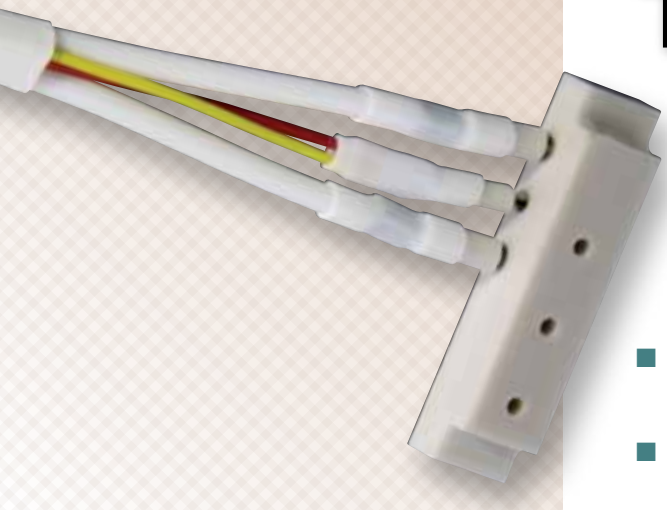
Watlow®
ULTRAMIC® Advanced Ceramic Heaters

heaters | sensors | controllers

WATLOW®
Better Thermal Solutions...*Faster*

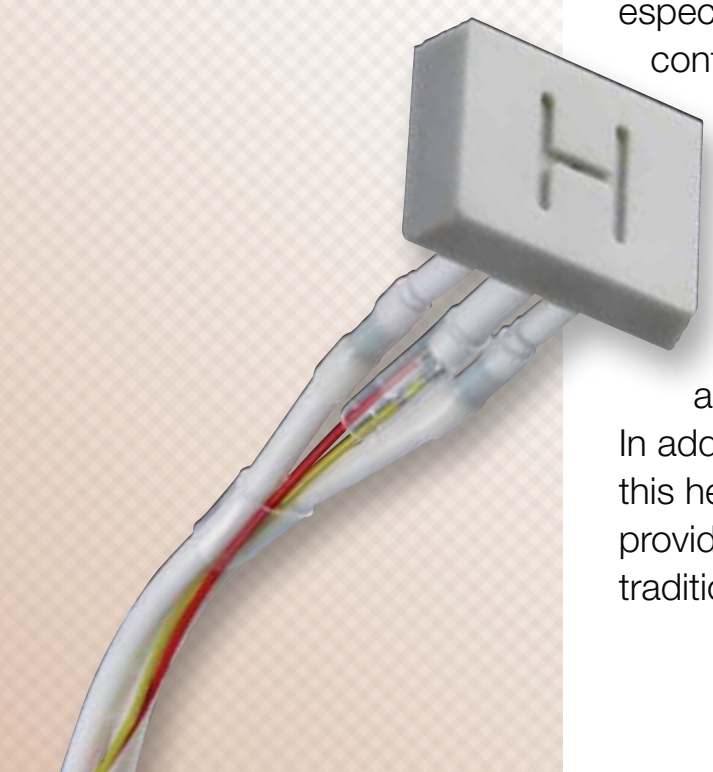


The Revolutionary ULTRAMIC®

- **Ultra-Fast Ramp Rates**
- **High Watt Densities**
- **Low Leakage Current**

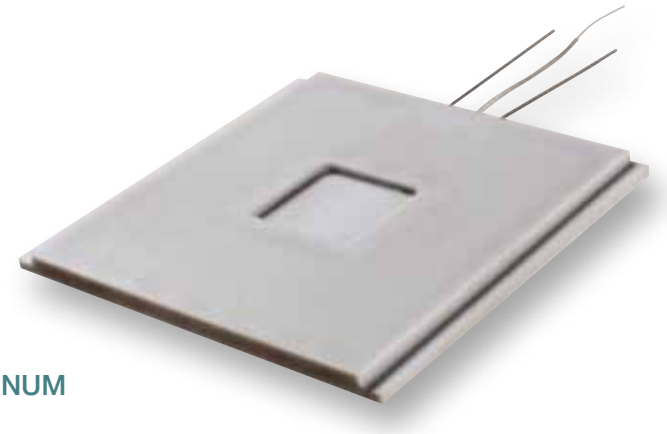
Watlow® ULTRAMIC® heaters are designed for thermal applications where the high performance of an advanced ceramic heater is required to ensure optimal effectiveness of the equipment or process.

ULTRAMIC heaters are constructed of aluminum nitride (AIN) and incorporate a thermally matched, proprietary heating element that provides maximum performance in challenging applications. AIN 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_2O_3), silicon nitride (Si_3N_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.

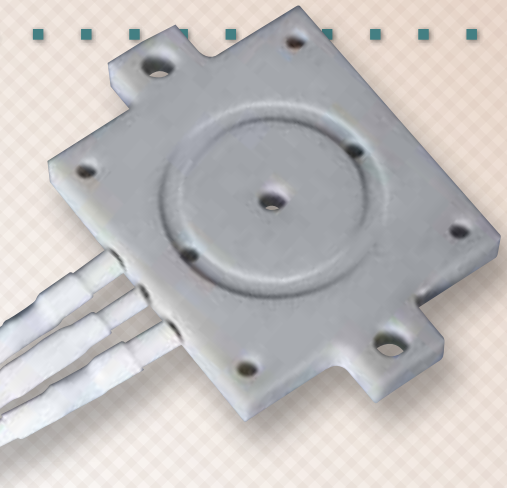
Table 1 *Material Properties at 25°C (77°F).*

Material	Thermal conductivity (W/K·m)	Thermal expansion coefficient (x10^{-6}/°C)	Heat capacity (J/g·K)	Density (g/cm^3)
AlN	**150**	**4.5**	**0.78**	**3.26**
Al_2O_3	30	7.2	0.88	3.96
Si_3N_4	40	3.2	0.71	3.25
Al	180	23.6	0.90	2.70
304 SS	16	17.2	0.50	8.00

Table 2 ***ULTRAMIC** Thermal and Physical Properties*

Thermal Properties		Physical Properties	
Temperature Coefficient of Resistance (TCR)	1.5 x 10^{-3}/°C	Hardness	1050 Hv@500g
Surface Temperature	600°C (1112°F)	Flexural Strength	>250 MPa
Terminal Temperature	400°C (752°F)*		

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



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/in^2. 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.

