Watlow®
ULTRAMIC® Advanced
Ceramic Heaters
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.
**ADVANCED CERAMIC HEATER CONSTRUCTION**

**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.

**BENEFITS OF ALUMINUM NITRIDE (AlN)**

Advanced ceramics are synthetic, inorganic compounds of exceptional purity. Ceramic compounds include alumina (Al$_2$O$_3$), silicon nitride (Si$_3$N$_4$) and 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/mm$^2$) 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.

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>Al$_2$O$_3$</td>
<td>30</td>
</tr>
<tr>
<td>Si$_3$N$_4$</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.
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.

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.

ULTRAMIC Heaters
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

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**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

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**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.

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**Mounting Guidelines**

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

<table>
<thead>
<tr>
<th>Configurations and Dimensions</th>
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### Maximum Area 4032 mm² (6.25 in²)

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<thead>
<tr>
<th></th>
<th>Length</th>
<th>Width</th>
<th>Thickness</th>
<th>Aspect Ratio</th>
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</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>
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<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>
</tr>
<tr>
<td>Inside Diameter I.D.</td>
<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>
<tr>
<td>Outside Diameter O.D.</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>
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### Machined Features

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

### Electrical Properties

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

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About Watlow

Watlow provides best-in-class engineering expertise and leading thermal products that enable customers to thrive. Our world-class technology is offered in industrial heaters, temperature sensors and electronics and communications. Watlow engineers solutions that give our customers a competitive advantage in their respective markets.

Watlow brings its experience to numerous industries, including semiconductor processing, diesel emissions, energy and environmental technologies, foodservice equipment and life sciences to name a few.

Since 1922, Watlow has grown in product capability, market experience and global reach. The company holds more than 450 patents and employs 2,200 people working globally through eight manufacturing facilities and three advanced technology centers. Headquartered in St. Louis, Missouri with sales offices in 16 countries around the world, Watlow continues to grow. Our pride and confidence stems from thrilling our customers with our products and the Watlow experience.