

SEMICONDUCTOR PROCESSING

THERMAL
TECHNOLOGIES FOR
GLOBAL INDUSTRY



Thermal Technologies

for

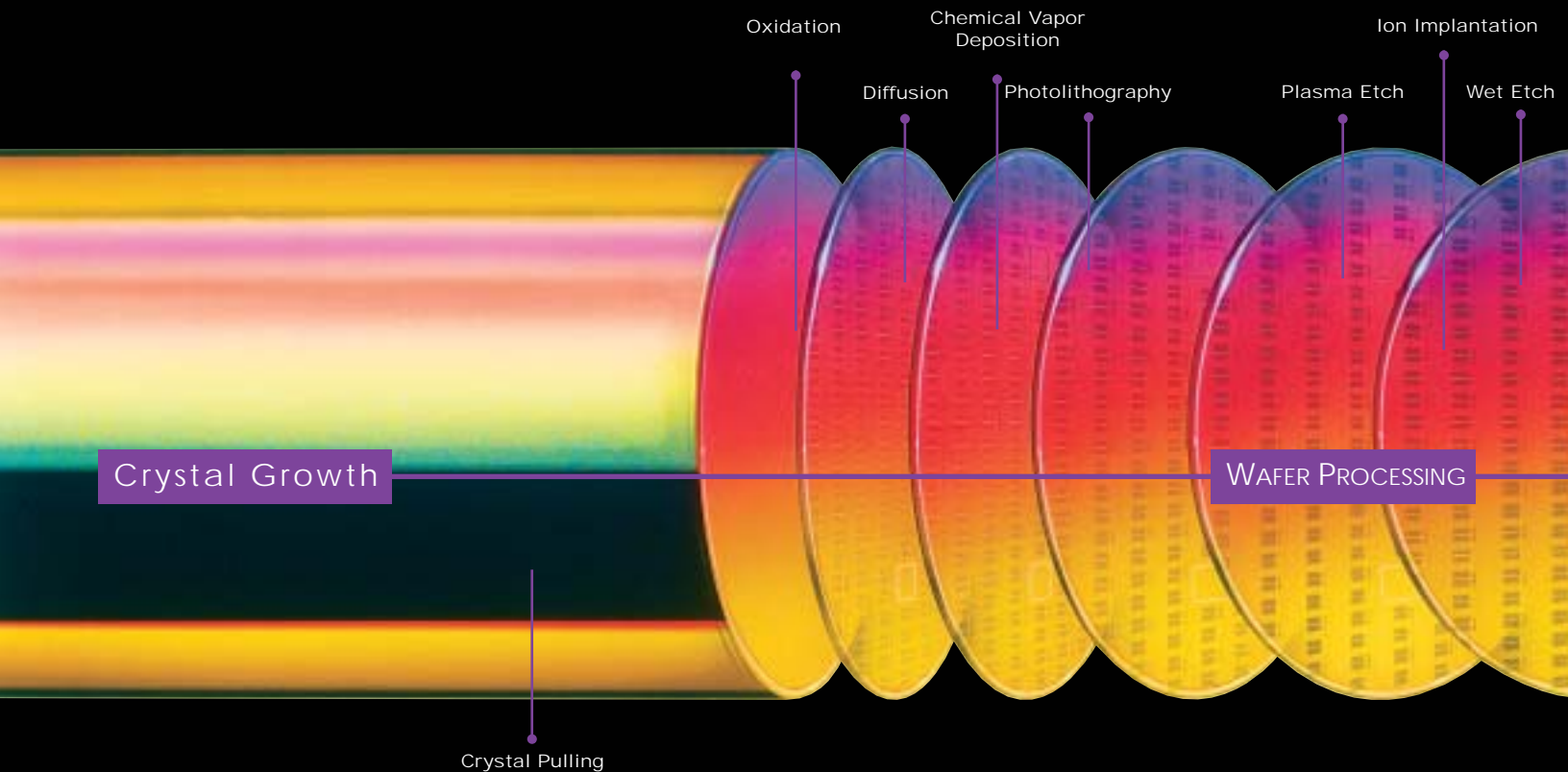
Global

Semiconductor
Industry

Watlow is the global leader in providing innovative thermal solutions for semiconductor applications ranging from crystal growth through front-end wafer process to back-end assembly.

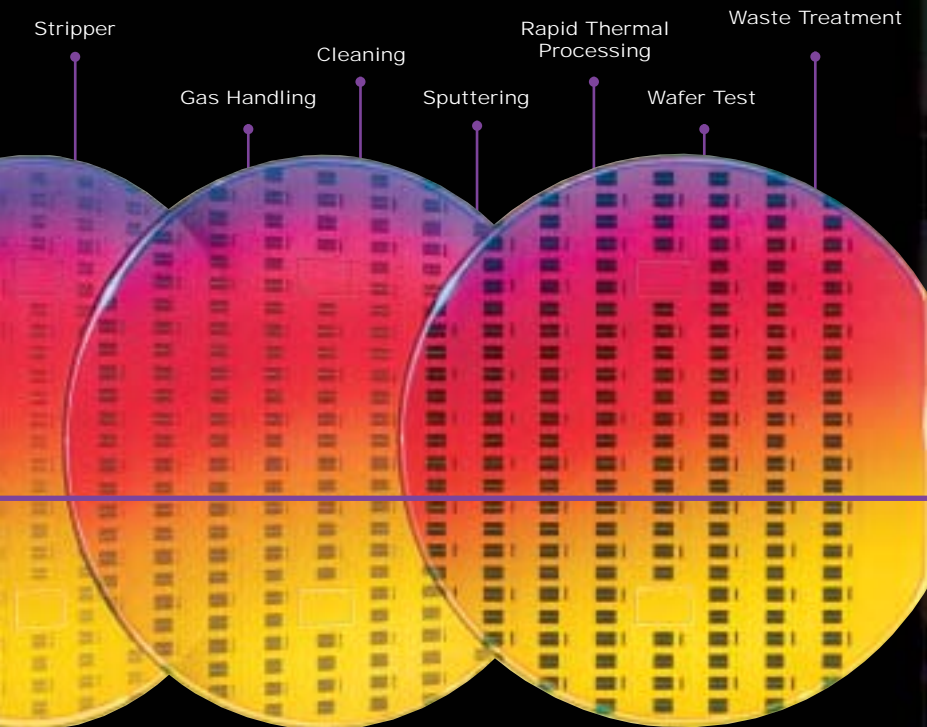
Ever since the first diode, temperature has played an important role in semiconductor manufacturing processes. Watlow was there at the beginning and continues to provide proven results to the industry's processes including in-situ deposition, etch and photolithography.

Watlow's solutions are based on an understanding of the Semiconductor Technology Roadmap. As dimensions shrink, temperature as a critical process variable increases in



importance for equipment and process engineers. Watlow meets the ongoing demands of the industry and the thermal challenges of new semiconductor processes. We continue to invest in R&D, global manufacturing and sourcing and introductions of new thermal technologies and solutions.

To better serve the semiconductor industry, Watlow has design, manufacturing, sales and technical support facilities in Asia, Europe and North America. We have developed new thermal technologies for deposition, dry and wet etch, photolithography, test and back-end assembly. As a global company, we support international design guidelines and agency approvals.



PACKAGING, ASSEMBLY AND TEST

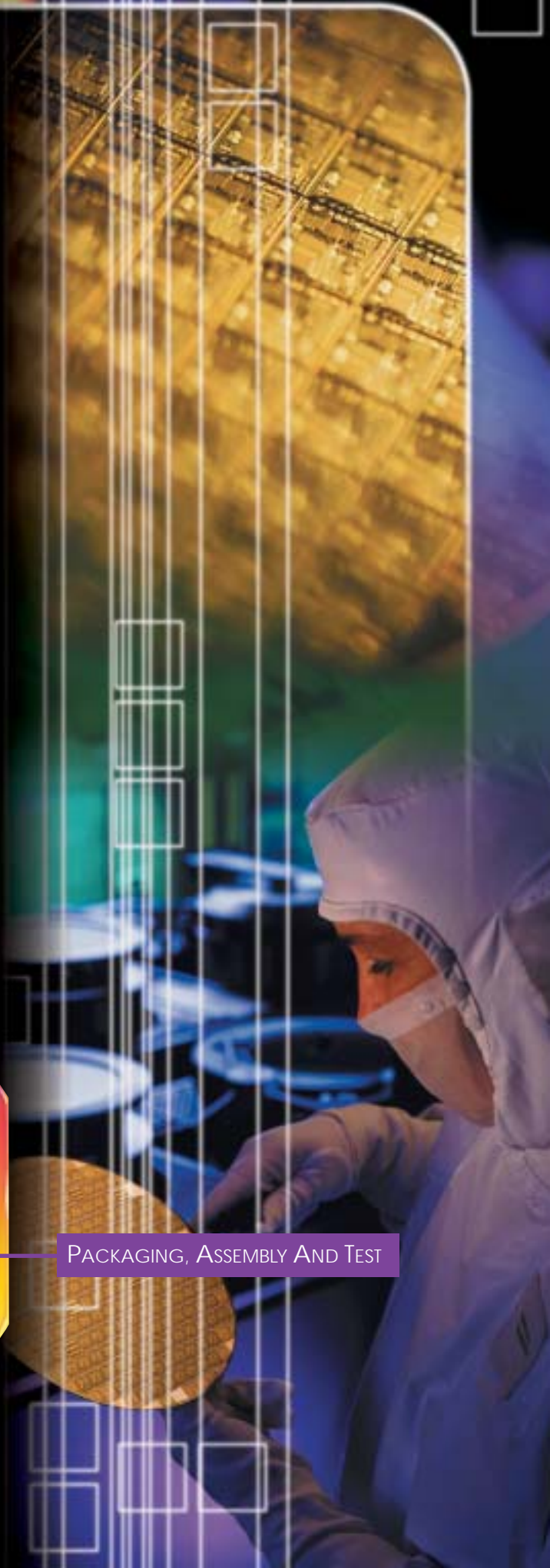


Table of Contents

Gas Delivery and Pump Line Thermal Solutions

High Uniformity Gas Delivery Line Heaters	2
STRETCH-TO-LENGTH® Gas Delivery Line Heaters	3
SERIES EHG Controllers	4
Pump Line Heaters	5
Temperature Control Consoles	6