Semiconductor Equipment Application

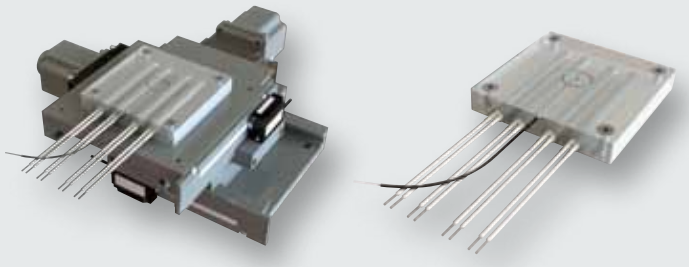
Eutectic die bonding equipment is used in the attachment of lead wires to the die before packaging of the integrated circuit (IC). Optimal bonding is achieved by ramping the solder and lead temperature through the eutectic state. Watlow's ULTRAMIC heater is ideal for this application because a temperature 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:

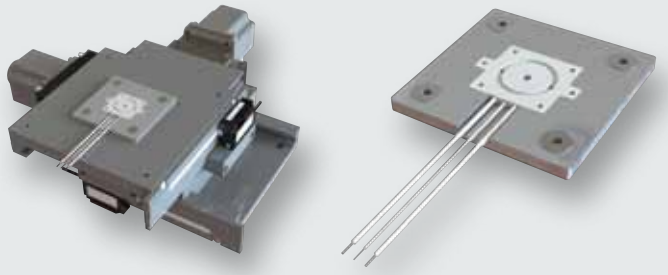
- Vacuum holes and grooves
- Surface flatness of 0.05 mm (0.002 in.)
- Surface finish <1.5 µm (64 µ-in.)

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.

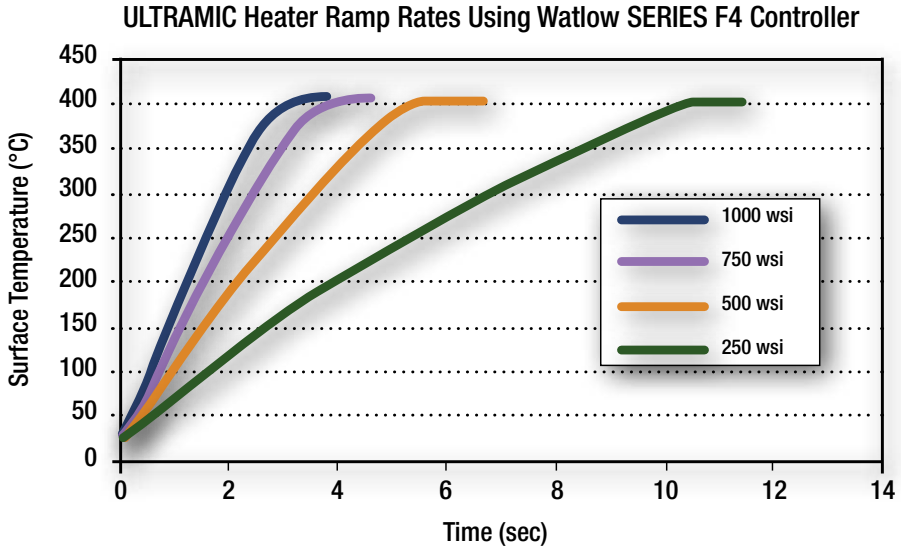
Traditional Heater Solution



ULTRAMIC Advanced Ceramic Heater Solution



These models depict how an ULTRAMIC heater could replace traditional heaters, resulting in a smaller, higher performance, and more easily integrated system solution.



ULTRAMIC temperature ramp rate as a function of watt density. Test completed using Watlow's SERIES F4 temperature controller.

Low Leakage Current

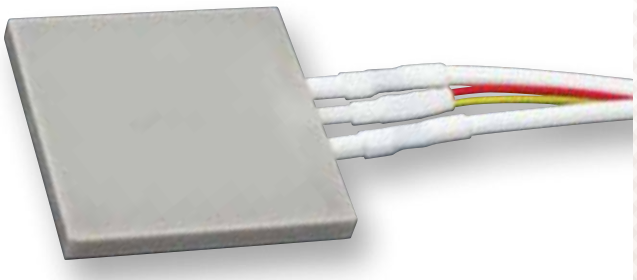
For many applications, such as medical devices, extremely low leakage current is critical for patient safety or system performance. To meet agency regulations, many device manufacturers resort to using step down isolation transformers and low voltage power supplies to enable the use of traditional heating 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.

