Watlow®
ULTRAMIC® Advanced
Ceramic Heaters

heaters | sensors | controllers

WATLOW®
Better Thermal Solutions...Faster
Watlow® ULTRAMIC® heaters are designed for thermal applications where the high performance of an advanced ceramic heater is required to ensure optimal effectiveness of the equipment or process.

ULTRAMIC heaters are constructed of aluminum nitride (AlN) and incorporate a thermally matched, proprietary heating element that provides maximum performance in challenging applications. AlN is especially suited for applications requiring a clean, non-contaminating heat source. Additionally, the excellent geometric stability ensures consistent part-to-part thermal contact during heating cycles.

Watlow ULTRAMIC heaters can operate up to 600°C (1112°F) with an ultra-fast ramp rate of up to 150°C (270°F) per second depending on the application, heater design and process parameters. In addition to delivering excellent thermal characteristics, this heater has high electrical isolation and typically provides superior chemical resistance as compared to traditional metal heaters.
CONSTRUCTING A CERAMIC HEATER

ULTRAMIC ceramic heaters are manufactured using a proprietary, sintering process. During sintering, ceramic powders are heated at a high temperature in a controlled environment, which facilitates densification and grain growth. A uniform grain size is created with no open porosity to ensure high mechanical strength and optimal thermal conductivity.

The green AlN matrix is constructed of two parts. The heating element is deposited on one of the AlN parts. Then, the parts are sintered together, making them one homogeneous assembly. The high thermal conductivity of AlN and an optimized circuit layout combine to produce superb temperature uniformity across the heater surface.

The following tables illustrate AlN’s unmatched capability due to its high thermal conductivity and low thermal expansion coefficient.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>MATERIAL PROPERTIES AT 25°C (77°F).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Thermal conductivity (W/K·m)</td>
</tr>
<tr>
<td>AlN</td>
<td>150</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>30</td>
</tr>
<tr>
<td>Si₃N₄</td>
<td>40</td>
</tr>
<tr>
<td>Al</td>
<td>180</td>
</tr>
<tr>
<td>304 SS</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2</th>
<th>ULTRAMIC Thermal and Physical Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Properties</td>
<td>Physical Properties</td>
</tr>
<tr>
<td>Temperature Coefficient of Resistance (TCR)</td>
<td>1.5 x 10⁻³/°C</td>
</tr>
<tr>
<td>Surface Temperature</td>
<td>600°C (1112°F)</td>
</tr>
<tr>
<td>Terminal Temperature</td>
<td>400°C (752°F)*</td>
</tr>
</tbody>
</table>

* 600°C (1112°F) extended capability offering available.

BENEFITS OF ALUMINUM NITRIDE (AlN)

AlN is an excellent choice for a ceramic heater platform as it allows for a homogeneous assembly for atmospheric or vacuum applications. The material also provides the durable heater construction and thermal transfer necessary for high temperature, fast cycling and long heater life. Additional features and benefits received by using AlN construction include:

- **High thermal conductivity:** Exhibiting thermal conductivity similar to aluminum provides rapid heat dissipation, enables the heater to be constructed with a high watt density and gives it the ability to thermally ramp at a rate of 150°C (270°F) per second.
- **Clean, non-contaminating material:** Using a carefully controlled microstructure, high temperature sintering produces a heater that is very hard (1100 Kg/mm²) and dense (> 99% theoretical density) with virtually no porosity. AlN is an ideal choice for applications requiring a “clean” heater.
- **Moisture resistance:** AlN is impervious to moisture unlike many hygroscopic dielectric materials used in conventional heater construction.
- **High dielectric strength and high insulation resistance:** AlN is an electrical insulator that features very low leakage current (< 10μA @ 500VAC), a highly preferred characteristic for many applications.
Ultra-Fast Ramp Rates

With the ongoing push for equipment productivity, improving heat/cool cycle times is one way to optimize system performance. The high thermal conductivity of AlN allows the ULTRAMIC heater to heat and cool quickly, and to be constructed with extremely high watt densities of up to 1000 W/in². These high watt densities enable ramp rates as high as 150°C (270°F) per second, resulting in higher productivity in applications such as semiconductor chip testing and eutectic die bonding.

