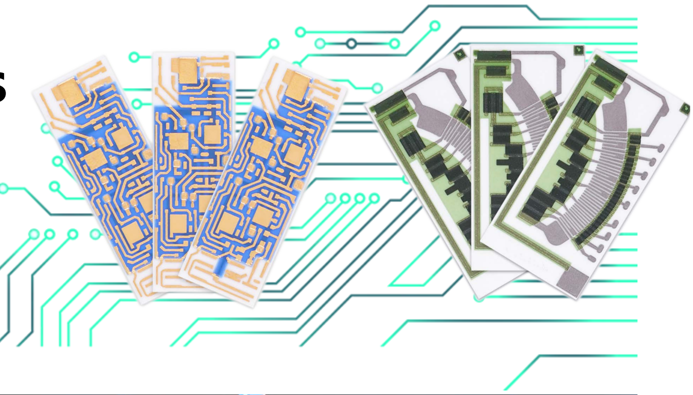
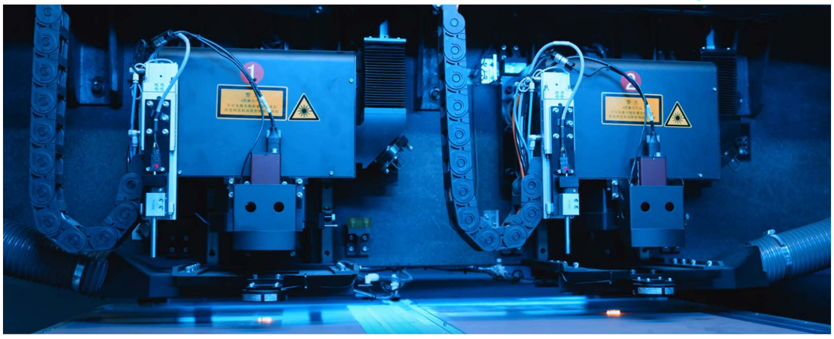
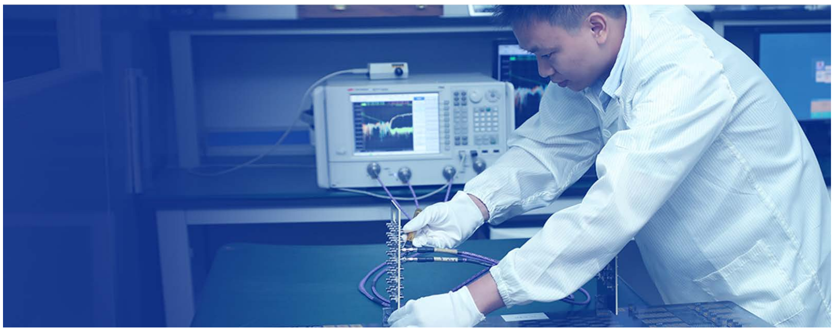
Thick Film Hybrid Circuits
Product Introduction







- ✿ Product Overview
- ✿ Design Guidelines

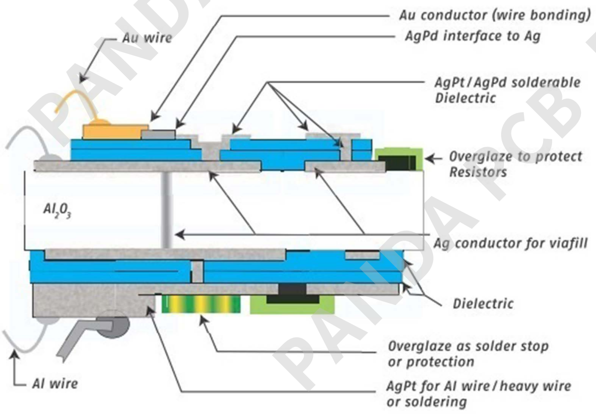
✿ Product Overview

What are Thick Film Hybrid Circuits ?

Thick Film Hybrid Circuits are highly reliable electronic circuits made by combining thick-film technology with ceramic substrates, involving the printing of conductive, resistive, precious metal, or insulating pastes onto alumina or aluminum nitride substrates, followed by processes like high-temperature sintering, laser trimming, photolithography, and bonding encapsulation, which integrate specific components such as resistors, capacitors, sensors, or heaters, widely applied in automotive, aerospace, medical, and telecommunications industries, offering advantages in customizability, and high power handling.