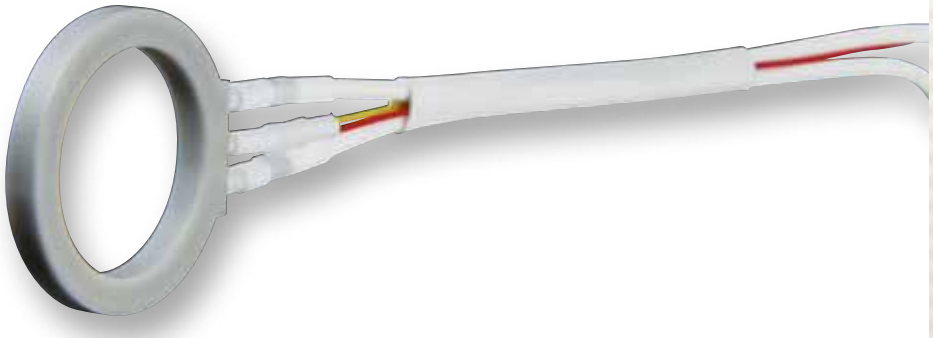
Superior Electrical Performance

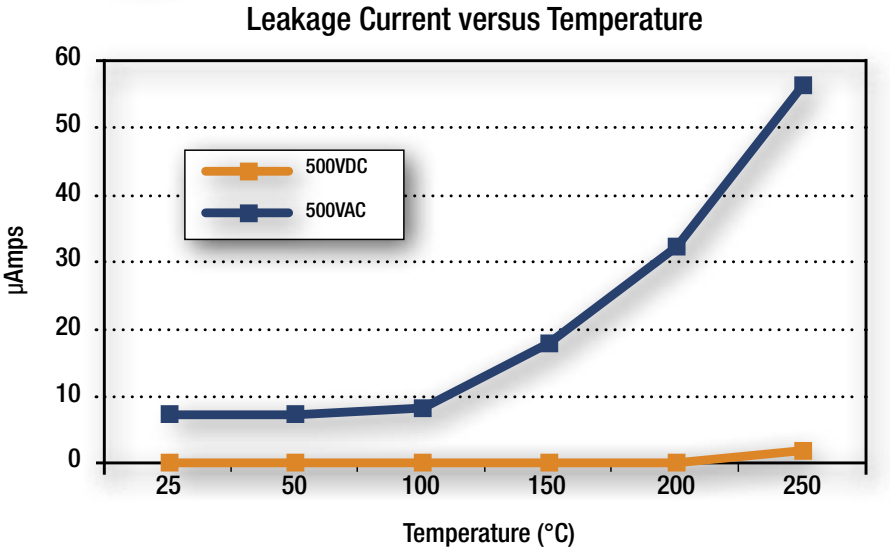
- Low leakage current; <10 µA at 100°C

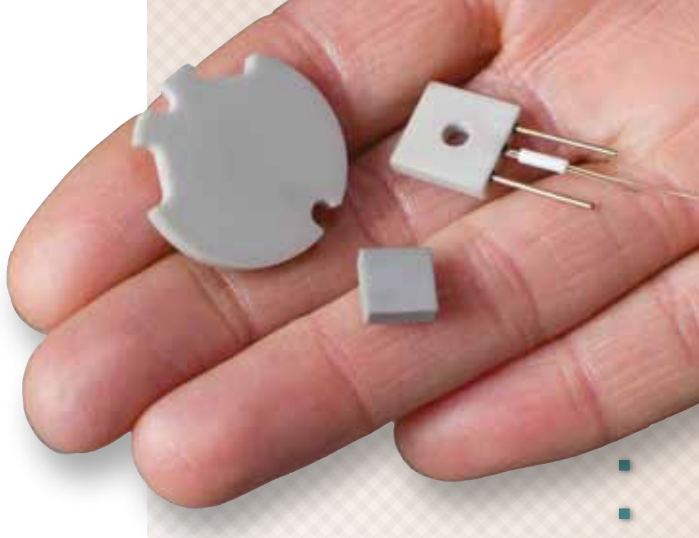
UL® and CE Agency Compliance

- 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

Product Design Capability

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

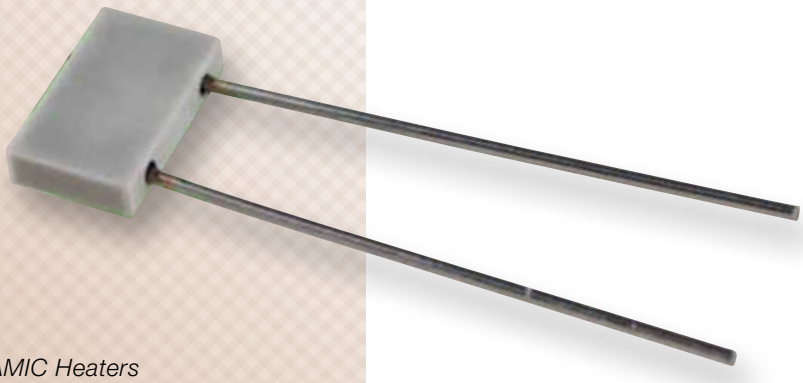
Various lead wire and termination options are available to meet specific application needs. Some of these options include:

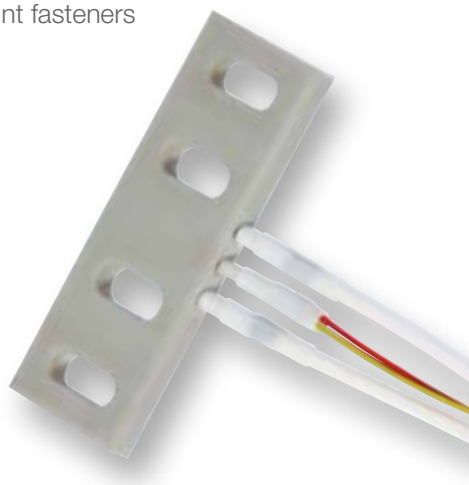
- Power terminals exit locations — extended from the side/edge or from the face of the heater
- Teflon® insulated silver-plated copper lead extension
- Lead extension length — standard length 305 mm (12 in.)
- Ceramic beads

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

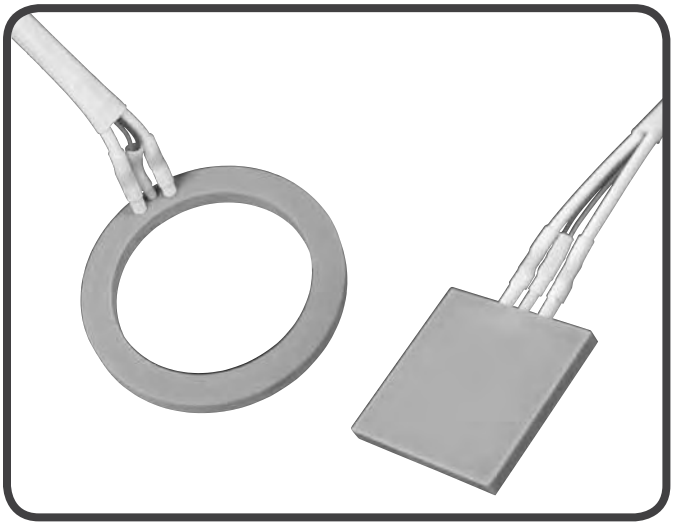
Maximum Area 4032 mm² (6.25 in²)				
	Length	**Width**	**Thickness**	**Aspect Ratio**
Flat Square	Min: 10 mm (0.393 in.) Max: 63.5 mm (2.5 in.)		Min: 2.5 mm (0.098 in.) Max: 5 mm (0.196 in.)	1
Rectangular	Max: 100 mm (3.94 in.)	Min: 8 mm (0.315 in.)	Min: 2.5 mm (0.098 in.) Max: 5 mm (0.196 in.)	<10
	Inside Diameter I.D.	**Outside Diameter O.D.**	**Thickness**	**Ring Wall Thickness**
Ring	Min: 0	Max: O.D. 77.5 mm (3.05 in.)	Min: 2.5 mm (0.098 in.) Max: 5 mm (0.196 in.)	Min wall thickness: 3 mm (0.118 in.)
Machined Features				
Straight Groove Custom Feature			**Hole Size Round Diameter**	
Depth: 0.5 mm min. (0.019 in.) Width: 1 to 2 mm (0.039 to 0.078 in.)			Min: 1 mm (0.039 in.)	
Electrical Properties				
Voltage				
12 to 480V				

ULTRAMIC® Advanced Ceramic Heaters

Watlow's high performance ULTRAMIC® advanced ceramic heaters are designed for thermal applications that require optimal effectiveness of equipment and processes.