Deposition and Etch Vacuum Chamber Thermal Management Solutions

Temperature Sensor Technologies	8
Large Thick Film Heater Panels	12
Thick Film Heaters on Ceramic Substrates	13
Wafer Chuck and Pedestal Assemblies	14
High Performance Metal Sheath Heaters	16

Wet Process Equipment

Thick Film Quartz Heater Modules	20
UNIVERSAL SOLVENT Heaters	21
STARFLOW Nitrogen (N ₂) Air Heaters	22
RAPID RESPONSE Heat Exchangers	23
VERSALINE 500 In-line Heaters	24

Temperature Controllers and Connectivity

Connectivity Solutions	26
Controller Products Connectivity Matrix	27
DIN-A-MITE® Power Controllers	28
SERIES D8 Temperature Controllers	28
SERIES PD Temperature Controllers	29
SERIES SD Temperature Controllers	29
SERIES SD Limit Controllers	29
Controller Products Agency Compliance, Recognitions or Approvals	30

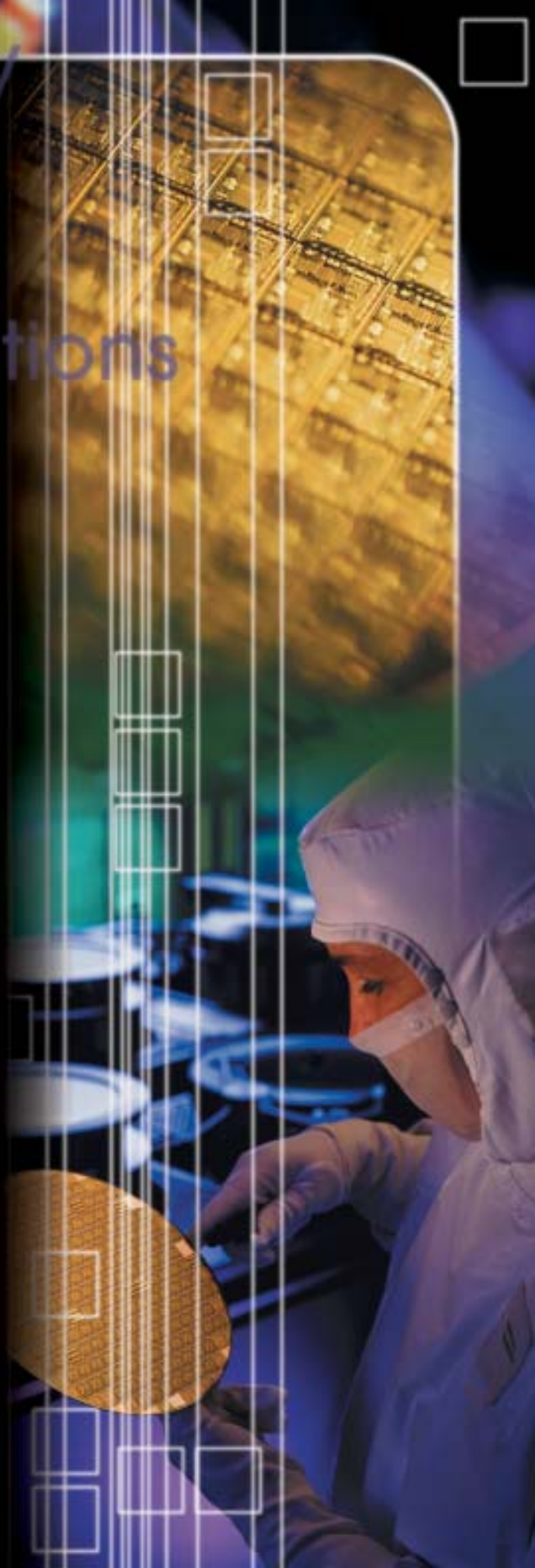
Design Services

Single Iteration	31
------------------	----

Gas Delivery and Pump Line Thermal Solutions

Controlling temperature of gases delivered to a vacuum chamber and out the pump lines is essential as the industry develops new processes in alignment with the Semiconductor Technology Roadmap. Platform based tools are designed to not only increase throughput, but also increase the thermal management challenges involved with providing consistent deposition and etch processes. Yields increase and preventative maintenance frequency can decrease when delivery and exhaust gases are controlled within the prescribed process parameters.

Watlow's gas and pump line heating systems were developed to provide flexibility in designing the optimum heating systems. Vacuum chamber plumbing systems can create a thermal challenge because of varying thermal mass, constricted spaces and last minute layout changes. The new STRETCH-TO-LENGTH® heating system and SERIES EHG controllers are standard solutions for hard to heat gas delivery lines. Integrated as a complete package, Watlow components reduce design time and system costs. Solutions with fast delivery for abatement applications are possible because Watlow has over one thousand standard heater configurations in our design files.



High Uniformity Gas Delivery Line Heaters



A number of gases used in semiconductor wafer processing require uniform heating of the gas lines in order to prevent condensation and potential contamination of the wafer process. Condensation occurs at cold spots and may result in expensive maintenance and tool down time. Contamination occurs when hot spots in the gas line cause the gases to break down and results in reduced yields.

Watlow's High Uniformity Temperature Solution starts with thermal profiling the gas lines in order to understand the thermal gradients resulting from component mass, material and physical orientation. The standard and custom modeled silicone rubber gas line heater solution results in a thermal system that meets specification and is repeatable for common tool designs.

Features and Benefits

Even heating to 200°C (392°F) for uniform temperature profiles over the entire heated line

- Helps eliminate condensation in lines and/or maintain process chemistry
- Insulated straight fillers for 100 percent line coverage (elbows and tees are trim-to-fit to proper length)

Cleanroom compatible silicone rubber construction

- Clean heaters will not contribute to particle generation

Environmental safety

- Reducing particle buildup decreases potential of employee exposure to hazardous materials during normal cleaning cycles

Optional UL® 94-VO flame retardant materials

- Fire-safe UL® 94-HB or UL®-VO material

Applications

Gas delivery lines

- Boron trichloride, BCl_3
- Chlorine trifluoride, ClF_3
- Dichlorosilane, (DCS), SiH_2Cl_2
- Tetraethylorthosilicate, TEOS
- Tungsten hexafluoride, WF_6
- Process gas line qualification

STRETCH-TO-LENGTH[®] Gas Delivery Line Heaters



Watlow's STRETCH-TO-LENGTH[®] gas line heating system was developed as an easy-to-assemble temperature solution with performance superior to heat tape. The flexibility of these heaters give engineers the ability to compensate for the size of different components thus reducing the potential for hot and cold spots.

Watlow's STRETCH-TO-LENGTH heaters are UL[®] recognized for U.S. safety standards and are SEMI S2-93 compatible with a high limit thermocouple and controller.

Features and Benefits

Easy to install two part system

- Conveniently fits on most gas line configurations

Flexible heater design gives engineers the flexibility to easily customize the thermal profile for each gas line application

- Standard designs and stocked product allow quick prototyping to determine energy distribution requirements for process improvements

Flexible standard system components

- Eliminate unnecessary lead times for custom designs

Silicone Rubber Heater Specifications

- Heater and insulation jacket material: reinforced silicone rubber fabric
- Color: insulation and outer jacket, orange; heater, orange
- Clean room strap fasteners
- Voltage: 120 to 240V~(ac)
- Maximum operating temperature: 200°C (392°F)
- Watt density: 0.31 W/cm² (2 W/in²) – Watlow recommends 80 percent line wrap for optimum performance
- Power lead wires: 305 mm (12 in.); #16 AWG UL[®] 1180 CSA, rated 13A, lead wire pair encapsulated in reinforced silicone rubber sleeving
- Heater interconnectable up to 13A circuit
- Material rated UL[®] 94-HB
- Heater materials are UL[®] rated to 200°C (392°F)

SERIES EHG Controllers

Watlow developed the SERIES EHG temperature controller for gas and pump line heater applications. This new thermal solution includes a compact temperature controller, thermocouple sensor and power switching device that are integrated into the heater's power cord. The SERIES EHG reduces system costs and substantially extends the life over conventional thermostat solutions.

