DUREX INDUSTRIES

closing the loop on thermal solutions

ISO 9001 REGISTERED COMPANY

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Advanced Ceramic Heater Thermal Solutions

Rapid Fire™ Aluminum Nitride (AIN) Heaters

Durex Industries' Rapid Fire aluminum nitride (AIN) ceramic heater solutions combine the thermal conductivity of aluminum and dielectric strength of specialty ceramics with physical properties similar to stainless steel. Additionally, a tungsten (W) RTD Sensor is integrated into the multi-layer heater construction to provide maximum control of this high watt density heater. New levels of machine design and thermal performance can be achieved through the excellent thermal, dielectric and physical properties of AIN heaters.

Ceramic heater technologies offer significant advantages over metal based sheath heaters that have limitations in thermal performance or material compatibility. Durex' ceramic heaters can operate in atmospheric and vacuum environments up to 1000°C (1832°F). With its excellent thermal conductivity, AIN heaters can be designed with a multi-layer construction that can deliver up to 2000 W/in^2 (310 W/cm^2). With chemical resistance to most acidic and alkaline solutions, these compact robust heaters are an ideal solution for demanding thermal applications. Ceramic heaters can be custom designed to optimize thermal performance for instrumentation and equipment applications.

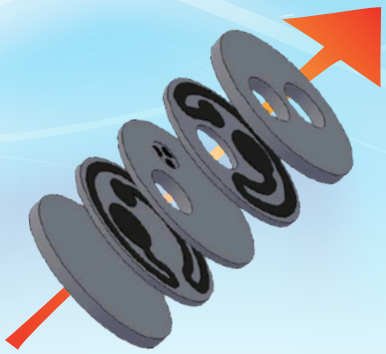
Rapid Fire AIN Advantages

- Thermal conductivity equivalent to aluminum for fast and uniform thermal response
- Watt density higher than any metal or ceramic heater technology for concentrated heat in a small area
- Integrated RTD sensor for optimum heater temperature control
- Dielectric strength eliminates need for magnesium oxide insulation (MgO) layer used in metal heaters
- Heater temperature up to 1000°C (1832°F) for high temperature applications
- Low porosity non-stick surface reduces potential for process contamination
- Chemically inert to most acid and alkaline environments
- High mechanical strength, hardness and wear resistance for industrial applications

Advanced Ceramic Heater Thermal Solutions

AIN Heater Capabilities

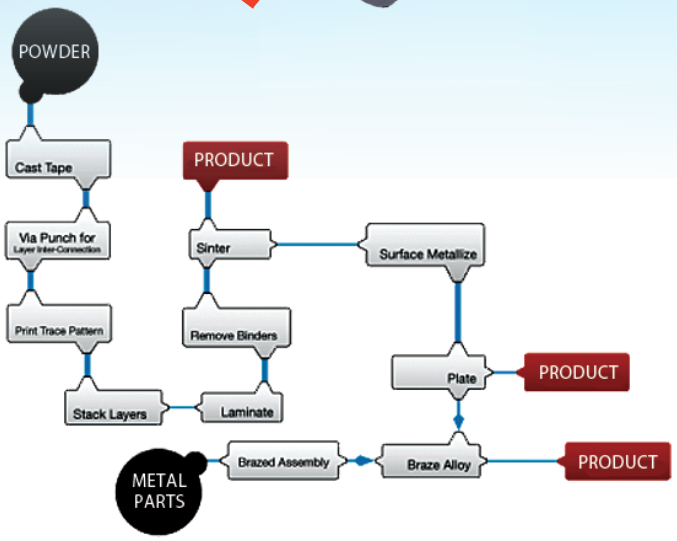
- Thermal conductivity equivalent to aluminum for fast and uniform thermal response
- Watt density: up to 2000 W/in^2 (310 W/cm^2).
- AIN thermal conductivity: 180 W/mK
- Rapid ramp rate: 0-400°C (32 to 752°F) in less than 2 seconds
- Atmospheric and inert gas environments applications
- Complex and 3 dimensional geometries
- Thickness: 0.05 in. to 0.200 in (1.27 mm to 5.08 mm)
- Size: Up to 10.25 in2 (66.13 cm^2)
- Encapsulated tungsten (W) RTD sensor
- Surface tungsten (W) or nickel (Ni) metallization



Multi Layer Ceramic Heater Design and Manufacturing

Multi-layer AIN heater design and manufacturing processes extend the capability and functionality of AIN thermal solutions. Starting with green state (power) ceramic materials, each layer is formed and pressed to the required dimensions. Metallic heater and sensor layers are sandwiched and pressed between the ceramic layers. The entire assembly is then sintered in a high temperature furnace to create a monolithic assembly. Layers may include combination of heater circuits, RTD sensor elements, ground planes, radio frequency (RF) grids, metallic and ceramic flow channels.

AIN heaters are used in applications where low thermal expansion and/or high thermal conductivity are required. When combined with internal chemically-bonded metallic conductors, these components may be used in high power electronic devices and rapid thermal cycling processes. Very high power densities can be realized by designing a solution with metallic structures for mounting and heat removal.



