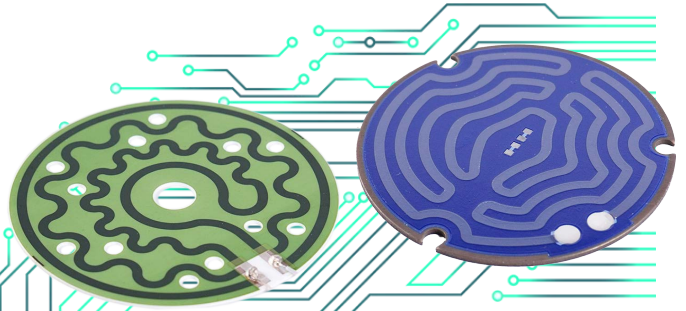


## Thick Film Heaters Product Introduction



### ❁ Product Overview



### ❁ Design Guidelines



# ❁ Product Overview

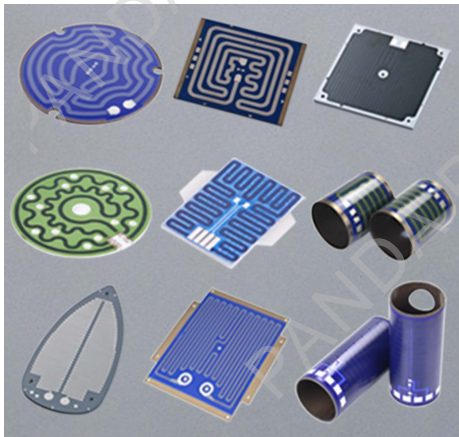
## What are Thick Film Heaters ?

**Thick Film Heaters** are efficient heating elements that use advanced thick film technology to print dielectric, resistive, conductive, and insulating materials onto flexible PI, ceramic, or stainless steel substrates, with a manufacturing process that involves precise material mixing, layer-by-layer printing, high-temperature sintering, and laser trimming to optimize heater design and performance, ensuring excellent resistance to high temperatures, wear, and corrosion for stable long-term operation in harsh environments.

**Thick Film Heaters** work by converting electrical energy into thermal energy. When current flows through the heating element, the resistive material generates heat, warming the surrounding environment. Their design allows for precise control of heating power and customization of shapes and sizes to meet various application needs.



## Main Types of Thick Film Heaters :



- **Ceramic-Thick Film Heaters:**

These heaters can withstand high temperatures (up to 1800°F) and are highly corrosion-resistant. Using screen printing technology, they offer customizable heating patterns, making them ideal for harsh environments.

- **Stainless Steel-Thick Film Heaters:**

Combining thick-film technology with stainless steel, these heaters provide excellent durability, corrosion resistance, and efficient heat transfer, making them perfect for demanding industrial applications.

- **Flexible Heaters (PI Heater and PET Heater):**

Made from polyimide (PI) or PET, these thin, lightweight, and flexible heaters adapt to various shapes and spaces. They heat quickly and are commonly used in automotive, medical, and electronics industries.

- **Mica Heaters:**

Constructed with mica insulation, these heaters offer excellent heat resistance and electrical insulation, making them ideal for high-temperature industrial processes requiring consistent heat and precision.

## Key Advantages of Thick Film Heaters :

- **No Electrical Complications:** Printed patterns reduce electrical inductance and capacitance found in wound resistance wires.
- **High Operating Temperature:** Ceramic thick-film heaters can operate up to 1800°F.
- **Corrosion Resistant:** Ceramic thick-film heaters excel in corrosive environments, while heaters develop a corrosion-resistant oxide layer.
- **Long Life:** With proper operation, thick-film heaters have a long service life. They last longer when operated below their maximum temperature rating.
- **Customizable Heating Patterns:** Allowing tailored heat distribution for uniform heating or varying power densities.
- **Lightweight:** Thin and lightweight, thick-film heaters provide rapid heating and energy-efficient performance.
- **Low Thermal Mass:** Ideal for rapid thermal response, thick-film heaters heat quickly with minimal energy.
- **Maximum Heat Transfer:** Direct surface contact ensures efficient heat transfer via conduction through thermally stable substrates.
- **Flexible Form Factors:** Customizable shapes and geometries to fit specific heating patterns and areas.