Features and Benefits

Long operational life

- Improves system reliability

Tight temperature control

- Assures process accuracy

Small sensor footprint

- Fits with almost any heater
- Responds quickly to temperature changes
- Controls high watt densities in low mass applications

UL® recognized

- Compliant with agency regulations

Reduced system cost

- A single EHG controller can be configured with heaters to reduce system cost

Pre-wired, in line control

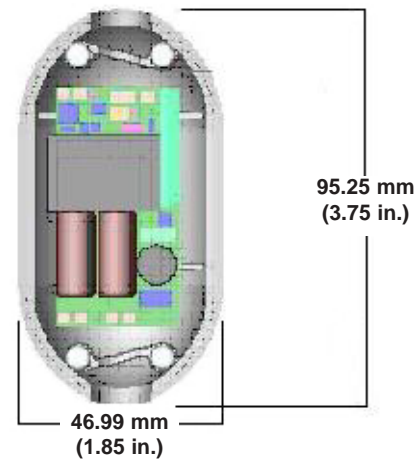
- Simplifies installation
- Two wire power connection

Durable housing with built-in strain relief

- Protects electronics
- Low risk of mechanical damage



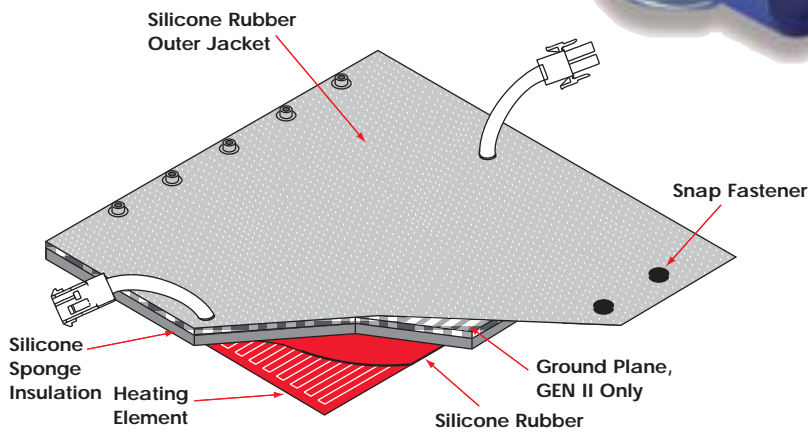
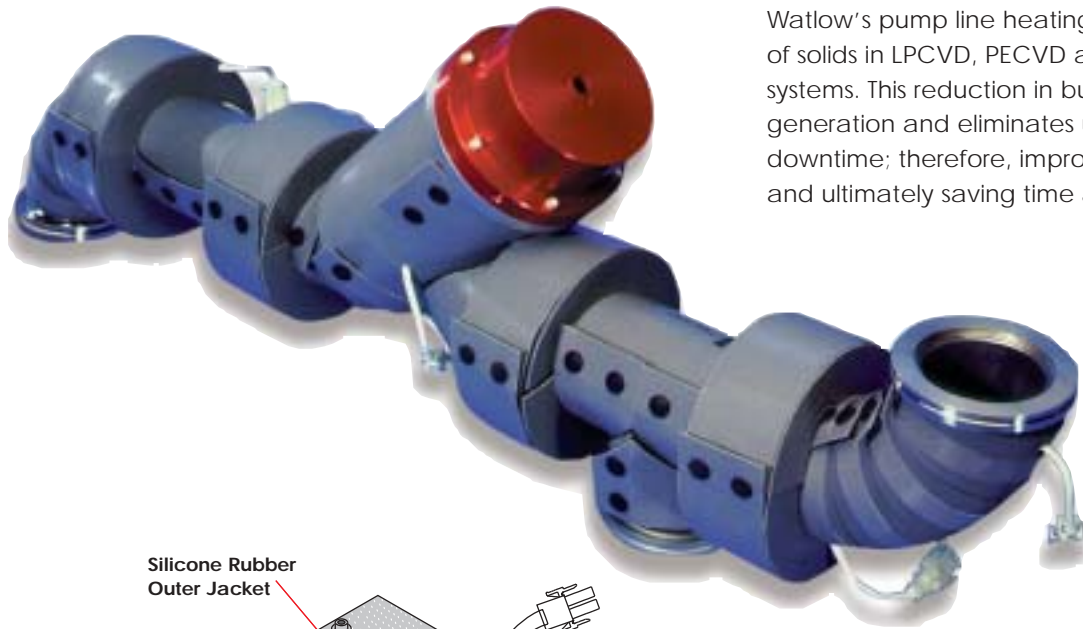
Dimensions



Integrated SERIES EHG System Versus Integrated Thermostat System

	Integrated SERIES EHG System	Integrated Thermostat System	SERIES EHG Benefit
Life comparison at rated amperage	Tested to greater than 4,000,000 cycles with 10 amp load	Rated 100,000 cycles	Longer product life of SERIES EHG system and high reliability in application
Switch hysteresis	3°C (6°F)	8°C (15°F)	SERIES EHG system will provide superior process control
Improved response time reduces overshoot on start-up	3°C (6°F) typical	14°C (25°F) typical	SERIES EHG system will respond to changes in temperature faster than thermostat
Warranty	2 years on material and workmanship	1 year on material and workmanship	Warranty can be extended because of superior SERIES EHG life
Zero cross switching	SERIES EHG has zero cross switching	Random switching during sine wave cycle	Reduces possibility of electrical mechanical interference

Pump Line Heaters



Watlow's pump line heating systems work to reduce buildup of solids in LPCVD, PECVD and metal etch vacuum piping systems. This reduction in buildup helps reduce particle generation and eliminates unscheduled maintenance downtime; therefore, improving the consistency of yields and ultimately saving time and money.

Watlow's pump line heating systems are compliant with global guidelines and specifications including CE, NEC, UL® and SEMI S2-93.

Applications

LPCVD

- Silicon nitride
- Titanium nitride

Metal etch

- Aluminum
- Tungsten

CVD

- Tungsten
- TEOS

PVD

Diffusion furnaces

FPD

Features and Benefits

Even heating up to 200°C (392°F)

- Eliminates cold spots that result in condensation or particle buildup in the line
- Tight contact fit improves heat transfer minimizing cold spots
- Modular heating system combines standard parts to cover custom lines

Easy on-off with reclosable fasteners

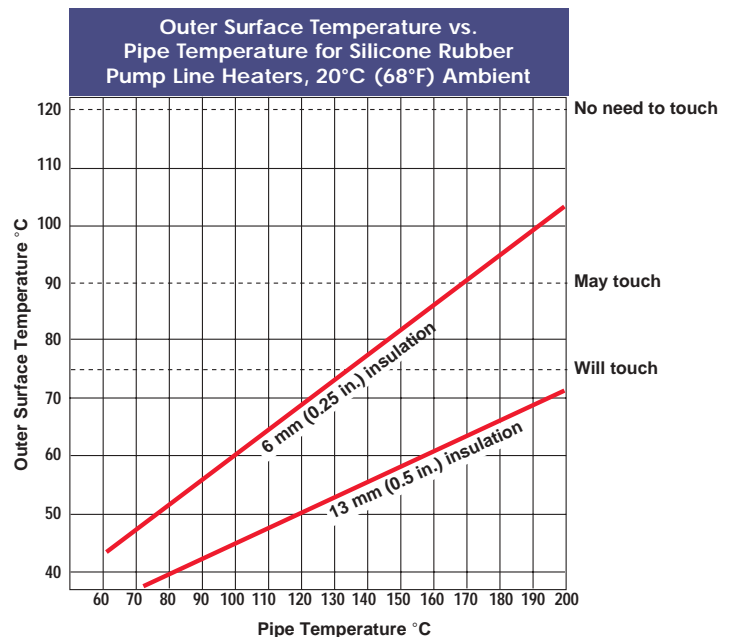
- Simplifies installation and maintenance
- Includes snap-type fasteners

Silicone rubber construction

- Cleanroom compatible reducing particle generation
- Reinforced silicone rubber fabric used on both heater and jacket
- Gray color used for insulation and outer jacket
- Red-orange color used for heater

Global electrical and agency standards

- Standard voltage: 120 and 208V~(ac)
- Heaters interconnectable up to a 13A circuit
- UL®, CE, NEC and SEMI S2-93 compliant



Temperature Control Consoles



Thermal solutions for gas delivery and pump line heating require precision temperature control. The best process control is achieved through PID temperature algorithms. Typically, several temperature zones are required to heat a line because of length, amperage and thermal mass of the stainless components. A turnkey temperature control console simplifies control and installation of the thermal subsystem. Watlow control consoles are plug and play and ready for installation in a tool or wafer fab. The control consoles have everything necessary to power and control a gas or pump line including temperature controllers with advanced PID algorithms with CE and UL* ratings, solid state switching and fusing.

