -40 to 125°C</p>





# Industries & Applications



## Industries

- Aerospace
- Analytical Instruments
- Automotive
- Automatic Testing Equipment
- Commercial Airlines
- Consumer
- Defense
- Health and Beauty Appliances
- High Technology
- Industrial Packaging Equipment
- Medical Diagnostics
- Medical Devices
- Military Aircraft
- Molecular Technology
- Oil & Gas
- Pharmaceutical
- RF and Microwave products
- Satellite and space exploration
- Semiconductor Fabrication
- Sensors
- Submarines
- Telecom
- Test & Measurement
- University & Research Institutions

## Applications

- Agis Radar Electronics
- Attenuators
- Automatic Test Stations
- CERN Large Hadron Collider
- Airbus A320, A350, Boeing 737, 787
- Crossovers, Jumpers
- Diagnostic Analyzers
- Heat Sinks for PC boards
- Mars Rovers
- Microwave Subsystems (Antennas, Filters, Isolators, Oscillators, Power Amplifiers, Radar, RC Networks)
- F-35 JSF, F-16 Fighting Falcon, F-15 Eagle, F-14 Tomcat
- Molecular blood testing
- Plasma Cleaners
- Resistors
- Semiconductor fabrication equipment
- Sensors (Hall Effect, Oxygen, Pressure, Proximity, pH, Temperature)
- Virginia-class, Seawolf-class subs
- Terminations
- Thermistors





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