Industry and Applications - (AIN) Capabilities

Industry and Applications	High Thermal Conductivity	High Temperature < 300°C	Temperature Uniformity	High Watt Density	Integrated Tungsten RTD	Ground or RF Plane	Complex / Intricate Geometries	Small Heater Footprint	Metalized Surface	Dielectric Strength	Low Surface Porosity	Inert to Many Chemical and Gases
Analytical Gas, Chromatograph Mass Spectrometer	●	●	●	●	●		●	●		●		●
Clinical Diagnostics Thermal Cyclers (PCR), Lab-on-a-Chip, Immunoassay…			●		●		●	●	●	●	●	
Energy Generation Fuel Cell Reformers, Energy Conversion and Conditioning…	●			●			●	●				
Medical Incubators, Fluid Warmers, surgical knives...			●				●	●		●	●	
Photonics Laser, Biomedical Optics, Imaging...	●	●	●	●	●		●	●	●	●		
Electronics Assembly Solder Flow, Die & Wire Bonding...	●	●	●	●	●	●	●	●		●	●	●
Semiconductor Chemical Vapor Deposition, Plasma Etch, Gas Delivery…	●	●	●	●	●	●	●				●	●

Cylindrical 3D AIN Heaters

Precision manufacturing processes and machining capabilities allow for unique 3D designs such as a cylindrical (tube) heater. Cylindrical heater applications include gas and liquid heating in instrumentation such as gas chromatographs, mass spectrometers, and medical devices. Cylindrical heaters can be designed for process temperatures in excess of 600°C (1112°F) with watt densities up to 1000 W/in^2 (155 W/cm^2). With design flexibility to distribute wattage and vary the length as well as inside and outside diameter, this heater can be customized to optimize performance in the application.

Industries and Applications

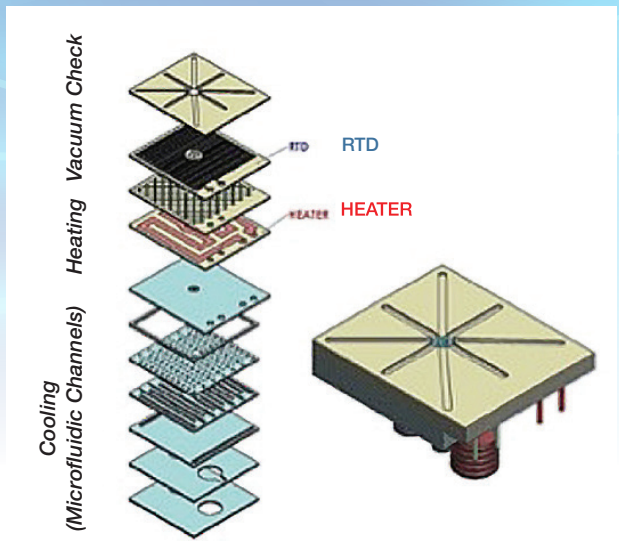
High watt density, low power consumption, fast temperature ramp rates, and up to 1000°C (1832°F) temperatures make AIN heaters an excellent thermal solution. Whether the application is for a high temperature environmental instrumentation application in a power plant or for burning test samples, AIN heaters are a robust solution that can provide the reliability required in the application.

Advanced Ceramic Heaters are small in size but Mighty in Power!

Advanced Ceramic Heater Thermal Solutions

Z-AXIS Thermal Solution™

Traditional industrial heater designs are usually 2-dimensional and have inherent heat transfer and thermal solution limitations. Durex' aluminum nitride (AlN) ceramic heater technology gives engineers the ability to actualize a Z-axis thermal solution. The AlN material layers and circuits are sintered at high temperature to form a monolithic 3-dimensional solution. This integrated thermal solution may include multi-layers of heater circuits, RTD sensor elements, RF grids, ground plains, cooling, gas and vacuum channels.



Monolithic AlN Chiller Technology

Heater Sheath Material Thermal and Physical Properties*

	Aluminum Nitride AlN	96% Alumina Al_2O_3	Silicon Nitride Si_3N_4	Aluminum Al	Stainless Steel 304	Description
Thermal Conductivity (W/K·m)	180	30	40	180	12	Thermal Conductivity is a measurement of a material's ability to conduct heat: higher value = faster more uniform heat transfer
Coefficient of Thermal Expansion ($x10^{-6}$/°C)	4.3	10.2	3.2	23.6	5.8	Coefficient of Thermal Expansion (CTE) is a measurement of material expansion resulting from change in temperature: lower value = less material expansion
Heat Capacity (J/g·K)	0.78	0.88	0.71	0.9	0.5	Heat Capacity is amount of heat required to raise temperature of a material one degree centigrade: higher value = less energy to heat material
Density (g/cm^3)	3.26	3.75	3.25	2.7	8	Density is the measurement of a material's weight to volume: lower value = less weight and fast heating
Vicker Hardness (GPa)	11.2	15.7	13.9	0.11	1.26	Vicker Hardness is a measurement of the physical hardness of a material: higher value = harder material
Young's Modulus of Elasticity (Gpa)	322	370	290	69	180	Young's Modulus of Elasticity is the ratio of a material's uniaxil stress over uniaxil strain : higher value = less tensile strength
Flexural Strength (Mpa)	350	400	610	276	520	Flexural Strength is the measurement of a material's bend or fracture strength: higher value = better material flexibility
Dielectric Strength (V/m) @ 25°C	16 x 10^6	18.1 x 10^6	13 x 10^6	N/A	N/A	Dielectric Strength is a measurement of a material's electrical insulation resistance: higher value = better electrical insulation

** Property values reflect typical performance and can vary by adding alloys and / or process procedures.*

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P/N CERM-AACH-0816

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