Constructed with aluminum nitride (AIN), ULTRAMIC heaters' thermally matched proprietary heating element provides maximum performance in challenging applications. AIN is especially suitable for applications that require a clean, non-contaminating heat source. Its excellent geometric stability ensures consistent part-to-part thermal contact during heating cycles.

Watlow AIN heaters operate up to 400°C (752°F)① 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 its excellent thermal characteristics, the ULTRAMIC provides high electrical isolation and typically provides superior chemical resistance compared to traditional metal heaters.



Performance Capabilities

- Standard operating temperature up to 400°C (752°F)①
- Watt densities up to 155 W/cm^2 (1000 W/in^2)
- Temperature ramp rate up to 150°C (270°F) per second (depending on application parameters)

Features and Benefits

Robust AIN ceramic

- Creates a homogeneous assembly for atmospheric and vacuum applications
- Provides durable heater construction and thermal transfer necessary for high temperature and long heater life
- Supports the design of a high watt density, fast responding heater in a very small package
- Ensures geometric stability due to low coefficient of thermal expansion

Superior electrical performance

- Assures low leakage current
- Enables high breakdown voltage

High thermal conductivity

- Makes for an ultra-fast temperature ramp rate of up to 150°C (270°F) per second (depending on application parameters)
- Allows for quick cool-down
- Provides extremely uniform temperatures over the heater's surface

Type K thermocouple integrated into assembly

- Ensures reliable heater/sensor interface
- Improves accuracy with optimized temperature sensing
- Provides ramping applications with a high response rate

UL® and CE agency compliance

- Meets global safety standards
- Includes RoHS compliance

Typical Applications

- Wire and die bonding
- Integrated circuit (IC) chip testing
- Mass spectrometry
- Clinical diagnostic equipment
- High speed packaging/sealing
- Respiratory therapy equipment

① 400°C (752°F) maximum operating temperature is standard. Higher temperature operation up to 600°C (1112°F) is available as an extended capability. Contact your Watlow representative for information.

ULTRAMIC Advanced Ceramic Heaters

Technical Data

Mounting Guidelines

- Temperature <200°C (392°F): bond with high-temperature epoxy adhesive
- Clamp using single or multiple-point fasteners

Optional Thermocouple

- Bonded Type K thermocouple for <400°C (752°F)

Specifications and Tolerances

Surface Finish

- Flatness: <0.05 mm (0.002 in.)
- Parallelism: <0.05 mm (0.002 in.)
- Surface roughness (Ra): <1.5 µm

Dimensional Tolerance (length/width/diameter)

- ± 1% of dimension (± 0.13 mm minimum)

Electrical Properties

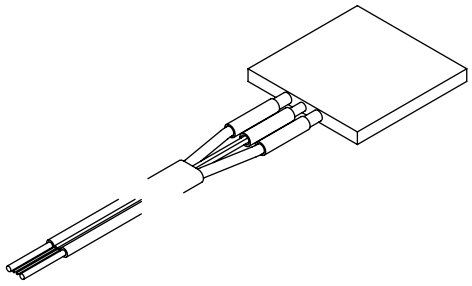
- TCR: 0.0015/°C
- Resistance tolerance: ±25%

Intellectual Property

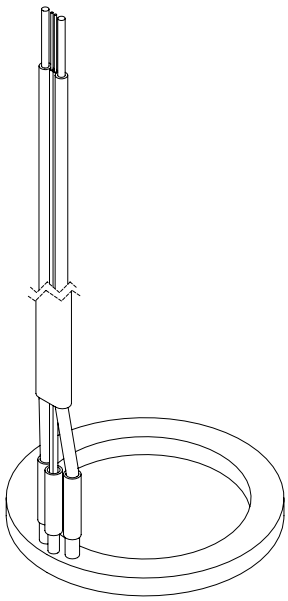
- U.S. Patents 7,696,455, 7,832,616 and 8,242,416

Lead Wire and Terminations

- Power terminals exit locations — extended from side edge or top face
- PTFE insulated silver-plated copper lead extension
- Lead extension length — standard length 305 mm (12 in.)
- Optional length of ceramic beads



Side Lead Exit



Top Lead Exit

EXTENDED CAPABILITY

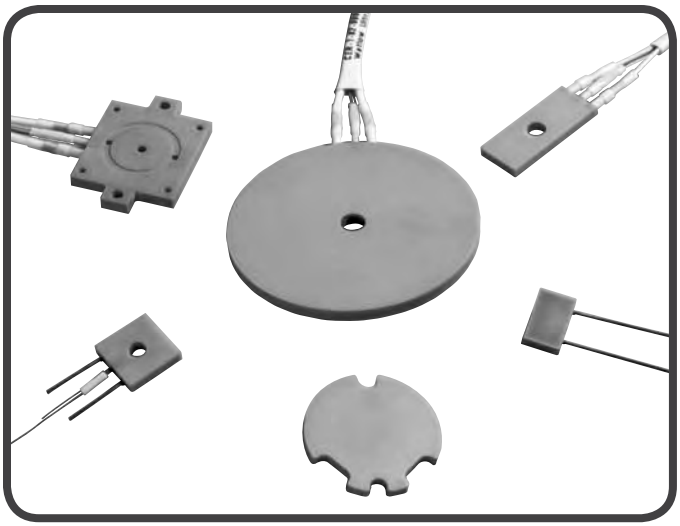
Extended Capabilities for ULTRAMIC Advanced Ceramic Heaters

Mounting Guidelines①

- In addition to the options listed on the previous page, a screw hole can be provided on custom designs (recommend insulation buffer such as mica spacer)

Optional Sensors

- 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



Configurations and Dimensions

Dimensional Features				
	Length	**Width**	**Thickness**	**Aspect Ratio**
Flat Square	Min: 8 mm (0.315 in.) Max: 100 mm (3.94 in.)		Min: 2.5 mm (0.098 in.) Max: 5 mm (0.196 in.)	1
Rectangular	Max: 100 mm (3.94 in.)	Min: 8 mm (0.315 in.)	Min: 2.5 mm (0.098 in.) Max: 5 mm (0.196 in.)	<10
	Inside Diameter I.D.	**Outside Diameter O.D.**	**Thickness**	**Ring Wall Thickness**
Ring	Min: 0	Max: O.D. 100 mm (3.94 in.)	Min: 2.5 mm (0.098 in.) Max: 5 mm (0.196 in.)	Min wall thickness: 3 mm (0.118 in.)

