industry: analytical
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WATLOW®
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subject:

Better Heaters Mean More Innovative Analytical Equipment Designs

How ULTRAMIC® advanced ceramic heaters offer more design flexibility for mass spectrometers and other pieces of analytical equipment

summary:

Advanced ceramic heaters offer a number of benefits when it comes to the design and marketing of analytical equipment. Many of the heaters used in today's analytical equipment are metal-sheathed heaters based on legacy technology designed some 20 or 30 years ago, potentially limiting design innovation. By contrast, today's advanced ceramic heaters are smaller, respond faster, can be more accurately controlled and can be more resistant to environmental contamination. They also offer more design flexibility and are easier to integrate into equipment, simplifying the manufacturing and assembly process. Watlow's ULTRAMIC advanced ceramic heaters in particular can help analytical equipment manufacturers improve product performance and design, as well as accelerate their time to market.

advanced heater technology:

Why Consider Advanced Ceramic Heaters?

Legacy Heater Technology Can Limit Innovative Designs

Analytical equipment, such as gas-chromatograph mass spectrometers (GC-MSs), are used to determine the presence of trace chemicals in a number of research, industrial and clinical settings. This equipment requires the ionization of the sample and inert gas, which in turn requires a heating element that can reach a precise temperature quickly.

Many of the heaters used in these machines today are metal sheathed, a long-standing technology that has been available for over 30 years. While such heaters are excellent for a wide variety of complex thermal applications, today's newer and more advanced analytical equipment requires higher performance and precision. Advanced ceramic heaters can achieve these higher performance and precision criteria while allowing for greater design flexibility and faster time to market.

To appreciate the contrast, it helps to understand some of the limitations faced by more traditional metal heaters. These heaters must be inserted into another block of metal inside the equipment to perform their thermal job. Because both the heater sheath and the block are made of metal, they cannot come into contact with the ion source, and often require additional electrical isolation. These design tradeoffs require a larger footprint, as well as a more complex assembly procedure.

Metal-sheathed heaters also typically require longer heat-up and cool-down time, given that there is more mass in the heater and holder combined. This results in slower system startup and changes between set points.

Advances in ceramic heater technology overcome many of these issues and offer greater design flexibility and performance. Advanced ceramic heaters allow equipment designers to:

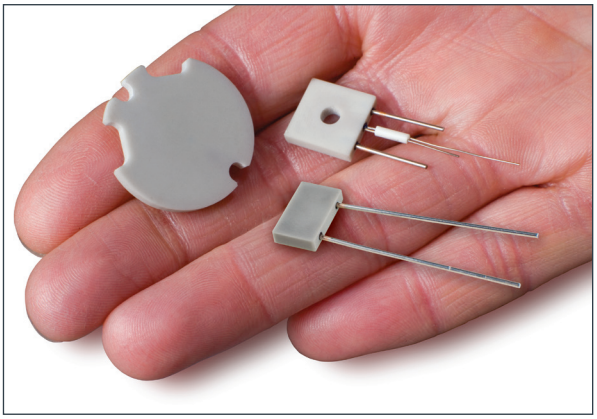
- Free up room for new components
- Reduce the machine's overall footprint
- Increase machine accuracy and performance
- Simplify the manufacturing and assembly process

What follows are some of the details as to *how* Watlow's ULTRAMIC advanced ceramic heaters realize these benefits for equipment designers.

application:

Using ULTRAMIC Heaters to Heat an Ion Source

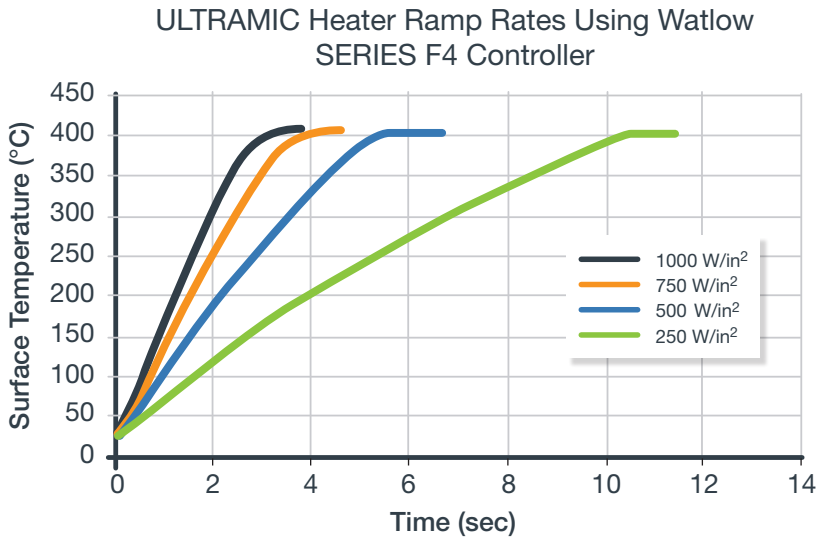
To allow for better, more innovative designs, Watlow developed ULTRAMIC, an advanced, high-performance ceramic heater. ULTRAMIC advanced ceramic heaters are designed for optimal performance in thermal applications where rapid thermal cycling and more precise control is required to ensure optimal effectiveness of the equipment and related processes.



ULTRAMIC heaters are constructed of aluminum nitride (AIN) and incorporate a thermally matched, proprietary heating element. These components, used together, can in the right circumstances, give rise to a number of unique properties:

- High electrical isolation, with low-leakage current
- Superior chemical resistance
- High thermal conductivity and fast temperature ramp (see ULTRAMIC heater ramp rate chart below)
- Superb temperature uniformity across the heater surface
- Incredible durability
- No open porosity

These unique properties provide a number of benefits when it comes to more advanced analytical equipment design.



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

	ULTRAMIC Heaters	Traditional Metal-Sheathed Heaters in Mass Spectrometers
Operate	**Up to 600°C**	**Up to 760°C (depending on insulation)**
Heat Ramp	**150°C per second**	**30°C per second**
Potential Watt Density	**Up to 1000 W/in²**	**Up to 200 W/in²**

ULTRAMIC vs. traditional design:

Benefits of ULTRAMIC Heaters: Better Designs

Improvement in a single component of a larger, more complex machine usually provides only incremental benefits. *However, when the limitations of that component also constrain the space of potential designs, improving that single component can lead to exponential improvements by opening up that space.*

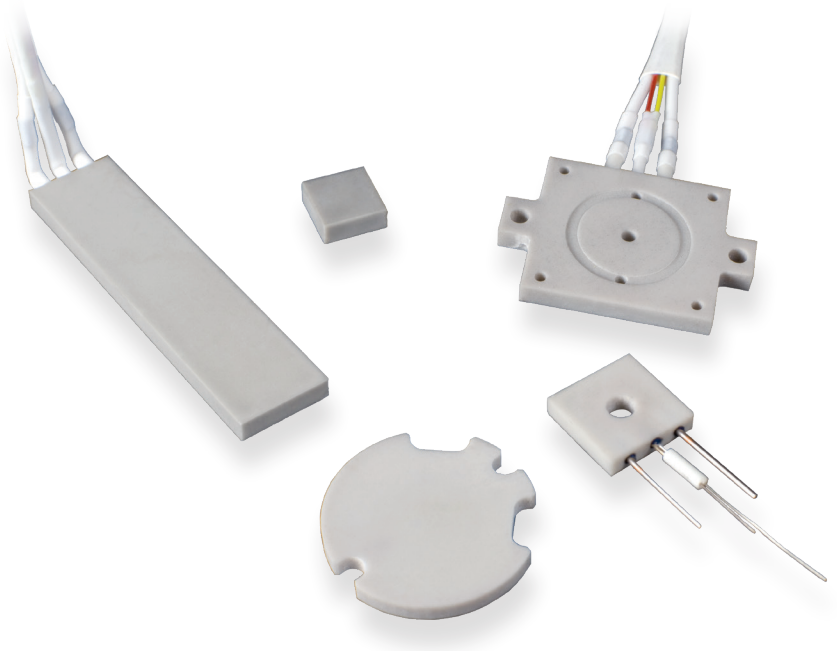
Here are a few examples of design improvements that are possible by incorporating ULTRAMIC heaters:

A Smaller Footprint

The drive to reduce the overall footprint of analytical equipment puts pressure on each component to become smaller and more efficient. ULTRAMIC heaters are significantly smaller than traditional ion source heaters. As such, they can be implemented into smaller spaces and are able to directly contact the voltage source without neutralizing the ion particles required in the spectrometry process. This could also allow for room to add other components that improve the overall product—an additional fan, for example.

a wide range of shapes and sizes

ULTRAMIC advanced ceramic heaters can be formed into a wide variety of shapes and sizes enabling a more tailored and integrated solution.



Faster Cycle Times

As mentioned previously, metal sheath heaters take longer to heat up and to cool down. This means a noticeable delay in achieving setpoints and more frequent and dramatic cycling. ULTRAMIC heaters heat and cool quickly, with an ultra-fast ramp rate of up to 150°C (270°F) per second (depending on the application, heater design and process parameters). This significant improvement in speed results in more rapid processing of samples.

Cleaner Operation

When making delicate measurements in the parts-per-million range (or finer), a small amount of contamination can ruin testing. The carefully controlled sintering process used for ULTRAMIC heaters produces a heater with virtually no porosity, making it an ideal choice for applications requiring a "clean" operating environment. Metal sheath heaters, on the other hand, have a known tendency to outgas, which can create challenges with respect to maintaining a clean operating environment. ULTRAMIC heaters do not outgas, release much less heat into the ambient environment (aka heat loss) and are completely vacuum compatible.

benefits of ULTRAMIC heaters:

The Business Case

All of the above benefits point to how ULTRAMIC heaters can help create better products for analytical applications. For example, a mass spectrometer using ULTRAMIC heaters is more likely to be smaller, faster, cleaner and more accurate—all qualities that will appeal to customers buying advanced analytical equipment.

Better products do not always *necessarily* make the most business sense, however. (Ever hear of Betamax? Or Google Glass, for that matter?) Thus, it is incumbent on any manufacturer to ensure that a strong and compelling business case can be made for any new product.

Fortunately, a strong business case can be made that rationalizes the use of advanced ceramic heaters for analytical equipment.

Easier Integration Means Faster Assembly

As previously mentioned, ULTRAMIC advanced ceramic heaters can come into direct contact with the ion source. This by itself is a significant advantage over metal sheath heaters, as there is no effect on the ionization of application. Additionally, ceramic heaters can withstand high voltages and do not require additional insulation. Furthermore, ULTRAMIC can be machined to precisely fit the space where needed. These innate design features reduce the number of components needed, as well as the complexity of the assembly process. Faster and easier assembly results in greater manufacturing efficiency.

Meeting UL® and CE Agency Compliance for Faster Time to Market

ULTRAMIC heaters already meet UL® and CE agency standards. When individual components already comply with these standards, it makes the process of getting the entire machine UL® and CE certified much quicker, thus reducing the time-to-market for the new machine. By contrast, most metal-sheathed heaters do not have UL® component recognition.

No Speed/Precision Trade-Off

For many analytical applications, precision is of paramount importance. In other applications, speed and throughput are a much bigger concern. ULTRAMIC heaters are more accurate and faster, which means that the same component can be used in machines for a much broader array of applications. This simplifies both the design process and purchasing.

takeaways:

Ceramic heaters produced with AIN have a number of beneficial properties that make them useful as heating elements in analytical equipment, such as gas chromatography and mass spectrometry equipment. These heaters have fewer limitations when compared to traditional metal-sheathed heaters, thus freeing up the space for new and more innovative design possibilities. They are also easier to integrate into equipment, simplifying the manufacturing and assembly process. Watlow's ULTRAMIC advanced ceramic heaters help analytical equipment manufacturers improve both their designs and their speed-to-market.