Features and Benefits

Integrated control package

- Advanced PID algorithms for precision temperature control
- Solid state SSR switching for long life
- Semiconductor fusing to protect system

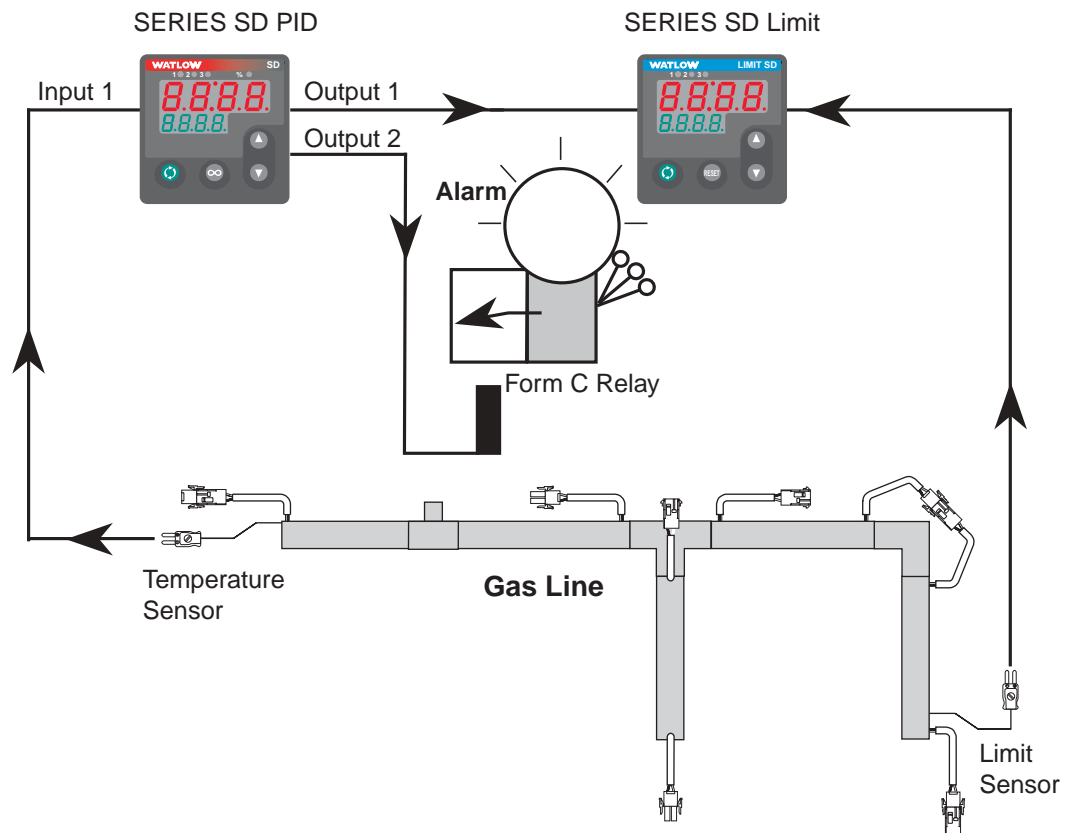
Turnkey package

- Plug and play system that is tested and ready for installation
- No external components required
- Space efficient self contained console

Regulatory and testing agencies

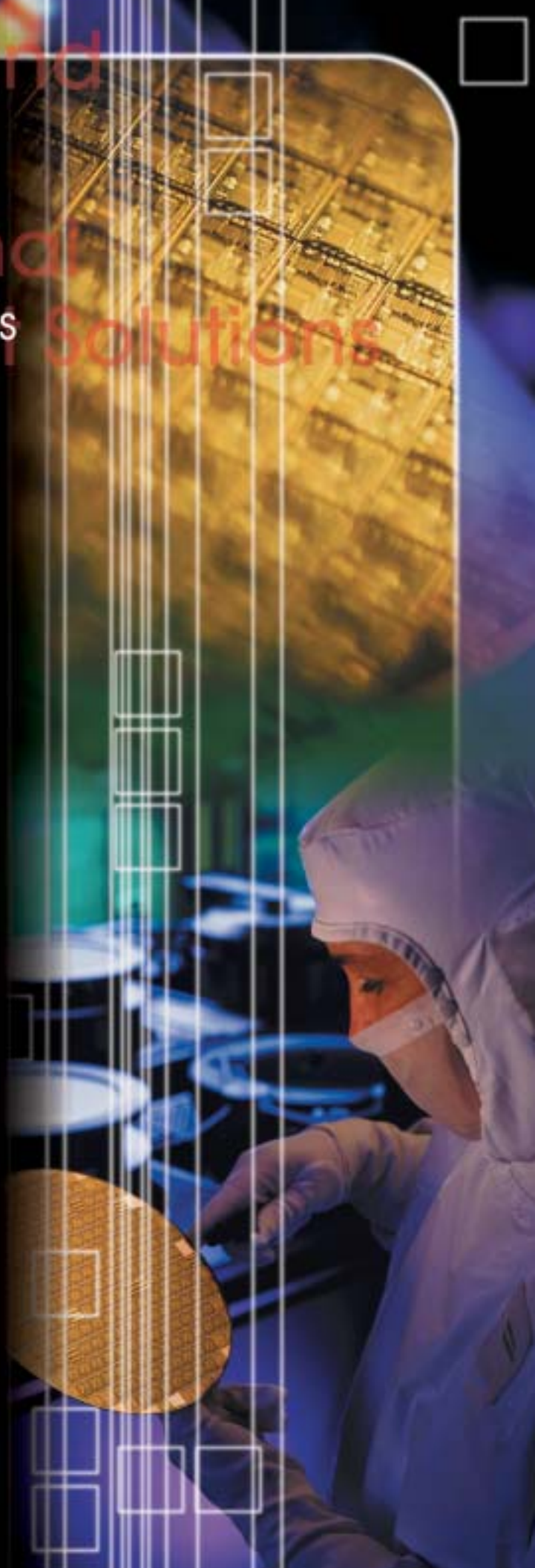
- CE, UL*, UL* 508, FM, SEMI S2 (Contact factory for agency approvals that apply to each control console model)

Plug and Play Control Console In Gas Line Heating Application



Deposition and Etch Vacuum Chamber Thermal Management Solutions

Uncontrolled thermal gradients in a vacuum chamber substantially reduce process repeatability and wafer yields. The harsh environment including chemical, plasma, vacuum and temperature increases potential for process contamination. One solution does not work for all vacuum-based applications. Watlow designs metal and ceramic heater and sensor components that are compatible with most vacuum environments. Watlow's new ceramic heaters include AlN and AlO₃ based designs that offer precise high temperature pedestal heater solutions for bake stations and in-situ vacuum environments. Metal heaters can be incorporated into the walls and lid of vacuum chambers to prevent condensation. Pure aluminum and higher temperature stainless steel assemblies are also excellent solutions for many CVD, PVD and etch applications. Watlow is prepared to supply the complete turnkey thermal subassemblies for vacuum applications.



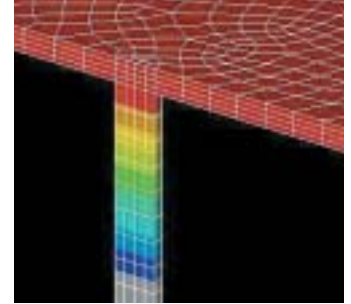
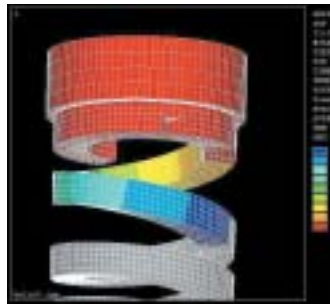
Temperature Sensor Technologies



MICROCOIL

MICROCOIL surface sensors are ideal for measuring chuck, internal wall, chip, heat sinks and circuit temperatures. The flexible probe design positions the sensor tip for optimal surface contact and isothermal response and accuracy. MICROCOIL can be designed as a single or dual probe and with metal or ceramic tips for maximum isothermal accuracy and process material compatibility.

U.S. Patent #6,257,758
European Patent #1,119,749



Features and Benefits

Miniature size

- Allows for precision measurement in tight spaces

XACTPAK® mineral insulated thermocouple cable

- Electronically isolated and shielded

Self leveling and loading

- Provides superior repeatability of measurement for a wide variety of surfaces and isothermal measurement accuracy

RADIO FREQUENCY Thermocouple Probe (RF)

RF immersion sensors are designed to reduce transient 13.56 MHz signals from being transmitted on the sensor leads in plasma environments. This results in a more stable and accurate measurement of chuck temperature.

Features and Benefits

3000V \pm (dc) dielectric rating

- Allows thermocouple to be used in platens with dc bias

High thermal conductivity design

- For accurate, repeatable measurements

High CMRR lead wire design

- Reduces induced error from EMI variety of surfaces



Temperature Sensor Technologies



TRUE SURFACE Thermocouple (TST)

TST is a surface sensor designed to reduce error in atmospheric applications where air currents can cause instability in temperature accuracy. A winner of *Control Engineering's* 2000 Editor's Choice Award, the TST achieves superior accuracy through a combination of isothermal design and shielding.