Machined Features	
Straight Groove Custom Feature	**Hole Size Round Diameter**
Width: 0.5 mm (0.019 in.)	Min: 0.5 mm (0.019 in.)

Electrical Properties	
Voltage	**Max. Temperature**
12 to 480V	400°C (752°F) standard, 600°C (1112°F) extended capability

① See www.watlow.com/ultramic for detailed mounting guide.

ULTRAMIC Advanced Ceramic Heaters

Technical Data

Product Ordering Information

Part Number	Dimensions mm (in.)	Thickness mm (in.)	Watt Density	Watts	Volts	Lead Exit
Square						
CER-1-01-00002	25 mm x 25 mm (0.98 in. x 0.98 in.)	2.5 mm (0.10 in.)	High	900	240	Side
CER-1-01-00374	50 mm x 50 mm (1.97 in. x 1.97 in.)	3.0 mm (0.12 in.)	Medium	1938	240	Side
CER-1-01-00093	25 mm x 25 mm (0.98 in. x 0.98 in.)	2.5 mm (0.10 in.)	Low	150	120	Side
CER-1-01-00097	19 mm x 19 mm (0.75 in. x 0.75 in.)	2.5 mm (0.10 in.)	Low	200	120	Side
CER-1-01-00333	15 mm x 15 mm (0.59 in. x 0.59 in.)	2.5 mm (0.10 in.)	Medium	150	48	Side
CER-1-01-00334	12 mm x 12 mm (0.47 in. x 0.47 in.)	2.5 mm (0.10 in.)	High	200	48	Side
CER-1-01-00335	8 mm x 8 mm (0.31 in. x 0.31 in.)	3.0 mm (0.12 in.)	Low	21.5	12	Top
Heaters With Holes						
CER-1-01-00540	12 mm x 12 mm ① (0.47 in. x 0.47 in.)	2.5 mm (0.10 in.)	Medium	100	24	Side
CER-1-01-00541	25 mm x 25 mm ② (0.98 in. x 0.98 in.)	2.5 mm (0.10 in.)	High	800	120	Side
CER-1-01-00542	50 mm x 50 mm ② (1.97 in. x 1.97 in.)	3.0 mm (0.12 in.)	Medium	1500	240	Side
Rectangular						
CER-1-01-00001	25 mm x 15 mm (0.98 in. x 0.6 in.)	2.5 mm (0.10 in.)	High	580	120	Side
CER-1-01-00003	50 mm x 10 mm (1.97 in. x 0.39 in.)	2.5 mm (0.10 in.)	Medium	582	120	Side
CER-1-01-00004	50 mm x 10 mm (1.97 in. x 0.39 in.)	2.5 mm (0.10 in.)	High	770	240	Side
CER-1-01-00005	50 mm x 25 mm (1.97 in. x 0.98 in.)	2.5 mm (0.10 in.)	Medium	1453	240	Side
CER-1-01-00007	75 mm x 25 mm (2.95 in. x 0.98 in.)	2.5 mm (0.10 in.)	Medium	1455	240	Side
CER-1-01-00098	25 mm x 15 mm (0.98 in. x 0.6 in.)	2.5 mm (0.10 in.)	Low	180	120	Side
CER-1-01-00105	50 mm x 25 mm (1.97 in. x 0.98 in.)	2.5 mm (0.10 in.)	Low	100	120	Side
Ring						
CER-1-02-00001	38 mm x 29 mm (1.50 in. x 1.14 in.)	3.0 mm (0.12 in.)	High	733	120	Top
CER-1-02-00002	77.5 mm x 59 mm (3.05 in. x 2.32 in.)	3.0 mm (0.12 in.)	Medium	770	240	Top
CER-1-02-00074	25.4 mm solid disk (1 in.)	2.5 mm (0.10 in.)	Medium	300	120	Side

① 3 mm (0.12 in.) hole in center of heater
② 5 mm (0.19 in.) hole in center of heater

See page 450 for lead exit details (full drawings and current list of standard designs available at www.watlow.com/ultramic)

Configurations include:
- Power lead wires with 305 mm (12 in.) of PTFE insulation
- Bonded Type K thermocouple with 305 mm (12 in.) PTFE insulated lead wires

Note: Maximum temperature is 400°C (752°F). Lead wires are rated to 205°C (401°F).
If ceramic beads are required, please contact your Watlow representative for a quote.

ULTRAMIC® Advanced Ceramic Heater Mounting Guidelines

The following information provides basic guidelines to consider when mounting ULTRAMIC® advanced ceramic heaters. Several factors can affect the performance and robustness of a mounting configuration including: application temperature, mating part material and flatness, surface finish and coefficient of thermal expansion (CTE).

Considerations

Coefficient of Thermal Expansion (CTE) – The ULTRAMIC heater's CTE is 4.5×10^{-6} / °C, substantially lower than the CTE offered by many common metal mating part and mounting materials. For example, aluminum's CTE is approximately five times higher than aluminum nitride's CTE. To minimize stress, CTE mismatch, clearance and part tolerances should be considered in design layouts.

Flatness and Surface Finish – For optimal heat transfer and to minimize stress, a mating part's surface should have a flatness and surface finish better than or equal to that of the heater. The standard flatness for an ULTRAMIC heater is 0.05mm (0.002"). The standard surface finish for an ULTRAMIC heater is < 1.5µm (64 µ in) Ra.

Dielectric Strength Considerations – The standard heater termination includes a short ceramic bead over a metal pin wire as shown in Figures 7 and 8 below. To ensure appropriate dielectric strength, consider the combination of the voltage, heater thickness, atmosphere and dielectric clearance. Suggested methods for ensuring sufficient dielectric strength include:

- Using an insulating material such as mica or epoxy between the terminals and the mating part
- Machining the part to increase dielectric spacing or designing the heaters with a perpendicular lead exit.(Figure 5)
- Extending the heater termination area beyond the mating part (as highlighted in Figures 7 and 8)

Adhesive Bonding

A high temperature and electrically insulating epoxy adhesive, such as COTRONICS' Duralco 4420, demonstrates good bonding strength up to 200º C (392ºF). The advertised ratings of high temperature adhesives are generally considered suitable for short-term excursions, such as cycling applications. Peak and continuous use temperature, especially when adhesive is used for electrical isolation, should be factored when selecting epoxy adhesives. .

