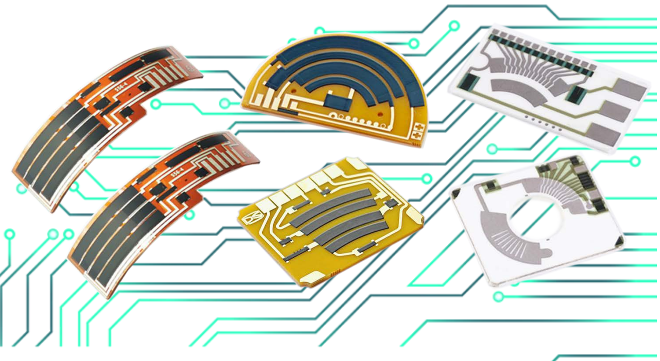
PANDA PCB

EXCELLENCE IN THICK FILM SENSORS

Thick Film Sensors Product Introduction



✿ **Product Overview**

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✿ Product Overview

What are Thick Film Sensors ?

Thick Film Sensors are sensor elements made using thick film technology to detect and measure physical parameters such as position, angle, temperature, pressure, humidity, and gas concentration; these sensors are produced through a cost-effective process in which thick film materials are applied to a circuit board to form functional sensing elements, ensuring high stability, durability, and widespread use in various industrial and commercial applications while maintaining cost-efficiency.

Thick Film Sensors offer versatility, allowing for the creation of sensors with a wide range of functions. By incorporating different materials and adjusting the composition of the thick film paste, these sensors can be customized to detect various physical or chemical stimuli.

Main Types of Thick Film Sensors :

1, Thick Film Resistive Sensors:
These sensors utilize the change in resistance of the thick film material for detection. When the sensor is exposed to a stimulus (e.g., temperature, pressure, or a specific gas), the physical or chemical properties of the thick film material alter, leading to a resistance change. This alteration can be measured and correlated to the intensity of the stimulus.

2, Thick Film Potentiometric Sensors:
Potentiometric sensors, like pH sensors, measure the potential difference (voltage) across a sensor electrode and a reference electrode. In thick film potentiometric sensors, the sensing electrode is often made from a thick film material sensitive to the ion concentration in the tested solution. The potential change is proportional to the ion concentration, enabling the determination of pH or other ionic concentrations.

3, Thick Film Thermistors:
Thermistors are temperature-sensitive resistors. In thick film thermistors, the resistance of the thick film material varies with temperature. The thermistor's resistance can either increase or decrease with temperature, depending on the material's characteristics (NTC for negative temperature coefficient and PTC for positive temperature coefficient). By measuring the resistance, the temperature can be determined.

4, Thick Film Gas Sensors:
Gas sensors often depend on the interaction between the target gas and the thick film material, leading to a change in the material's electrical properties. This change can be in resistance, as in resistive sensors, or in the work function, detectable as a voltage change in potentiometric sensors.

5, Thick Film Capacitive Sensors:
Capacitive sensors rely on changes in capacitance between two conductive layers separated by a dielectric material. In thick film sensors, one or both of the conductive layers may consist of thick film materials. When a stimulus affects the dielectric properties of the material (such as humidity or a change in permittivity due to a chemical reaction), the capacitance between the layers changes. This alteration in capacitance is then measured and utilized to determine the presence or concentration of the target stimulus.

✿ Product Overview

Advantages of Thick Film Sensors :

- **Cost-Effectiveness:** Thick film sensors are cost-effective compared to thin film or MEMS sensors, thanks to screen-printing techniques that enable mass production.
- **Versatility:** These sensors can measure various physical parameters like temperature, pressure, humidity, and position, making them suitable for diverse applications from automotive to environmental monitoring.
- **Ruggedness and Reliability:** Thick film sensors are durable, resistant to mechanical stress and damage, ensuring long-lasting reliability.
- **Customization and Flexibility:** The thick film process allows easy customization to meet specific application needs, offering flexibility in sensitivity ranges and environmental adaptability.
- **Integration Capability:** Thick film sensors integrate multiple functions onto a single substrate, creating compact, efficient systems.
- **Simplicity of Processing:** Processing is simple, enabling quick prototyping and faster product development.
- **Robustness and Durability:** Thick film sensors perform well in harsh environments, such as extreme temperatures, humidity, and corrosive conditions, ideal for industrial and automotive use.
- **Low Power Consumption:** Many thick film sensors use minimal power, making them suitable for energy-efficient applications like wireless networks and portable devices.
- **Ease of Fabrication:** Fabrication is simple and does not require the precision or cleanroom conditions of other sensor types, reducing manufacturing complexity.