Features and Benefits

Isothermal measuring junction

- Offers excellent thermal conductivity for the measuring junction

Molded insulator

- Isolates the isothermal measuring junction from ambient airflow

Compact, universal package

- Fits into corners and other tight locations easily (11.2 mm (0.44 in.) wide by 6.1 mm (0.24 in.) high) and the molded insulator is removable for applications where an even smaller package is needed

Temperature rating of 200°C (400°F)

- Offers superior application flexibility for a wide variety of surfaces



Tapered Thermocouple Probe

The Tapered Thermocouple Probe is designed to provide rapid temperature response in applications where the sensor is inserted in an electrostatic chuck, gas line or wherever a fast accurate temperature measurement needs to take place in a small area. Tool design using the Tapered Thermocouple Probe is miniaturized by the combination of tapered tip construction and a new mini-bayonet style fitting.

Features and Benefits

NIST traceable cable calibration certification

- Calibration offset information allows the controller to compensate for known error
- INFOSENSE™ calibration code can be used with compatible Watlow controller to double sensor accuracy ($\pm 0.5^{\circ}\text{C}$ ($\pm 0.9^{\circ}\text{F}$) or ± 0.2 percent)

Tapered tip option

- Faster response time in more rigid sheath designs



Applications

Electrostatic chucks

Gas lines

Chambers

Large Thick Film Heater Panels



Features and Benefits

Large single piece heater construction

- Superior flatness and temperature uniformity specifications

Material compatibility

- Vacuum applications to 10⁻⁶ millitorr
- Designed for ultra-pure applications

Thick film heater circuit

- Operating temperature to 550°C (1022°F)
- Consistent part-to-part temperature uniformity

Agency Approvals

- Thick film heaters UL® recognized under File E52951

Applications

Pre-heat station

Bake-out station

Annealing station

Solar panels

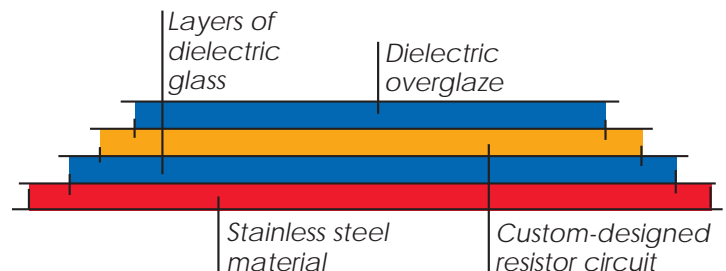
Color filters

Processing requirements for wafer, solar panel and display technologies are growing in physical size in order to increase throughput and reduce the cost of each manufactured device. For example, more chips can be produced on a 300 mm wafer than on a 200 mm wafer and large glass panels can produce more flat panel displays. In addition to size, new processes require tools that can operate at higher, more accurate and more uniform temperatures. Applications may be in atmospheric or vacuum environments.

Watlow developed our large thick film heater capabilities to address the industry's growing processing requirements. Our large panel thick film on stainless steel construction provides uniform heating to 550°C (1022°F) in a vacuum environment. Using thick film technology, overall weight of the assembly is greatly reduced and the single piece heater construction gives us the ability to manufacture a very thin profile heater. Temperature uniformity and accuracy come from our ability to precisely pattern and distribute the wattage of a thick film heater circuit and to maintain flatness requirements across a very large surface area. Thick film technology also gives designers the ability to zone heater circuits and reduce potential hot and cold spots resulting from boundary conditions. The ability to apply precision heater circuits on a larger stainless steel surface makes thick film heaters the ideal choice for large processing tools.

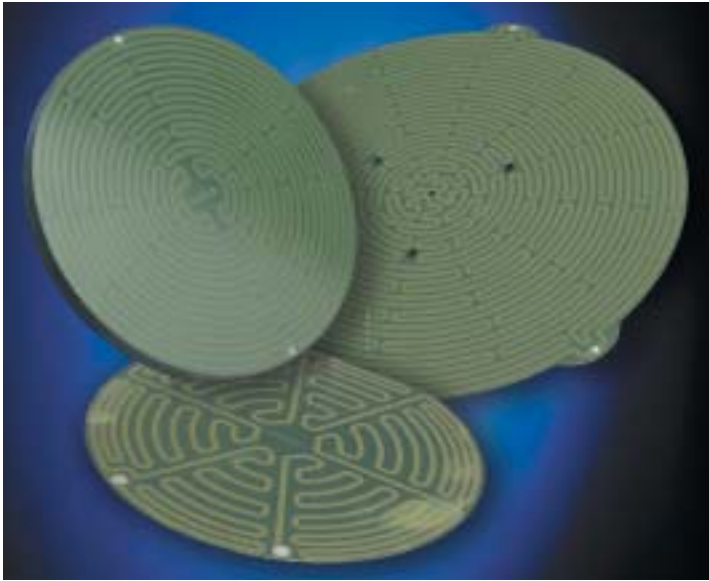
Compared to alternative heating technologies on the market today, thick film heaters are very process friendly and operate with negligible process contamination through outgassing.

Construction of Thick Film on Stainless Steel Heater



UL® is a registered trademark of Underwriter's Laboratories, Inc.

Thick Film Heaters on Ceramic Substrates



Features and Benefits

Multiple circuit design capability and heater patterning

- Customizable heater design ensuring precise temperature profile
- Multi-zone capability

High thermal conductivity materials

- Rapid thermal response in applications requiring fast heat up and cool down
- Promote uniform surface temperature

Thin ceramic substrate

- Allows heater to be designed with a lower profile
- Reduces heater mass for faster thermal cycling

High dielectric material and thick film system

- Ideal for applications requiring high isolation resistance

Material compatibility

- Ideal for most ultra-pure semiconductor applications
- Ideal for use in demanding spaces

Watlow's thick film heaters on aluminum nitride (AlN) provide superior thermal characteristics, small heater profile, chemical compatibility and ultra pure materials that are critical for processing wafers in deposition, etch and photolithography applications. Thick film heater technology allows design of multizone heater circuits that can be repeatedly manufactured to assure consistent process temperature in tools with vertical or horizontal wafer chuck assemblies.

General Specifications

- Maximum operating temperatures of 300°C (572°F) for aluminum nitride and 500°C (932°F) for alumina
- Voltages of up to 480V~(ac)
- Watt densities up to 23.25 W/cm² (150 W/in²) for aluminum nitride and 3.56 W/cm² (23 W/in²) for alumina
- Ramping capabilities of up to 40°C (104°F) per second
- Flat shapes of up to 355.6 mm (14.0 in.) square
- Cylindrical shapes of up to 50.8 mm (2.0 in.) in diameter
- Thickness from 0.5 mm (0.025 in.) up to 12.5 mm (0.500 in.)

Applications

Wafer pre-heat bake stations

Photolithography track systems

Annealing

Wafer probers

Chip bonding

IC test

Atmospheric rapid thermal processing

Wafer Chuck and Pedestal Assemblies



Heated chucks and shafted pedestal heaters are used in critical in-situ wafer processing applications where proximity to the wafer requires precise thermal, electrical, metallurgical and mechanical specifications. Watlow has developed several innovative solutions that address specific application requirements from CVD to wafer probing.

Combining dissimilar metals by advanced machining and welding processes is a demonstration of Watlow's innovative culture. A specific example of this process is an aluminum pedestal heater with a stainless steel shaft. The stainless steel material reduces the thermal losses through the shaft and results in precision perpendicularity with a superior vacuum seal. The shaft provides an ideal way to get the lead wires out of the process chamber. The heated pedestal achieves excellent temperature uniformity and is delivered with semiconductor-grade cleaning and packaging.

Applications

Chemical Vapor Deposition (CVD)

Dry etch

Ashers

Photolithography track

Wafer probers

IFC E-Beam (Interference Fit Construction Electronic-Beam) Welded Pedestal Assembly

IFC construction is ideal for high temperature and corrosive vacuum environments. Watlow's IFC manufacturing process secures tubular heater elements and optional cooling tubes into the substrate material without the use of a secondary vacuum brazing operation. The assembly is subsequently electron beam welded for vacuum service, including shafts, flanges or other customer fittings. IFC heater assemblies are ideal for PECVD applications, delivering excellent temperature uniformity performance in a demanding process environment.

Specifications

- Performance to 700°C (1292°F)
- Materials
 - Inconel®
 - 304 and 316 Stainless Steel
 - Nickel
- Tubular heater element and optional heat/cool tube
- Perpendicularity to better than 0.1 mm
- Flatness to 0.005 mm on 300 mm wafer chuck



Inconel® is a registered trademark of Special Metals Corporation.

Wafer Chuck and Pedestal Assemblies

Aluminum Heat or Heat/Cool Pedestal Assemblies

Tubular or cable heaters are precisely formed and cast into aluminum using Watlow's proprietary low pressure casting process. Heater assemblies are precision machined to customer specifications such as wafer lift pin holes, vacuum connection features and vacuum groove patterns. Similar and dissimilar metals can be e-beam welded to form a shaft, providing an exit for electrical lead wires.