Examples of Mounting Methods using Mechanical Fasteners

Figure 1

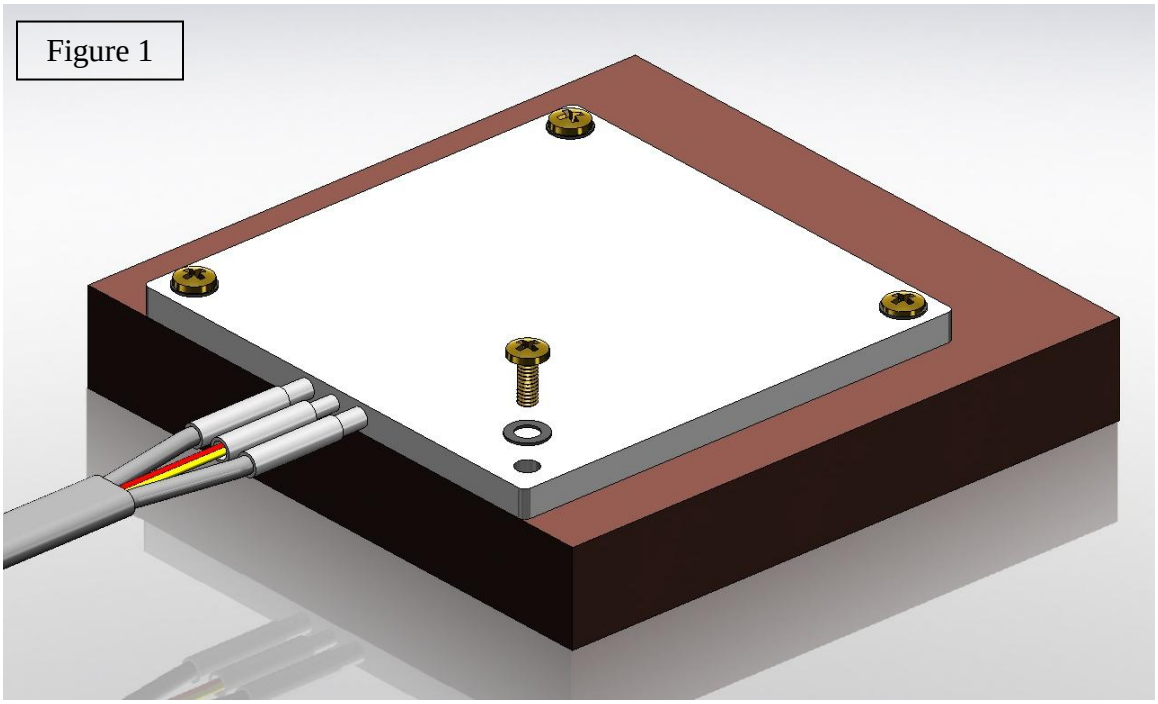


Figure 2

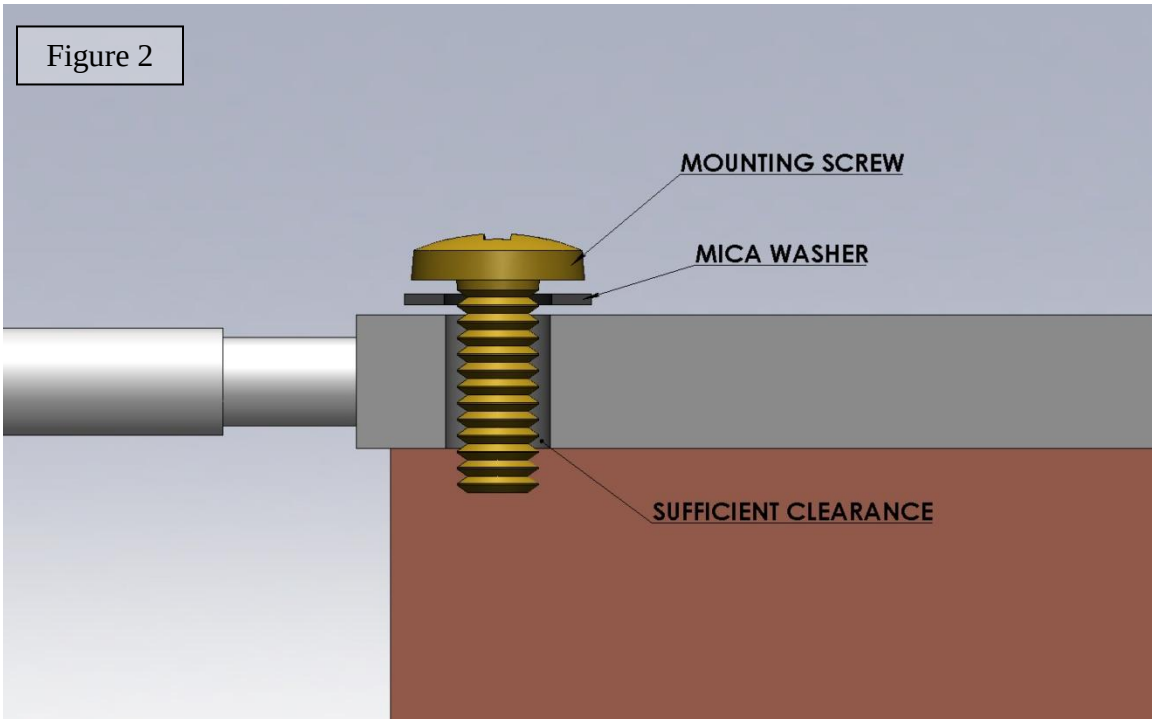