Thick Film Hybrid Circuits are known for their stability, good adhesion, and resistance to temperature changes, humidity, and mechanical stress. They offer advantages like cost-effectiveness, compactness, and strong electrical performance.

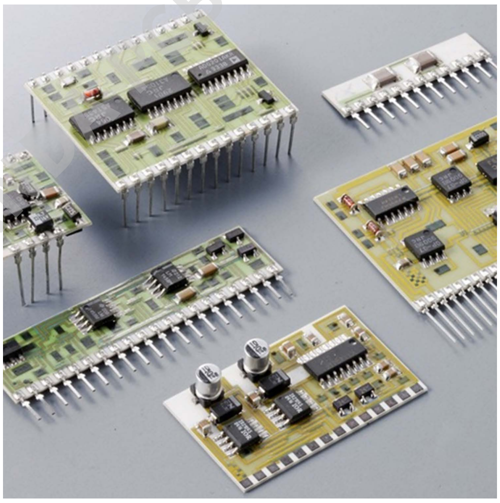
Typical Stack-Up of Thick Film Hybrid Circuits :



Typical stack-up of a Thick Film Hybrid Circuit varies based on functionality and application. A typical configuration includes:

- **Ceramic Substrate: The base layer, made from materials like alumina (Al2O3), beryllium oxide (BeO), or aluminum nitride (AlN), providing structural support.**
- **Conductor Layer: Metallic traces, often made of silver-palladium, gold-palladium, or other metals, printed onto the ceramic substrate.**
- **Dielectric Layer: Provides insulation and prevents short circuits and interference.**
- **Resistor Layer: Contains screen-printed resistors for specific resistance values, if needed.**
- **Additional Layers: Depending on the design, layers for capacitors, inductors, or other components may be added.**
- **Protective Coating: A layer applied to protect against moisture, temperature, and physical damage, ensuring circuit longevity and reliability.**

Key Advantages of Thick Film Hybrid Circuits :



- **Low CTE: With strong interatomic bonds, Thick film hybrid circuits endure high and fluctuating temperatures while remaining stable.**
- **Excellent Thermal Insulation: Thick film hybrid circuits reduce heat flow, protecting components from damage.**
- **Long-Term Reliability: Hybrids last decades, much longer than commercially packaged semiconductors.**
- **High Thermal Conductivity: Ceramic substrates dissipate heat effectively, improving performance and preventing heat-related damage.**
- **Multi-Layering: Additional layers can be added without compromising component safety, making them suitable for heavy-duty tasks.**
- **Integration Capability: Easily integrates with passive and active components, enhancing circuit functionality.**
- **Custom Packaging: Provides flexibility in shape, style, and performance improvements.**
- **Wide Application Range: Used in automotive, industrial, medical, consumer electronics, telecommunications, and more.**
- **Low Failure Rate: Exhibits lower failure rates under environmental stresses, ensuring long-lasting reliability.**

✿ Product Overview

Appilcations of Thick Film Hybrid Circuits :

1, Electronic Components:

- **Resistors, Voltage Dividers: Used to create precise resistors with adjustable resistance values.**
- **Capacitors, Diodes, Sensors: Utilized in miniaturized, high-density circuits.**

2, Automotive Electronics:

- **Control Systems: Employed in ECUs, sensor modules, and lighting controls due to their high-temperature and vibration resistance.**
- **Sensors: Used in automotive sensors like temperature, oxygen, and pressure sensors.**

3, Industrial Control:

- **Automation Systems: Applied in sensors and control circuits for stable, durable performance.**
- **Process Control: Used in instruments for measuring temperature, humidity, and pressure in harsh industrial environments.**

4, Aerospace:

- **Spacecraft and Satellites: Essential for mechanical strength, high-temperature, and radiation resistance.**
- **Navigation Systems: Used in inertial navigation, withstanding extreme radiation and temperature fluctuations.**

5, Optoelectronics and Laser Technology:

- **Laser Driver Circuits: Provide stable, efficient power management for high-power lasers.**
- **Optical Sensors: Used in sensors for monitoring light signals.**