Applications of Thick Film Sensors :

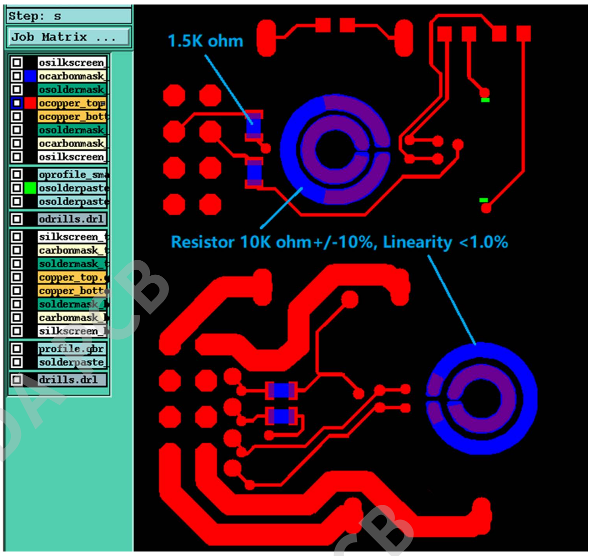
- **Automotive Industry:** Thick film sensors are used in automotive applications like fuel level sensing, throttle position, and airbag deployment. Their resistance to harsh conditions, including temperature fluctuations and chemicals, makes them ideal for these uses.
- **Environmental Monitoring:** These sensors detect gases and pollutants, thriving in outdoor conditions and extreme weather, making them reliable for long-term monitoring.
- **Medical Diagnostics:** Thick film sensors are used in devices like blood glucose monitors, offering the stability and precision needed for accurate medical readings.
- **Consumer Electronics:** Used in products like temperature and touch sensors, thick film sensors are compact, cost-effective, and ideal for consumer electronics.
- **Aerospace and Defense:** Thick film sensors meet the extreme demands of aerospace and defense, working in high altitudes, pressures, and temperatures for applications like aircraft control systems and space probes.
- **Industrial Process Control:** These sensors monitor pressure, temperature, and humidity in extreme environments, offering durability and reliability for industrial process control.
- **Energy Management:** Used in smart meters and solar panels, thick film sensors help monitor and control energy consumption and production, ensuring long-term stability.
- **Smart Packaging:** In packaging, thick film sensors enable smart solutions for monitoring product freshness and environmental factors, easily integrating into materials without affecting functionality.

✿ Design Guidelines

Design Guidelines :

Thick Film Sensors design involves various aspects, from electrical performance to manufacturing details that require careful planning. First, engineering design specifications are crucial for the stability and reliability of the circuit. During the design process, factors such as minimum trace width, spacing, the minimum footprint of the carbon film resistor, sheet resistivity, and resistor value tolerance must be considered.

Material selection plays a decisive role in the manufacturing and performance of thick film resistors. Common substrates include PI (polyimide), ceramics (e.g., Al2O3), and FR4, with ceramics being widely used due to their excellent thermal management and electrical isolation properties. The choice of conductive paste, resistor paste, dielectric paste, and insulating paste directly impacts the temperature stability, long-term drift characteristics, and mechanical stress resistance of the resistor. The design must not only consider the electrical and thermal properties of the materials but also assess their compatibility and the manufacturability of the process to ensure the production of high-quality thick film resistors with long-term stability and efficiency.



1, Engineering Specification

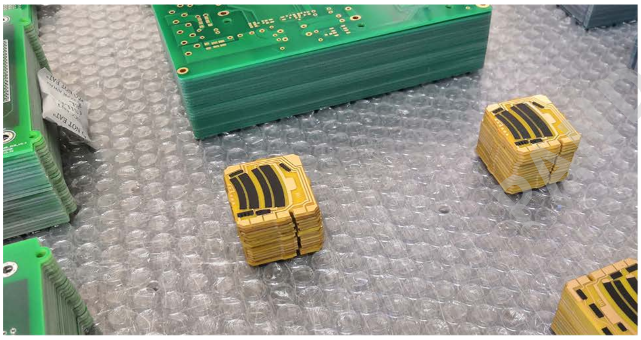
Items:	Typical Values	Advanced Capabilities
1, Substrates :	FR4, Ceramic (Al203, ALN, BeO, ZrO2), Polyimide (Flexible PI), Stainless Steel (SUS304), Mica	FR4, Ceramic (Al203, ALN, BeO, ZrO2), Polyimide (Flexible PI), Stainless Steel (SUS304), Mica
2, Conductor (Paste) Materials :	Copper, Silver , Gold , 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