Eutectic die bonding equipment is used in the attachment of lead wires to the die before packaging of the integrated circuit (IC). Optimal bonding is achieved by ramping the solder and lead temperature through the eutectic state. Watlow’s ULTRAMIC heater is ideal for this application because a temperature ramp of up to 150°C (270°F) per second can be achieved while also achieving a fast cool down in preparation for processing the next device.

Benefits of using ULTRAMIC heaters in semiconductor applications include:

- Vacuum holes and grooves
- Surface flatness of 0.05 mm (0.002 in.)
- Surface finish <1.5 μm (64 μ-in.)

Maximum and minimum power densities can vary with voltage, surface area and application parameters. Contact factory to determine optimum voltage and power for your application.

These models depict how an ULTRAMIC heater could replace traditional heaters, resulting in a smaller, higher performance, and more easily integrated system solution.
For many applications, such as medical devices, extremely low leakage current is critical for patient safety or system performance. To meet agency regulations, many device manufacturers resort to using step down isolation transformers and low voltage power supplies to enable the use of traditional heating technologies. These transformers add size, weight and cost to the system. In many cases, an ULTRAMIC heater can eliminate the need for these transformers by providing the required electrical performance, even at standard line voltages, in a small, clean package.

**Superior Electrical Performance**
- Low leakage current; <10 μA at 100°C

**UL® and CE Agency Compliance**
- Designed to meet global safety standards
- RoHS compliant

**Medical Application**

High flow respiratory therapy equipment adds warmth and moisture to breathing gases through the nasal cannula of patients. This equipment must provide the perfect mix of temperature, humidity and oxygen without discomfort to the patient. The ULTRAMIC heater is able to deliver the heat needed to generate proper humidity and temperature to maximize patient comfort. Because the equipment needs to be portable, the small size and light weight ULTRAMIC heater is a great fit. The extremely low leakage current and integrated thermocouple of the heater ensures safety for the patient and operator.

Benefits of using the ULTRAMIC heaters in medical applications include:
- Low leakage current of <1 μA at 120V
- Integrated thermocouple
- Small size and light weight
Analytical Instrumentation Application

Mass spectrometers are used to determine the presence of trace chemicals in industrial, environmental and clinical applications. With detection capabilities into the part-per-trillion levels, cleanliness is of paramount concern. For use with ion sources, the chemical compatibility, low porosity and fine surface finish make the ULTRAMIC heater an excellent choice where contamination of the sample is of concern.

Benefits of using ULTRAMIC heaters in analytical applications include:

- Process temperatures up to 600°C (1112°F)
- Chemical compatibility
- High dielectric strength
- Easy system integration

APPLICATION MINIATURIZATION

Miniaturization, or reducing the size of products and components, is an ongoing effort in virtually all industries. Parallel with reducing size is the need for increased precision and reduced system cost. With sizes as small as 8 mm (0.31 in.) and green state CNC machining capability, ULTRAMIC heaters help meet these needs and can often replace multiple components in a system.

INTEGRATED THERMOCOUPLE

Watlow’s ULTRAMIC heater with integrated Type K thermocouple provides a convenient way of controlling temperature with a high watt density heater without going through the trouble of installing a separate temperature sensor. The benefits of using an integrated sensor include:

- Ensures reliability of heater/sensor interface with the bonded assembly process
- Improves accuracy with optimized temperature sensing
- Provides high response rate in ramping applications

In addition to, or in place of the standard bonded thermocouple, a drilled hole or slot can be provided for installing an externally mounted sensor.

LEAD WIRE AND TERMINATIONS

Various lead wire and termination options are available to meet specific application needs. Some of these options include:

- Power terminals exit locations — extended from the side/edge or from the face of the heater
- Teflon® insulated silver-plated copper lead extension
- Lead extension length — standard length 305 mm (12 in.)
- Ceramic beads

MOUNTING GUIDELINES

This product can be mounted within a system in numerous ways. The mounting guidelines depend on the temperature in the application. Below are general rules for mounting and detailed mounting guide can be found at www.watlow.com/ultramic:

- Temperature <200°C (392°F): bond with high-temperature epoxy adhesive
- Temperature >200°C (392°F): screw hole can be provided (recommend insulation buffer such as mica spacer)
- Clamp using single or multiple-point fasteners
**Watlow’s Service and Support**

**Delivery**
A development engineer can quickly and easily acquire a standard heater to determine its suitability in an application. These standard heaters are available for shipment in one to three business days. Custom configurations are routinely manufactured to meet specific application requirements. Delivery of these orders is dependent on the complexity of the design.