6, Communication Equipment:

- **RF Modules: Applied in RF circuits, communication boards, and antennas, requiring high-temperature resistance.**
- **Satellite and Radar Systems: Used for their thermal stability and anti-interference properties.**

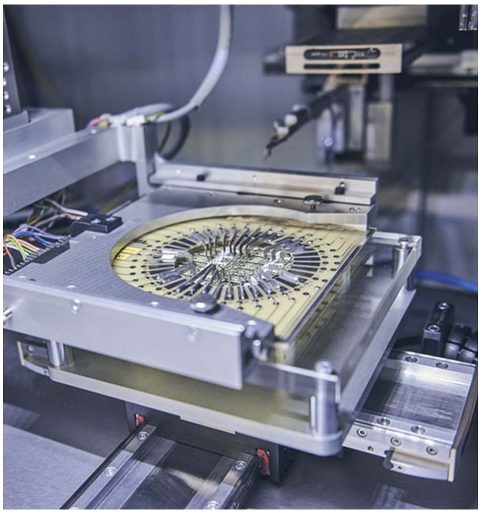
7, Consumer Electronics:

- **Home Appliances: Used in control modules for TVs, fridges, and air conditioners, operating reliably under heat and humidity.**
- **Mobile Devices: Helps increase circuit density in small, low-power devices.**

8, Military and Defense:

- **Weapon Systems: Used in missiles, radar, and communication systems for ruggedness and high-temperature resistance.**
- **Electronic Warfare: Used in circuits that require high-frequency, low-temperature, and anti-jamming features.**

Why Choose Custom Thick Film Hybrid Circuits ?



- **Tailored Performance: Custom designs are made to meet precise requirements, ensuring optimal performance for specific needs such as high-frequency or power applications.**
- **Cost Efficiency in High-Volume Production: Custom thick film hybrid circuits help streamline manufacturing processes, making them cost-effective for large-scale production while maintaining high quality.**
- **Flexibility in Design: Thick film hybrid circuits allow for direct integration of components such as resistors and capacitors onto the substrate, creating compact, space-efficient designs.**
- **Durability and Reliability: Custom thick film hybrid circuits are built to withstand harsh environments, including extreme temperatures and exposure to chemicals, ensuring long-lasting and reliable performance.**
- **Miniaturization of Devices: By combining multiple functions on a single substrate, custom thick film circuits help reduce the overall size of electronic devices, contributing to miniaturization.**
- **Specific Applications: These thick film hybrid circuits are designed for specialized fields like medical, aerospace, automotive, and telecommunications, ensuring they meet the precise demands of each industry.**

✿ Design Guidelines

Design Considerations of Thick Film Hybrid Circuit :

1, Material Selection:

- Choose appropriate substrates such as alumina, ceramics, or glass, based on the thermal, mechanical, and electrical requirements.
- Select conductive inks for resistors, capacitors, and conductors, ensuring they meet the necessary electrical properties.

2, Layout Design:

- Component Placement: Arrange components to minimize space while ensuring functionality.
- Trace Widths: Calculate trace widths to handle the required current and maintain signal integrity.
- Clearances: Maintain proper spacing between traces to prevent short circuits or interference.

3, Thermal Management:

- Design with heat dissipation in mind. Use larger surface areas for resistors, heat-sensitive components, or add heat sinks if necessary to manage high temperatures.

4, Electrical Performance:

- Ensure proper impedance matching and consider the electrical characteristics such as resistance, capacitance, and inductance.

5, Component Integration:

- Integrate passive components (resistors, capacitors) onto the substrate to save space and improve reliability.
- Ensure active components are securely bonded and shielded from environmental factors.

6, Manufacturing Considerations:

- Design with process limitations in mind, such as the feature sizes and resolution that the thick film process can achieve.
- Consider the thermal expansion properties of materials to avoid issues like cracking or delamination during production.

7, Environmental and Reliability Factors:

- Choose materials that can withstand environmental stressors like moisture, chemicals, and mechanical forces.
- Test your design under the expected operating conditions to ensure long-term reliability.

8, Cost Optimization:

- Optimize designs for high-volume production, minimizing complexity and reducing material costs.