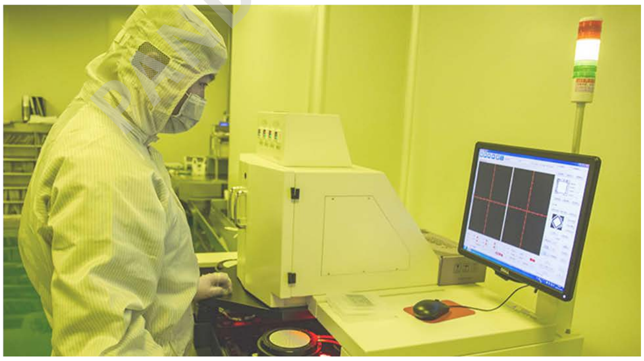
2, Optional Metallization Processes

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 Layers	1, 2 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	Al2O3, AlN, ZrO2, PbO, SiO2, ZTA, Si3N4, SiC, Sapphire, Polycrystalline Silicon, Piezoelectric	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, Ceramic Substrates

Substrates :	Alumina (Al_2O_3)	Aluminum Nitride (AlN)	Beryllium Oxide (BeO)	Zirconium Dioxide (ZrO_2)
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

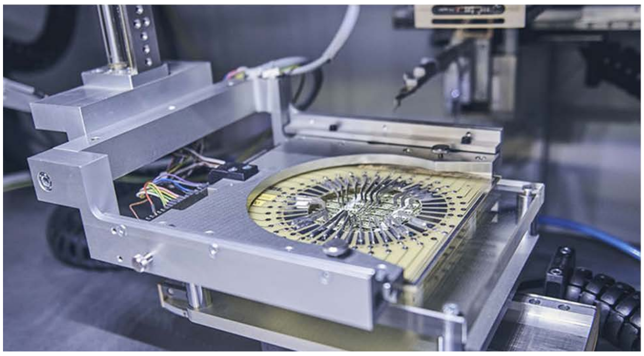




4, Conductive Paste

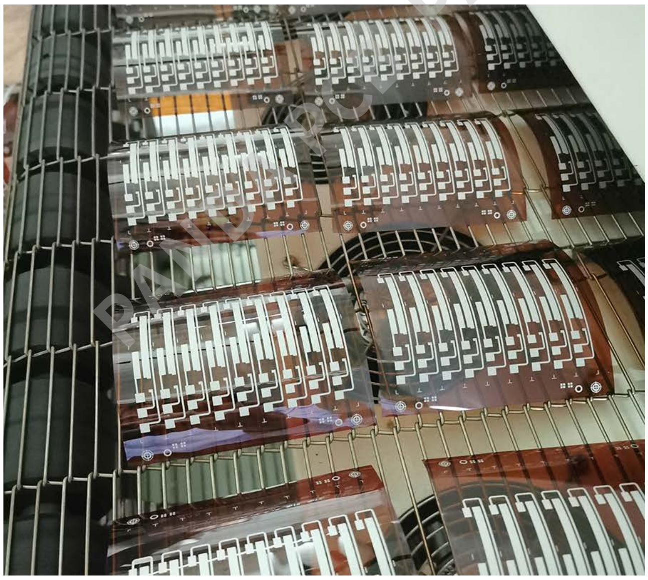
Paste (Materials) :	Conductor Width/Space	Soldering / Bonding
Gold :	8/8mil (0.20/0.20mm)	Gold is a good conductor material and allows thermo-compression gold wire bonding and eutectic die attachment. It is, of course, costly and has poor solderability.
Silver :	8/8mil (0.20/0.20mm)	Soldering & Silver 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.





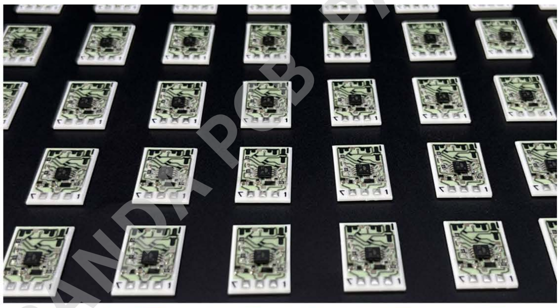

5, Resistive Paste

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 :	$\geq 10^{12}$ Ω•cm	$\geq 10^{12}$ Ω•cm	$\geq 10^{12}$ 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