Figure 3

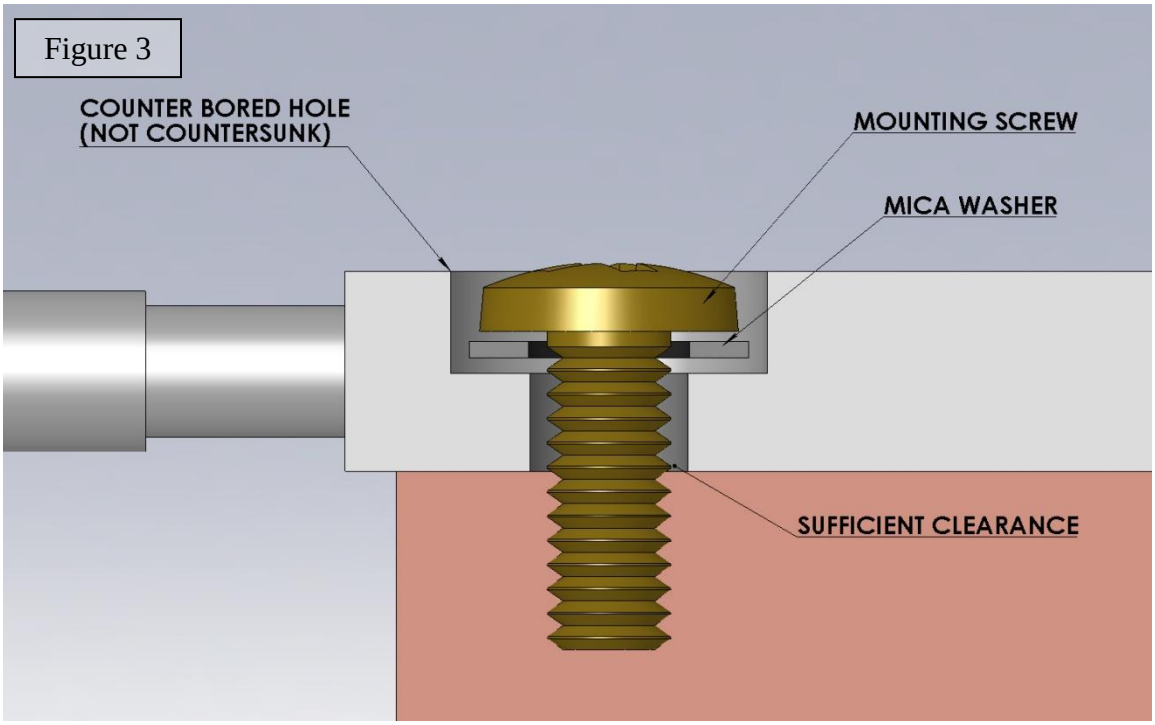


Figure 4

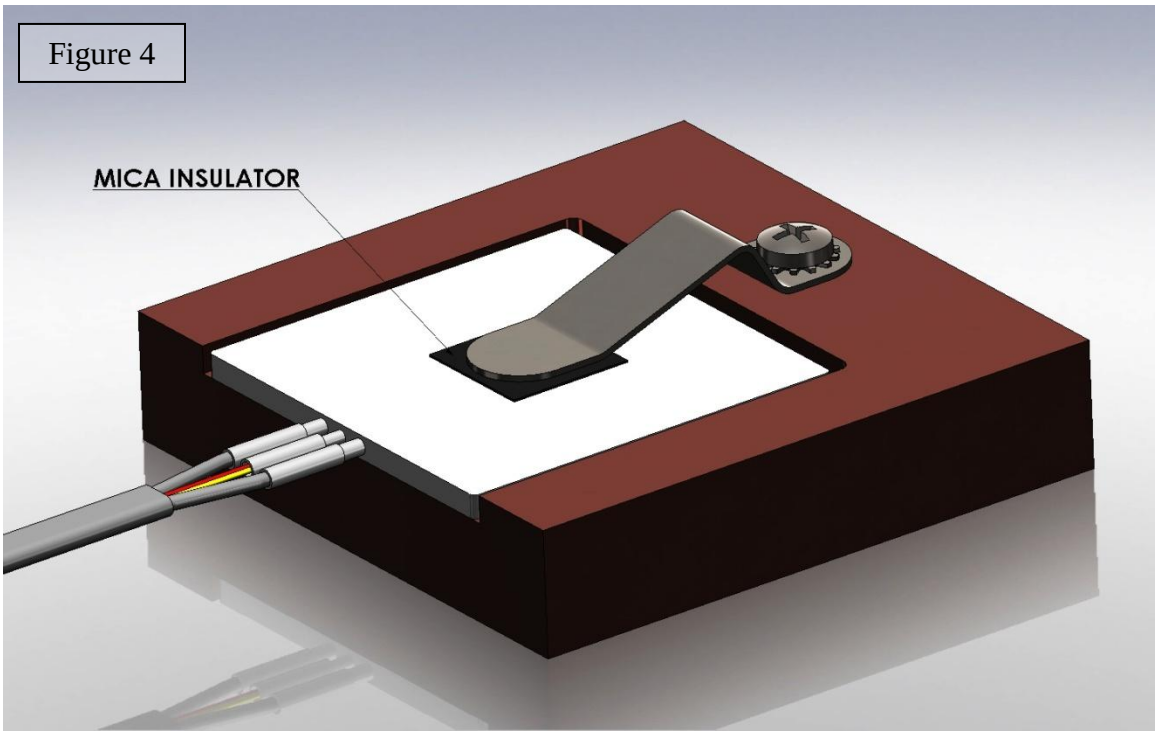


Figure 5