1, Engineering Specification

Items:	Typical Values	Advanced Capabilities
1, Substrates :	FR4, Ceramic (Al203, ALN, BeO, ZrO2), Polyimide (Flexible PI), Stainless Steel	FR4, Ceramic (Al203, ALN, BeO, ZrO2), Polyimide (Flexible PI), Stainless Steel
2, Conductor (Paste) Materials :	Copper, Silver , Gold , Silver-Palladium, Palladium-Gold, Platinum-Silver, Platinum-Gold	Copper, Silver , Gold , Silver-Palladium, Palladium-Gold, Platinum-Silver, Platinum-Gold
3, Thick Film Carbon Thickness :	15um +/-5 um	30um +/-5 um
4, Conductors Thickness :	12um+/-5um	20um+/-5um
5, Min Width of Thick Film Line :	0.30 mm +/-0.05 mm	0.20 mm +/-0.05 mm
6, Min Space of Thick Film Line :	0.30mm +/-0.05 mm	0.20 mm +/-0.05 mm
7, Min Overlap (Carbon to Conductor) :	No less than 0.25mm	0.20mm (Minimum)
8, Sheet Resistivity (ohms/square):	Printed resistors in milli ohm to mega ohm range (Customizable) with tolerances of 1-10% are fabricated and protected with overglaze materials.	Printed resistors in milli ohm to mega ohm range (Customizable) with tolerances of 0.5-10% are fabricated and protected with overglaze materials.
9, Resistor Value Tolerance (ohms) :	+/-10.0% (Standard) (Customizable)	+/-0.5% (Laser trimming)
10, Linearity :	+/-1.0% (Standard) (Customizable)	+/-0.2 ~ +/-0.5% (Laser trimming)
11, Synchronism of Double Channels :	+/-2.0% (Standard) (Customizable)	+/-1.0% (Laser trimming)
12, Durability of Carbon Ink (Life time) :	0.5 Million (Min), 2.0 Million (Standard)	5.0-10.0 Million (Max) with Surface Polishing
13, Working Temperature :	- 40°C / + 150°C	- 40°C / + 180°C

2, Optional Metallization Processes

Metalization Types :	Thick Film Substrates (Screen-Printed)		Thin Film Substrates (Photo-Imaged)		
Process Types :	TFM Capabilities	HTCC / LTCC Capabilities	DBC Capabilities	DPC Capabilities	AMB Capabilities
Layer Counts :	1, 2, 3, 4, 5, 6 Layers	1, 2, 4, 6, 8, 10, 12 Layers	1, 2 Layers	1, 2 Layers	1, 2 Layers
Max Board Dimension :	200*230mm	200*200mm	138*178mm	138*190mm	114*114mm
Min Board Thickness :	0.25mm	0.25mm	0.30mm~0.40mm	0.25mm	0.25mm
Max Board Thickness :	2.2mm	2.0mm	2.0mm	2.0mm	1.8mm
Conductor Thickness :	10um - 20um	5um - 1500um	1oz - 9oz	1um - 1000um	1oz- 22oz
Min Line Width/Space :	8/8mil (0.20/0.20mm)	6/6mil (0.15/0.15mm)	10/10mil (0.25/0.25mm)	6/6mil (0.15/0.15mm)	12/12mil (0.30/0.30mm)
Substrates Types :	Al203, ALN, BeO, ZrO2	Al203, ALN, BeO, ZrO2	Al2O3, AlN, ZrO2, PbO, SiO2, ZTA, Si3N4, SiC, Sapphire, Polycrystalline Silicon, Piezoelectric Ceramics	Al2O3, AlN, ZrO2, PbO, SiO2, ZTA, Si3N4, SiC, Sapphire, Polycrystalline Silicon, Piezoelectric Ceramics	Al203, ALN, BeO, ZrO2, Si3N4
Min Hole Diameter :	4mil (0.15mm)	4mil (0.15mm)	4mil (0.1mm)	4mil (0.1mm)	4mil (0.1mm)
Outline Tolerance :	Laser: +/-0.05mm	Laser: +/-0.05mm	Laser: +/-0.05mm	Laser: +/-0.05mm	Laser: +/-0.05mm
	Die Punch: +/-0.10mm	Die Punch: +/-0.10mm	Die Punch: +/-0.10mm	Die Punch: +/-0.10mm	Die Punch: +/-0.10mm
Substrate Thickness :	0.25, 0.38, 0.50, 0.635, 0.80,1.0, 1.25, 1.5, 2.0mm, Customizable	0.25, 0.38, 0.50, 0.635, 0.80,1.0, 1.25, 1.5, 2.0mm, Customizable	0.25, 0.38, 0.50, 0.635, 0.80,1.0, 1.25, 1.5, 2.0mm, Customizable	0.25, 0.38, 0.50, 0.635, 0.80,1.0, 1.25, 1.5, 2.0mm, Customizable	0.25, 0.38, 0.50, 0.635, 0.80,1.0, 1.25, 1.5, 2.0mm, Customizable
Thickness Tolerance :	0.25-0.38: +/-0.03mm	0.25-0.38: +/-0.03mm	0.25-0.38: +/-0.03mm	0.25-0.38: +/-0.03mm	0.25-0.38: +/-0.03mm
	0.50-2.00: +/-0.05mm	0.50-2.00: +/-0.05mm	0.50-2.00: +/-0.05mm	0.50-2.00: +/-0.05mm	0.50-2.00: +/-0.05mm
Surface Treatment :	Ag, Au, AgPd, AuPd	Ag, Au, AgPd, AuPd	OSP/Ni Plating, ENIG	OSP/ENIG/ENEPIG	OSP/ENIG/ENEPIG
Min Solder PAD Dia :	10mil (0.25mm)	10mil (0.25mm)	8mil (0.20mm)	6mil (0.15mm)	8mil (0.20mm)