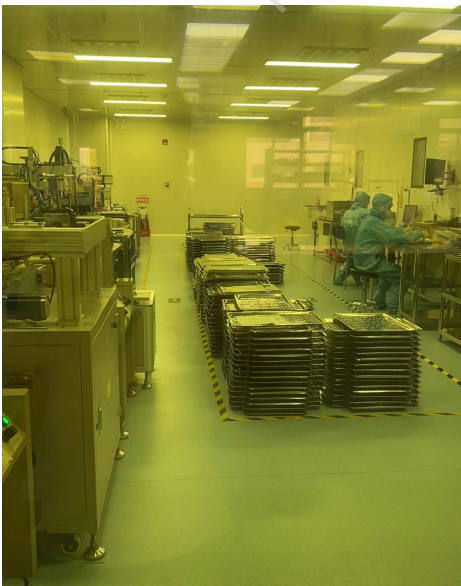




# ❁ Product Overview

## Applications of Thick Film Heaters :

- **Industrial:** Electronic enclosures, plastic fabrications, water heating, packaging lines, and hot plates.
- **Food and Beverage Equipments:** Hot food displays, warming trays, storage warming, holding cabinets, brewing temperature maintenance, and portable food delivery.
- **Aviation and Transportation:** Instrumentation, oil and battery heating, personal comfort, deicers, over the road truck and railcar freeze protection.
- **Food Service:** Warming holding cabinets, fryer systems, display shelves, prep stations, grilling platters, heated dishware, and appliances.
- **Automotive:** Cabinet comfort heating, battery warming, fuel cell temperature maintenance, motor heating, mirror defogging, steering wheel and seats heating, door handle de-freezing, and coolant heaters.
- **Medical and Life Sciences:** Instrument warming, MRI equipment, temperature therapy, dialysis, CPAP, surgical devices, vessel sealer, DNA analysis and testing, blood diagnostics, blood and fluid warming, and sterilization.
- **Analytical Instruments and Research Institutions:** Imaging equipment, thermal analysis, chromatography, spectrometers, separation and membrane sciences.
- **Semiconductor:** High temperature burn-in and testing equipment, water heating, wafer chuck heaters.
- **Security:** Explosives detection, alcohol detection, chemical detection, and cameras lens defogging.
- **Printers:** Thermal printers, 3D-Printers, card printers, laser printers, commercial and industrial printers.
- **Health and Beauty Appliances:** Skin spa and facial steamer, heating pads and blankets, personal hair styling and drying tools, heating body and foot massager, and sauna belts.



## Why Choose Custom Thick Film Heaters ?

- **Precision and Accuracy:** Custom heaters meet specific power, temperature, and response time needs for precise performance.
- **Application-Specific:** Customization allows heaters to fit unique shapes, sizes, and configurations for any application.
- **Material Compatibility:** Custom materials ensure compatibility with surrounding components, improving reliability and lifespan.
- **Efficiency and Energy Use:** Optimized for energy efficiency, reducing power consumption and costs without sacrificing performance.
- **Reliability and Durability:** Built to withstand harsh conditions, custom heaters offer greater reliability than off-the-shelf options.
- **Thermal Performance:** Tailored designs provide better heat distribution and faster heat-up times, crucial for many applications.
- **Integration with Control Systems:** Custom heaters can integrate with control systems for precise temperature management in sensitive processes.
- **Regulatory Compliance:** Designed to meet specific industry standards, ensuring legal compliance.
- **Cost-Effectiveness:** Though initially more expensive, customization reduces long-term costs by minimizing modifications and replacements.
- **Innovation:** Custom heaters enable innovative solutions, keeping companies competitive in the market.

# ✿ Design Guidelines

## Design Guidelines :

**1, Substrate Selection:** Choosing the appropriate substrate material is essential for thermal stability and compatibility with the application environment. Common substrate materials include alumina (Al<sub>2</sub>O<sub>3</sub>), aluminum nitride (AlN) and stainless steel, known for their excellent thermal conductivity and mechanical strength.

**2, Thermal Design:** Effective thermal management is critical to prevent overheating and ensure uniform temperature distribution across the heater surface. Factors such as substrate thickness, heater layout, and heat sink integration must be carefully considered to achieve desired thermal performance.

**3, Material Selection:** Selecting high-quality thick film materials is vital for achieving desired electrical and thermal properties. Materials such as resistive pastes, dielectric layers, and protective coatings must be chosen based on their temperature stability, electrical conductivity, and compatibility with the substrate material.

**4, Heater Configuration:** The design of the heater element, including its size, shape, and pattern, directly influences its heating characteristics and efficiency. Optimizing the heater configuration involves balancing factors such as heating uniformity, power density, and space constraints within the application.

**5, Electrical Considerations:** Proper electrical design is essential to ensure safe and reliable operation of the thick film heater. This includes selecting appropriate voltage ratings, current-carrying capacity, and insulation techniques to minimize the risk of electrical breakdown and ensure compliance with regulatory standards.

**6, Environmental Compatibility:** Printed Thick Film Heaters may be subjected to various environmental conditions, including moisture, corrosive gases, and mechanical stress. Design considerations should include measures to enhance the heater's resistance to environmental factors, such as encapsulation, conformal coatings, and protective housings.