Specifications

- Performance to 450°C (842°F)
- Materials depending on the metallurgical, thermal and mechanical properties required
 - Pure (99.7 percent) aluminum – Alloy 170.1
 - Aluminum Alloy 356
 - Aluminum Alloy 319
- Perpendicularity to better than 0.1 mm
- Flatness to 0.005 mm on 300 mm wafer chuck
- Optional cooling tube

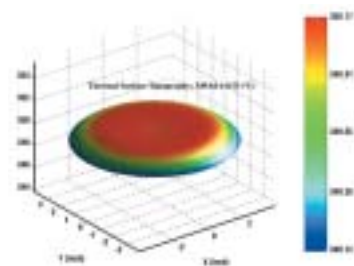


Sandwiched Pedestal Assemblies

A sandwich pedestal assembly is a combination of a mica foil, Kapton®, silicon rubber or other heater combinations that are trapped between two or more machined metal plates or ceramic plates. The assembly may include combinations of sensors, controllers, cabling and other electrical or mechanical components. This construction is excellent for unique geometry heater assemblies, and certain high temperature and process material applications.

Engineering Support

Watlow uses in-house engineering capabilities to optimize the design and performance of pedestal heater assemblies. These include the use of finite element analysis (FEA) software to evaluate the thermal and mechanical characteristics for a part in typical wafer processing boundary conditions. For more complex analysis, the services of Single Iteration, Watlow's engineering services division, offer additional technical skills and resources at the expert level. Please see page 31 for more information regarding Single Iteration.

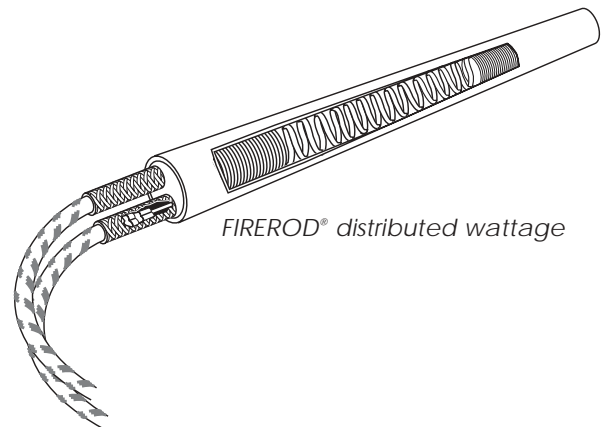


Kapton® is a registered trademark of E.I. du Pont de Nemours & Company.

High Performance Metal Sheath Heaters

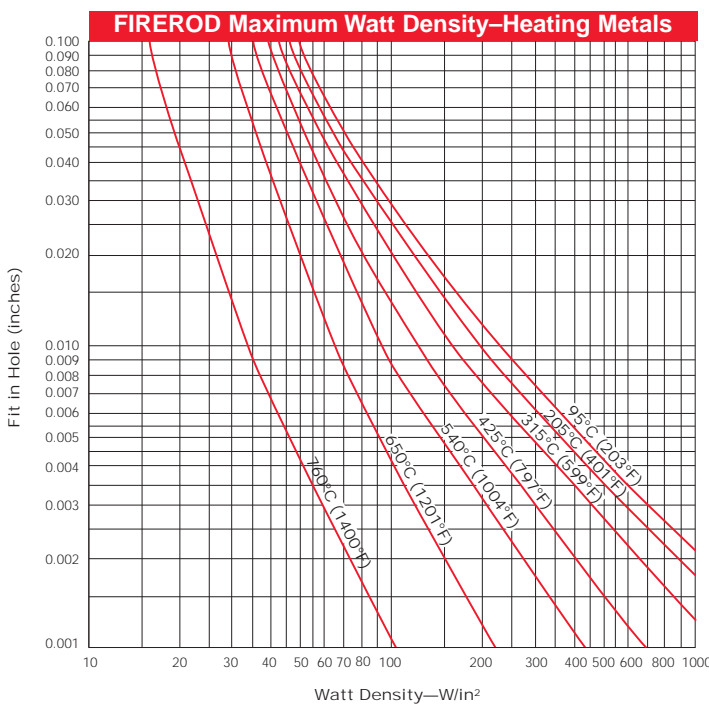


Maintaining uniform temperature in a vacuum chamber is critical for establishing consistent processes. High performance metal sheath heaters are the choice for many of the CVD and plasma etch vacuum chamber applications. Heaters are an integral component in the vacuum chamber's critical thermal subsystems. Watlow uses our application expertise to design special heaters that meet precision semiconductor specifications for heating external chamber walls and lids and in-situ wafer chucks. Electrical, thermal, mechanical and environmental specifications determine the best heater solution.



FIREROD® Cartridge Heaters

Watlow's FIREROD® cartridge heaters provide superior heat transfer, uniform temperature and resistance to oxidation and corrosion, even at high temperatures. FIREROD heaters can be cleanroom compatible using Teflon® insulated lead wires or mineral insulated leads which feature a stainless steel sheath.



Features and Benefits

Nickel-chromium resistance wire

- Precisely wound and centered in the unit, assures even, efficient distribution of heat to the sheath

Minimal spacing between the element wire and sheath

- Results in lower internal temperature, giving you the ability to design with fewer or smaller heaters that operate at higher watt densities

UL® and CSA approved flexible stranded wires

- With silicone fiberglass oversleeve, insulate the wire to temperatures of 250°C (480°F)

Incoloy® sheath

- Resists oxidation and corrosion from many chemicals, heat and atmospheres

Incoloy® is a registered trademark of Special Metals Corporation.

Teflon® is a registered trademark of E.I. du Pont de Nemours and Company.

High Performance Metal Sheath Heaters



Cable Heaters

The versatile Watlow cable heater can be formed to a variety of shapes for high-tech semiconductor applications. Cable heaters from Watlow are small diameter, high-performance units, fully annealed and readily bent to desired configurations.

Flat spiral cable heater configurations are the heart of many turnkey platen heater assemblies. Coil assemblies are used in wire bonding, while flat spiral assemblies are used in photolithography and chemical vapor deposition. Star wound cable heaters can be used for a variety of nitrogen, air and liquid applications.

Features and Benefits

High ductility

- Allows the heater to be cold-formed into almost any shape

Low mass

- Allows for quick response to both heating and cooling

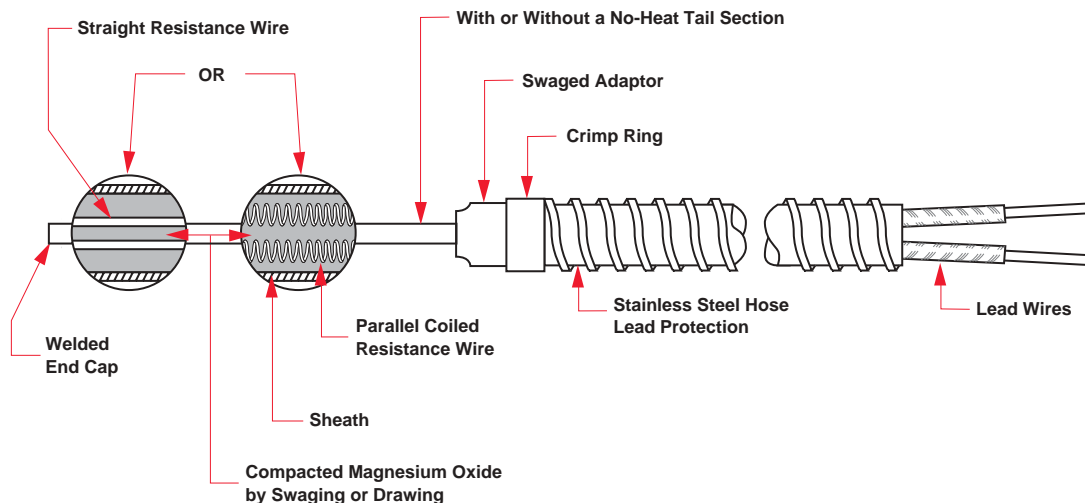
Heater sheath can be brazed

- Allows the permanent attachment of mounted fittings to the heater

Standard 304 stainless steel or optional 316L stainless steel or Inconel® 600

- Provide high temperature corrosion and oxidation resistance along with ideal thermal expansion properties

Cable Heater Construction

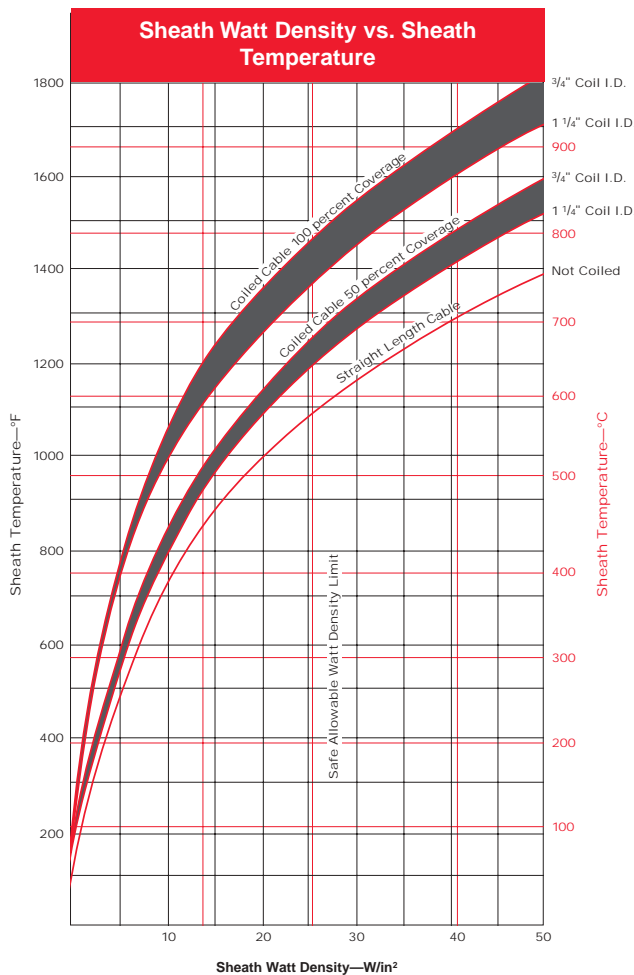


High Performance Metal Sheath Heaters



Round and Flat Tubular Heating Elements

High performance tubular heaters are used in both radiant and convection modes to provide uniform temperature profiles in core wafer process applications. Tubular elements and assemblies from Watlow generate all the heat necessary in these processes; and are virtually 100 percent energy efficient.