3, Optional Substrates

Substrates :	Alumina (Al2O3)	Aluminum Nitride (AlN)	Beryllium Oxide (BeO)	Zirconium Dioxide (ZrO2)
Max Application Temperature :	662 - 1832	1832	2300	2432
Max Power Density (W/in²):	75	1010	250	300
Max Ramp Up Speed (°F/sec):	122	572	400	350
Thermal Conductivity (W/mK):	20-35	180-220	200-300	2.0-5.0
Density (g/cm³):	3.75	3.26	2.8	5.9
Dielectric Loss:	0.0001 - 0.001	0.0001 - 0.0005	0.0001 - 0.0002	0.0005 - 0.001
Dielectric Constant:	9.4 - 10.2	8.5 - 9.0	6.0 - 7.0	25 - 30
CTE, ppm/°C:	6.0 - 8.0	4.0 - 5.0	7.0 - 9.0	10.0 - 11.0
Substrate Thickness (mm):	0.25 - 2.0	0.25 - 2.0	0.25 - 2.0	0.25 - 2.0
Typical Max. Dimension (inch):	6 x 12	5 x 11	6 x 6	4 x 4
Theoretical Total Wattage (W):	5400	55000	15000	20000

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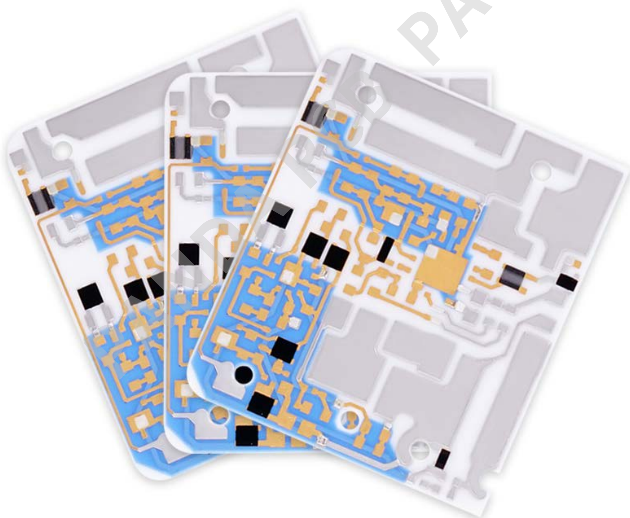