**Rapid Prototyping**
If our standard units do not meet your application needs, Watlow can rapidly accommodate more complex designs that have specific shapes and features such as holes and vacuum grooves.

**Optimized Performance**
Using a finite element analysis (FEA) technique, the heater circuit is optimized and the thermal performance simulated prior to manufacturing. With FEA, custom prototypes can be delivered in weeks rather than months.

For a current list of the standard product offering visit www.watlow.com/ultramic

### Configurations and Dimensions

<table>
<thead>
<tr>
<th>Maximum Area 4032 mm² (6.25 in²)</th>
<th>Length</th>
<th>Width</th>
<th>Thickness</th>
<th>Aspect Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat Square</td>
<td>Min: 10 mm (0.393 in.) Max: 63.5 mm (2.5 in.)</td>
<td>Min: 2.5 mm (0.098 in.) Max: 5 mm (0.196 in.)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Rectangular</td>
<td>Max: 100 mm (3.94 in.) Min: 8 mm (0.315 in.)</td>
<td>Min: 2.5 mm (0.098 in.) Max: 5 mm (0.196 in.)</td>
<td>&lt;10</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Inside Diameter I.D.</th>
<th>Outside Diameter O.D.</th>
<th>Thickness</th>
<th>Ring Wall Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min: 0</td>
<td>Max: O.D. 77.5 mm (3.05 in.)</td>
<td>Min: 2.5 mm (0.098 in.) Max: 5 mm (0.196 in.)</td>
<td>Min wall thickness: 3 mm (0.118 in.)</td>
</tr>
</tbody>
</table>

### Machined Features

<table>
<thead>
<tr>
<th>Straight Groove Custom Feature</th>
<th>Hole Size Round Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth: 0.5 mm min. (0.019 in.) Width: 1 to 2 mm (0.039 to 0.078 in.)</td>
<td>Min: 1 mm (0.039 in.)</td>
</tr>
</tbody>
</table>

### Electrical Properties

<table>
<thead>
<tr>
<th>Voltage</th>
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<tr>
<td>12 to 480V</td>
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</tbody>
</table>
Watlow Products and Technical Support Delivered Worldwide

North American Technical Support & Sales Offices
North America  1-800-WATLOW2
               (1-800-928-5692)
Asian Technical Support & Sales Offices
Australia      +61 3 9335 6449
China          +86 21 3381 0188
Japan          +81 3 3518 6630
Korea          +82 2 2628 5770
Malaysia       +60 3 8076 8745
Singapore      +65 6773 9488
Taiwan         +886 7 288 5168

European Technical Support & Sales Offices
France         +33 (0) 1 41 32 79 70
Germany        +49 (0) 72 53 / 94 00-0
Italy          +39 024588841
Spain          +34 91 675 12 92
United Kingdom +44 (0) 115 964 0777

Latin American Technical Support & Sales Office
Mexico         +52 442 217 6235

About Watlow
Watlow designs and manufactures industrial heaters, temperature sensors, controllers and system assemblies – all of the components of a thermal system. Designing and manufacturing the complete thermal system allows Watlow to recommend, develop and deliver the optimum thermal solution for our customers’ equipment and process heat requirements.

Watlow manufactures thermal systems for a broad range of industries including: semiconductor processing, photovoltaics, energy processing, diesel emissions, foodservice equipment, medical equipment and aerospace. Watlow customers receive the highest level of technical engineering combined with exceptional customer service.

Since 1922, Watlow has grown in product capability, market experience and global reach. We hold more than 200 patents and employ 2,000 employees working in 12 manufacturing facilities in the United States, Mexico, Europe and Asia. We also have sales offices in 15 countries around the world. Our company has grown at an exponential rate, but our commitment remains the same – to provide our customers with superior products and services for their individual needs.

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