Features and Benefits

Precision bending with intricate formations

- Enables heating element to be designed around available space to maximize heating efficiency

High temperature moisture-resistant seals

- Protect against moisture contamination and are rated to 400°C (752°F)

MgO insulation filled sheath

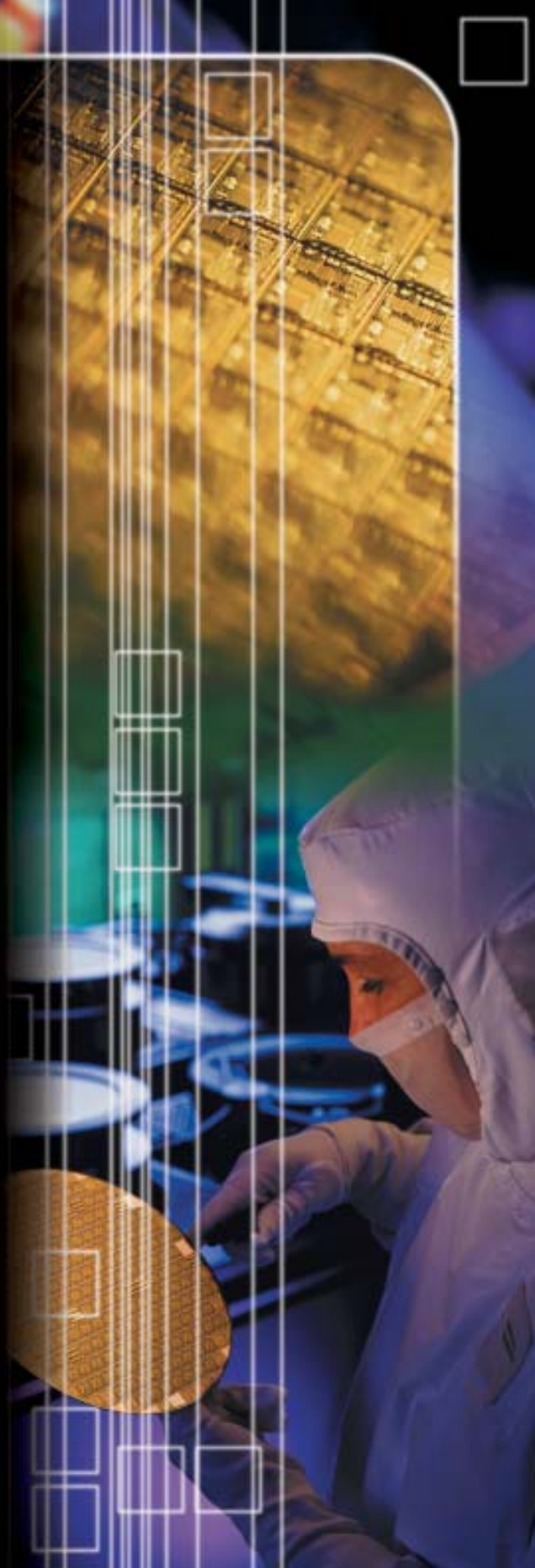
- Maximizes dielectric strength, heat transfer and life

Stainless steel studs

- Fusion-welded to terminal pins for mechanical strength with ceramic insulators

Wet Process Equipment

Wet chemical solutions are methods for etching and cleaning wafers in many semiconductor processes. Wet bench, CMP and hot DI water applications present challenges in an environment that has potential for wafer contamination and process variations that may cause defects and safety concerns. To meet the demands of wet process applications Watlow has developed a family of thermal components for acid, water, CO₂, air and solvent applications. Thick film quartz heating technology, because of its fast response, cleanliness and low external temperature is the foundation of what is rapidly becoming the industry's preferred method of heating chemicals. Watlow's UNIVERSAL SOLVENT heater provides NEMA 7 enclosures and redundant cooling systems that can be incorporated for safety. RAPID RESPONSE heat exchangers and STARFLOW air heaters are used to heat gases for cleaning and drying of wafers. These heater and control solutions can be designed and supplied as a critical subsystem for OEM applications.



Thick Film Quartz Heater Modules



Watlow thick film quartz heater modules are intended for use in deionized (DI) water and aggressive chemical heating applications. This product employs Watlow's patented thick film on quartz technology to significantly advance the state-of-the-art in ultra pure process heating.

These superior thick film heaters can be applied in areas where space is at a premium or where conventional heaters cannot be used because the voltage and wattage combination precludes using other types of resistive heaters. Due to the unique nature of a thick film circuit, these heaters can be designed to vary heat output across the entire surface.

U.S. Patent # 6,037,574

Features and Benefits

Small heater module size

- Compared to other heating technologies, saves space in expensive tools, cleanrooms and wafer fabs

Elimination of the need for clean-dry-air (CDA) purge

- Other heating systems, such as infrared, require CDA purge

Reduction of the possibility of quartz devitrification

- Can occur in high temperature IR heating systems

Elimination of potential metal contamination

- Can occur with Teflon® (PFA) heating systems

Reduction of preventive maintenance (PM)

- Increases tool uptime

Applications

Aggressive chemicals such as:

- Ammonium hydrochloride, NH_2 (HCl)
- Hydrochloric acid, HCl
- Hydrobromic acid, HBr
- Hydrogen peroxide, H_2O_2
- Phosphoric acid, H_3PO_4
- Ultra pure 18MW deionized water, H_2O
- Nitric acid, HNO_3
- TMAH (Tetra Methyl Ammonium Hydroxide) $(\text{CH}_3)_4\text{NOH}$
- Sulphuric acid, H_2SO_4
- Piranha Etch (sulphuric acid + hydrogen peroxide)
- RCA standard clean1 (SC₁) (DI + ammonium hydroxide + hydrogen peroxide)
- RCA standard clean 2 (SC₂) (DI + hydrochloric acid + hydrogen peroxide)

UNIVERSAL SOLVENT Circulation Heaters



Applications

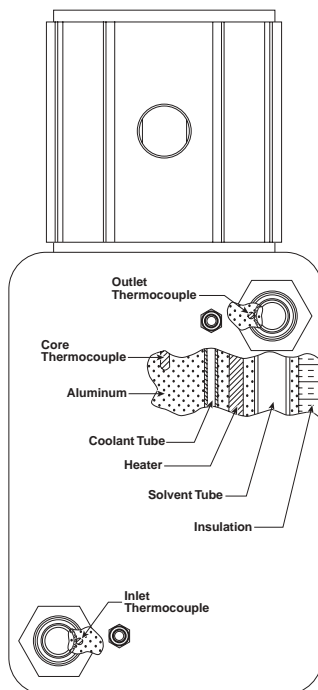
Wafer cleaning equipment

Post etch wet strip

Photoresist removal

Low flash point solvents including

- EKC
- ACT
- NMP



Watlow's UNIVERSAL SOLVENT circulation heaters provide a safe and efficient means of heating low flash-point solvents. A heating element, solvent tube and cooling tube are cast into an aluminum body. The aluminum body acts as a heat exchanger as the solvent circulates through the system. Safety is a major concern when heating solvents. The solvent heater is equipped with high limit sensors and thermostats for redundant over temperature protection. Additionally, the cooling tube when connected to a water supply, allows for rapid cool down of the system for normal preventative maintenance or in the event of an over temperature condition. A NEMA 7 electrical enclosure protects the electrical terminations from igniting vapor and liquids. When combined with the Watlow cascade temperature control, the UNIVERSAL SOLVENT circulation heater provides a superior solution for uniform accurate solvent temperatures to the wafer process.