4, Conductive Paste

Paste (Materials) :	Conductor Width/Space	Soldering / Bonding
Gold :	8/8mil (0.20/0.20mm)	Gold is a good conductor material and allows thermo-compression gold wire bonding and eutectic die attachment. It is, of course, costly and has poor solderability.
Silver :	8/8mil (0.20/0.20mm)	Soldering & Silver is lower in cost, and solderable, but is not leach-resistant with tin/lead solders.More seriously, silver atoms migrate under the influence of DC electric fields, both causing short-circuits and reacting with many of the resistor paste formulations.
Platinum-Silver :	6/6mil (0.15/0.15mm)	Soldering & Surface Mount, Palladium and platinum alloyed to the gold and silver produce good conductor pastes,with good adhesion to the substrate, good solderability, and moderately good wire bonding characteristics.. Copper and nickel are examples of materials that have been proposed for paste systems as substitutes for noble metals.
Palladium-Silver :	8/8mil (0.20/0.20mm)	Soldering & Surface Mount ,Solderable, Wire bondable, (good aged adhesion general purpose), Silver-palladium conductor inks are the most commonly used materials, with both price and performance (primarily resistance to solder) increasing with palladium content.
Platinum-Gold :	6/6mil (0.15/0.15mm)	Soldering & Au or Al Wire Bonding, Solderable (excellent aged adhesion with no migration).
Palladium-Gold :	8/8mil (0.20/0.20mm)	Soldering & Au or Al Wire Bonding, Wire bondable.

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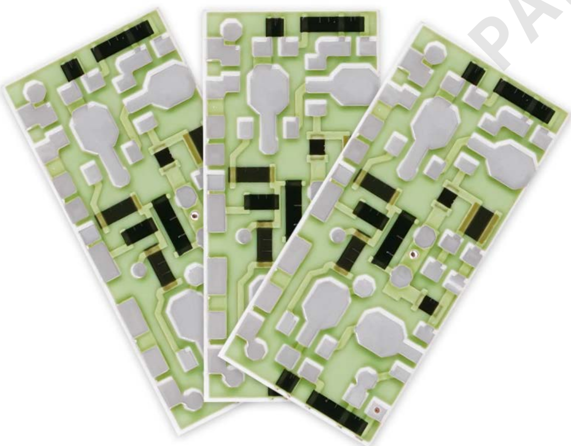
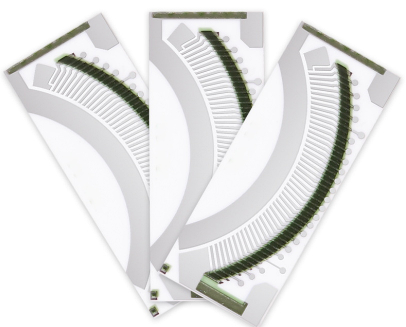
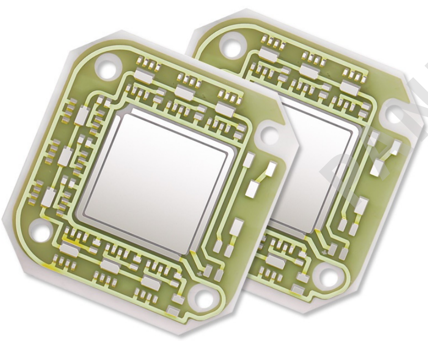
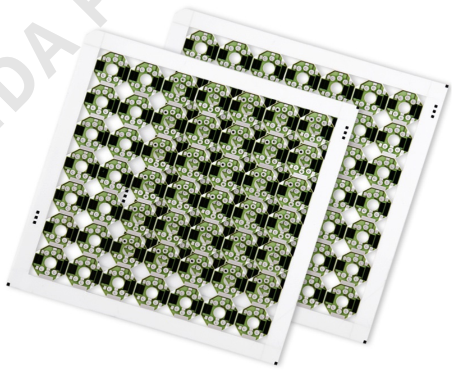