**7, Manufacturability and Cost:** Designing for manufacturability involves optimizing the manufacturing process to achieve high yield rates and minimize production costs. Considerations such as material utilization, process efficiency, and automation can significantly impact the overall cost-effectiveness of Thick Film Printed Heater production.

## 1, Unique Characteristics of Each Type Substrates

Substrates :	Alumina (Al <sub>2</sub> O <sub>3</sub> )	Aluminum Nitride (AlN)	Beryllium Oxide (BeO)	Aluminum (Al)	Stainless Steel
Max Application Temperature :	662 - 1832	1832	2300	302	1202
Max Power Density (W/in <sup>2</sup> ):	75	1010	250	400	200
Max Ramp Up Speed (°F/sec):	122	572	400	302	315
Thermal Conductivity (W/mK):	20-35	180-220	200-300	173	15
Density (g/cm <sup>3</sup> ):	3.75	3.26	2.8	2.7	7.8
Dielectric Loss:	0.0001 - 0.001	0.0001 - 0.0005	0.0001 - 0.0002	/	/
Dielectric Constant:	9.4 - 10.2	8.5 - 9.0	6.0 - 7.0	/	/
CTE, ppm/°C:	6.0 - 8.0	4.0 - 5.0	7.0 - 9.0	24	5.8
Substrate Thickness (mm):	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	0.6, 1.0, 1.2, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 6.0, 8.0, 10.0mm, Customizable
Theoretical Total Wattage (W):	5400	55000	15000	115200	57600

## 2, 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.





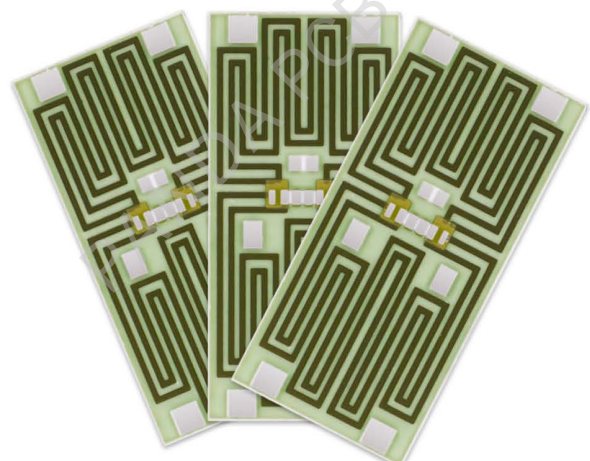
### 3, Resistive Paste

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 <sup>4</sup> S/m to 10 <sup>8</sup> 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 <sup>9</sup> 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.



## 4, 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 ( $\epsilon_r$ ) :	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 :	$\geq 10^{12} \Omega \cdot \text{cm}$	Resin-based materials usually exhibit extremely high insulation resistance, effectively isolating electrical currents and preventing leakage.
Dielectric Loss :	$\leq 0.01$ (Epoxy), $\leq 0.005$ (PI), $\leq 0.0002$ (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 $\times 10^{-6}$ (Epoxy), 10 ~ 40 $\times 10^{-6}$ (PI), 100 ~ 200 $\times 10^{-6}$ (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 :	$\geq 10^{13} \Omega \cdot \text{cm}$	Resin materials typically have very high volume resistivity, making them ideal for electrical isolation applications.
Surface Resistivity :	$\geq 10^9 \Omega \cdot \text{cm}$	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 :	$\geq 20 \text{ N/cm}^2$	Epoxy resin has good adhesion strength, making it suitable for various substrates, such as metal and ceramics.



## 5, Insulating Paste

Material Types :	Glass Enamel (Overglaze)	Epoxy Resin	Organic Polymers (Polyurethane, Polystyrene)
Insulation Resistance :	$\geq 10^{12} \Omega \cdot \text{cm}$	$\geq 10^{12} \Omega \cdot \text{cm}$	$\geq 10^{12} \Omega \cdot \text{cm}$
Dielectric Constant ( $\epsilon_r$ ) :	5 ~ 7	3 ~ 4.5	2 ~ 3.5
Dielectric Loss :	$\leq 0.01$	$\leq 0.01$	$\leq 0.01$
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 :	$30 \sim 50 \times 10^{-6} / ^\circ\text{C}$	$30 \sim 60 \times 10^{-6} / ^\circ\text{C}$	$50 \sim 150 \times 10^{-6} / ^\circ\text{C}$
Density :	2.5 ~ 3.0 g/cm <sup>3</sup>	1.1 ~ 1.4 g/cm <sup>3</sup>	1.1 ~ 1.4 g/cm <sup>3</sup>
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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