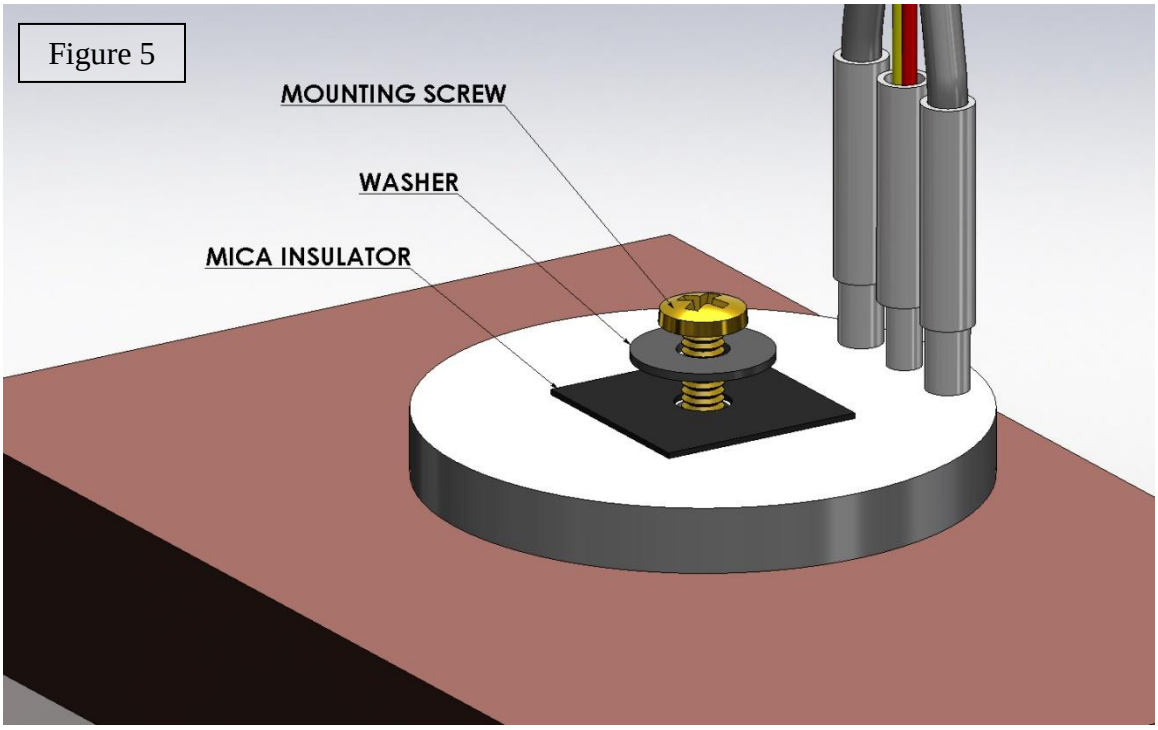


Figure 6

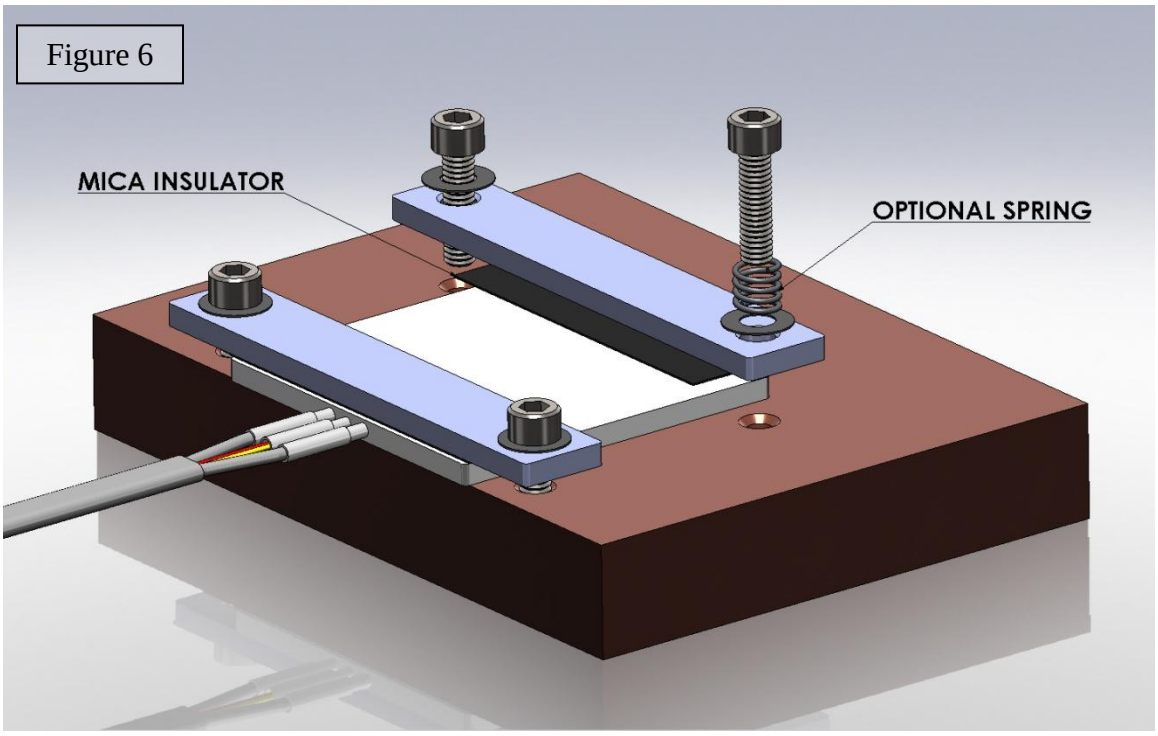


Figure 7

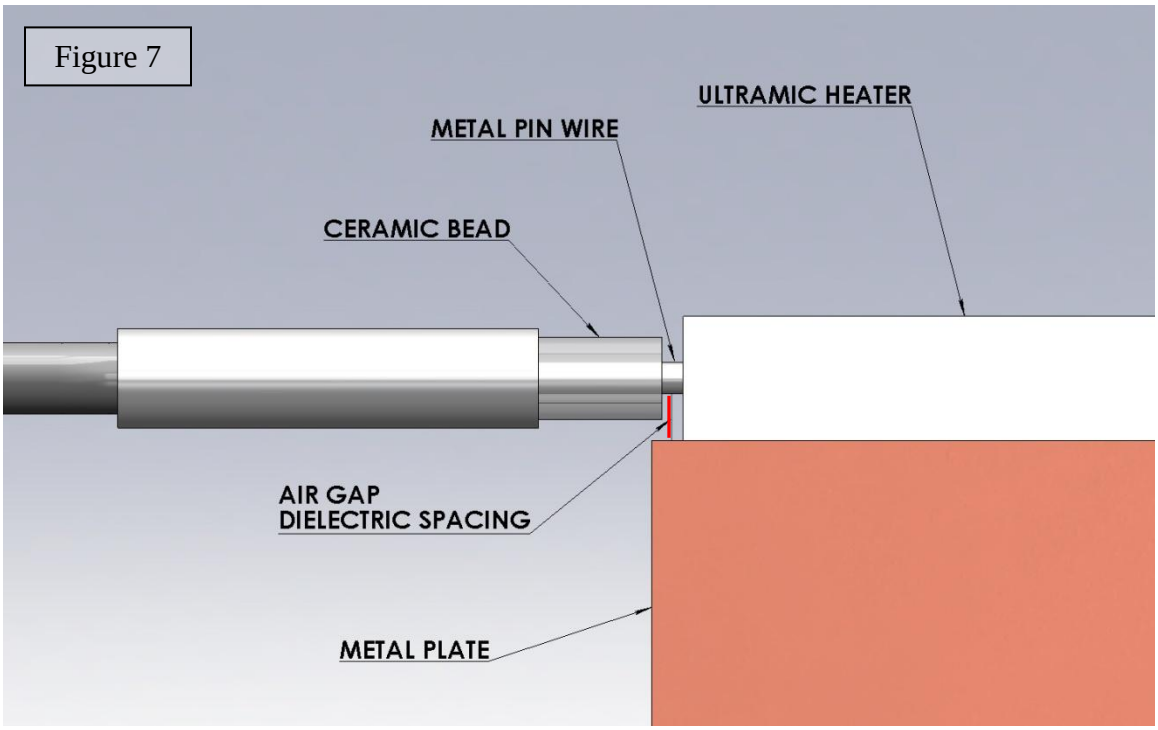


Figure 8