5, Resistive Paste

Performances :	Common Values/Range	Description
Resistance Value :	1Ω to several MΩ	The resistance value depends on the type and ratio of carbon black, typically ranging from 1Ω to Mega ohm.
Resistance Tolerance :	±1% to ±10%	High-precision resistors can achieve ±0.1% tolerance used laser trimming process.
Temperature Coefficient (TCR) :	±50ppm/°C to ± 200ppm/°C	High-quality resistive paste should have a low TCR, preferably below ± 100ppm/°C.
Stability :	≤1%	Resistors must undergo high-temperature aging and humidity tests to ensure stability.
Sintering Temperature :	850°C to 950°C	The sintering temperature for carbon paste depends on material properties, typically in this range.
Conductivity :	10^6 S/m to 10^8 S/m	Conductivity depends on the type and ratio of carbon black, affecting resistance precision and stability.
Surface Smoothness :	Ra≤ 1 μm	The surface must be free of cracks, bubbles, and non-uniform layers to ensure good mechanical and electrical properties.
Insulation Resistance :	≥10^9 Ω	Carbon paste should have good insulation properties to avoid leakage or short circuits.
Mechanical Strength :	≥100 MPa	The resistive layer must have good compressive and bending strength to ensure the reliability of the resistor.
Volatility :	Solvent residue ≤ 1%	High volatility solvents help with even coating and drying, but excessive volatility may affect electrical performance.
Oxidation Resistance :	>1000 hours	High-quality carbon paste should have strong oxidation resistance to extend the service life.
Humidity Resistance :	≥1000 hours	Resistors should be able to withstand high-humidity conditions to ensure long-term stable performance, no significant changes.

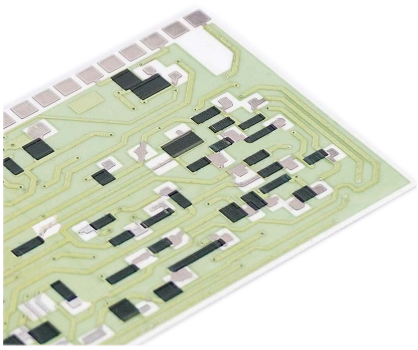
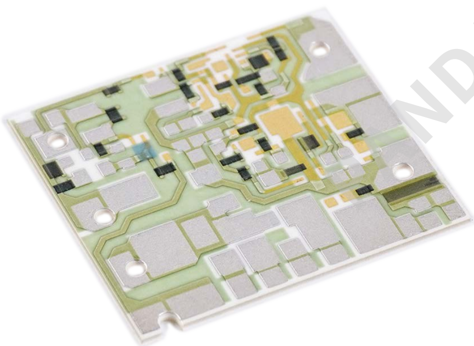
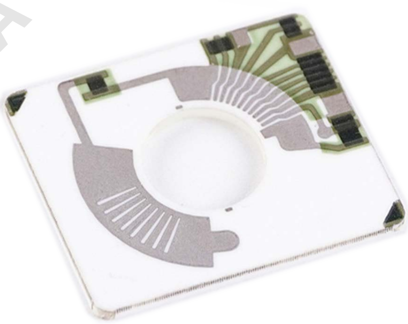






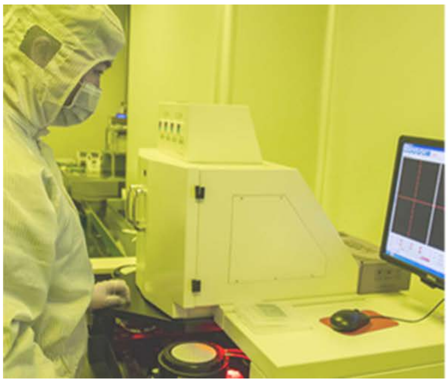
6, Dielectric Paste

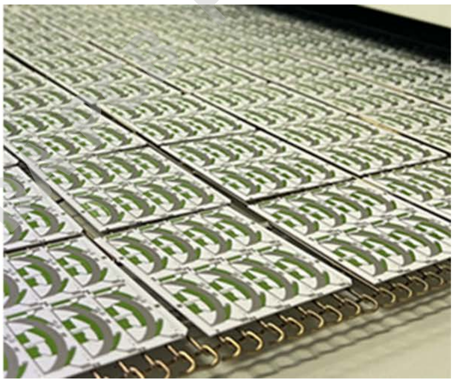
Performances :	Typical Value	Explanation
Material Types :	Epoxy Resin, Polyimide, Polyurethane, Polytetrafluoroethylene	These resin types are commonly used to manufacture dielectric materials, providing good electrical insulation, thermal stability, and mechanical strength.
Dielectric Constant (εr) :	3 ~ 4.5 (Epoxy), 3.0 ~ 3.5 (PI), 2.1 ~ 2.5 (PTFE)	Epoxy and polyimide are typically used in low-to-medium frequency circuits, while PTFE is preferred for high-frequency applications due to its lower dielectric constant.
Insulation Resistance :	≥ 10^{12} Ω•cm	Resin-based materials usually exhibit extremely high insulation resistance, effectively isolating electrical currents and preventing leakage.
Dielectric Loss :	≤ 0.01 (Epoxy), ≤ 0.005 (PI), ≤ 0.0002 (PTFE)	Polyimide and PTFE have lower dielectric loss, making them ideal for high-frequency applications.
Operating Temperature :	-55 ~ +180°C (Epoxy), -50 ~ +250°C (PI), -200 ~ +260°C (PTFE)	The sintering temperature for carbon paste depends on material properties, typically in this range.
Sintering Temperature :	150 ~ 200°C	Resin-based dielectric materials require lower sintering temperatures, making them more energy-efficient compared to ceramic materials.
CTE, ppm/°C :	20 ~ 60 × 10^{-6} (Epoxy), 10 ~ 40 × 10^{-6} (PI), 100 ~ 200 × 10^{-6} (PTFE)	PTFE has a higher thermal expansion coefficient but offers excellent chemical stability and corrosion resistance. Epoxy and polyimide have lower coefficients, making them more thermally stable.
Volume Resistivity :	≥ 10^{13} Ω•cm	Resin materials typically have very high volume resistivity, making them ideal for electrical isolation applications.
Surface Resistivity :	≥ 10^{9} Ω•cm	Resin materials exhibit high surface resistivity, ensuring that surface leakage currents are minimized.
Thermal Conductivity :	0.2 ~ 0.3W/m•K (Epoxy), 0.2 ~ 0.3W/m•K (PI), 0.1 ~ 0.3W/m•K (PTFE)	Resin materials have low thermal conductivity, requiring additional heat dissipation designs to ensure thermal stability.
Adhesion Strength :	≥ 20 N/cm²	Epoxy resin has good adhesion strength, making it suitable for various substrates, such as metal and ceramics.

7, Insulating Paste

Material Types :	Glass Enamel (Overglaze)	Epoxy Resin	Organic Polymers (Polyurethane, Polystyrene)
Insulation Resistance :	≥ 10^{12} Ω•cm	≥ 10^{12} Ω•cm	≥ 10^{12} Ω•cm
Dielectric Constant (εr) :	5 ~ 7	3 ~ 4.5	2 ~ 3.5
Dielectric Loss :	≤ 0.01	≤ 0.01	≤ 0.01
Operating Temperature :	-40 ~ +450 °C	-55 ~ +180 °C	-40 ~ +150 °C
Sintering Temperature :	600 ~ 800 °C	150 ~ 200 °C	120 ~ 180 °C
Thermal Conductivity :	1.0 ~ 1.5 W/m•K	0.2 ~ 0.3 W/m•K	0.1 ~ 0.3 W/m•K
CTE, ppm/°C :	30 ~ 50 × 10^{-6} /°C	30 ~ 60 × 10^{-6} /°C	50 ~ 150 × 10^{-6} /°C
Density :	2.5 ~ 3.0 g/cm³	1.1 ~ 1.4 g/cm³	1.1 ~ 1.4 g/cm³
Adhesion Strength :	High (suitable for metal substrates)	High, good adhesion properties	Medium (depends on polymer type)
Chemical Stability :	Excellent, resistant to acids, alkalis, and solvents	Good, resistant to most chemicals, but sensitive to some solvents	Moderate, some polymers like PVC have strong chemical resistance
Arc Resistance :	Excellent	Good	Moderate
Mechanical Strength :	High (hard and brittle)	Medium, good flexibility	Low, but good flexibility
Characteristics :	High-temperature sintering, excellent electrical insulation, good thermal and chemical stability	Low-temperature sintering, good adhesion and flexibility, good chemical resistance	Good flexibility, suitable for flexible circuits, but poor high-temperature performance





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