Features and Benefits

Fluid path constructed independent from heater sheath

- Solvent is never in contact with heater element
- Indirect heating eliminates hot spots caused by poor flow or start up conditions

Cast aluminum construction

- Accurate process temperature control
- Rugged and durable
- Higher reliability due to less components and nonwelded construction
- Long heater life

316L SS passivated and electropolished solvent tube

- Provides material compatibility with most semiconductor solvents
- Ensures contamination resistant surface for heated solvent
- Seamless tubing assures higher reliability and cleanliness

Electrical enclosure constructed for hazardous environments

- Reduces risk of accidental combustion of solvent vapors

Operates to 1500 PSI or greater with appropriate fittings

- Economic high pressure operation

Self draining construction

- Eliminates trapped material that may add contamination to the process
- Economic time-saving operation

Agency ratings

- UL®, CSA recognized heater elements
- NEMA 7 Class 1, Divisions 1 and 2, Groups B, C and D electrical enclosure

STARFLOW Nitrogen (N₂) Air Heaters



Throughout many steps in the semiconductor manufacturing process, Watlow cable circulation heaters help to improve process time and operating efficiency. Using clean, hot gases reduces wafer drying time. The STARFLOW circulation heater is engineered to heat a flowing gas stream up to temperatures of 760°C (1400°F). Because the element is sheathed, the unit can operate in gas streams that require a clean environment, as well as atmospheres that contain contaminants and moisture. Watlow's star wound coiled cable heater provides extremely efficient and reliable heating.

Features and Benefits

Small diameter heater

- Quick response

Internal star wound elements

- Fast, efficient heating

Sheathed element

- Able to heat in clean or impure streams

316L stainless steel construction

- Rugged, corrosion resistant

Electropolishing available on all wetted surfaces

- Reduces particulate contamination

Type J or K thermocouples

- Precise control
- High limit safety

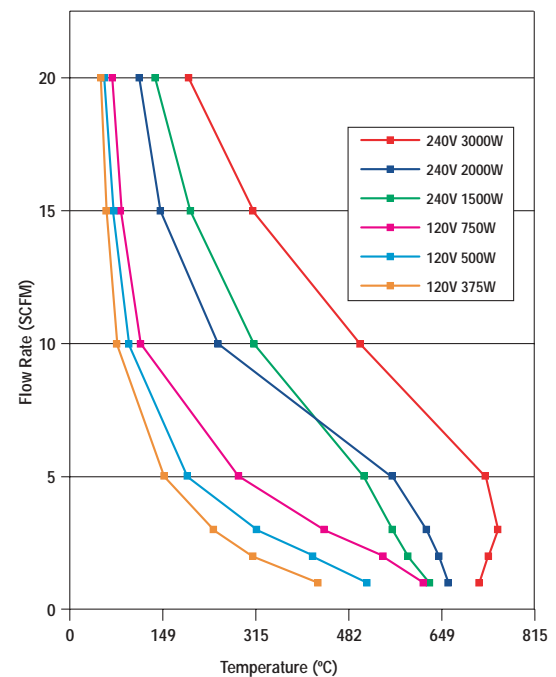
Replaceable heater and thermocouple

- Reduces replacement cost

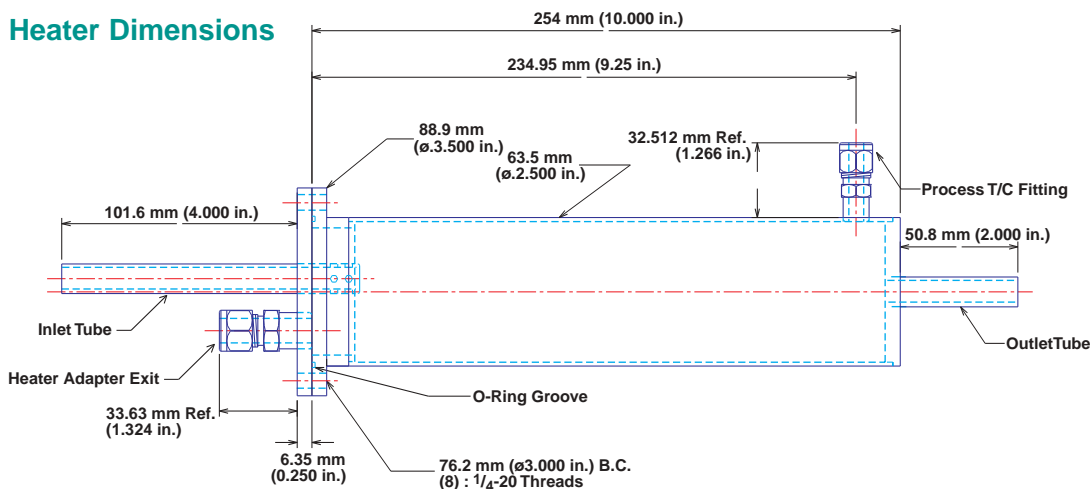
Shipment from stock

- Reduces downtime

Flow Rate Chart



Heater Dimensions



Applications

Ashers

Spin rinser dryers

Cleaning stations

Localized gas line heating

Solder reflow

RAPID RESPONSE Heat Exchangers



Applications

Wafer cleaning

Surface preparation

Gas handling

On demand deionized water

Watlow's RAPID RESPONSE electric heat exchanger (RRHE) is a compact, fast responding and low internal volume circulation heater. This unit is unique because it has the ability to operate under very high pressure with low thermal mass in a small footprint. These features provide a versatile, precisely controlled and compact design for applications such as CO₂ cleaning tools. As die dimensions shrink, cleaning processes become more critical. Watlow's RRHE was designed to facilitate the transition to 90-nanometer technology.

Features and Benefits

Compact size and lightweight design

- Substantially reduces physical space required by other circulation heater technologies

Fast thermal response

- Allows low flow conditions to be efficiently heated

High and low working pressure availability

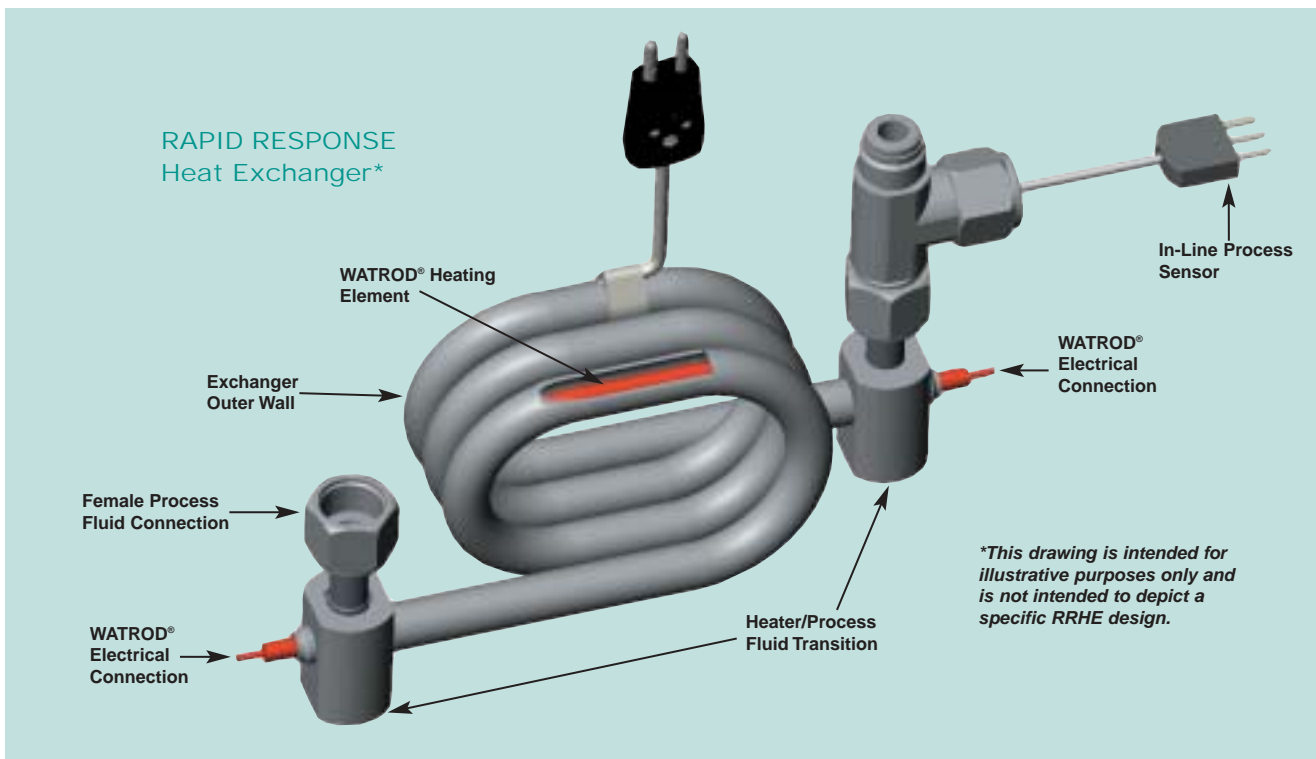
- Wide range of operating pressures

Low internal volume

- Significantly increases heater efficiency
- Minimizes overall system volumetric impact

Use with gases and liquids

- Equally effective for all media states



VERSALINE 500 In-Line Heaters



VERSALINE 500 In-line heater is ideal for applications where a high watt density circulation heater is required but space is limited. All the necessary components including a FIREROD® heater, inlet/outlet lines, thermocouple and housing are presented in a compact package.

This assembly is proven for various applications with flow rates ranging from 0.028 to 0.368 CMM (one to 13 CFM).

Features and Benefits

Integrated thermocouple and enclosure

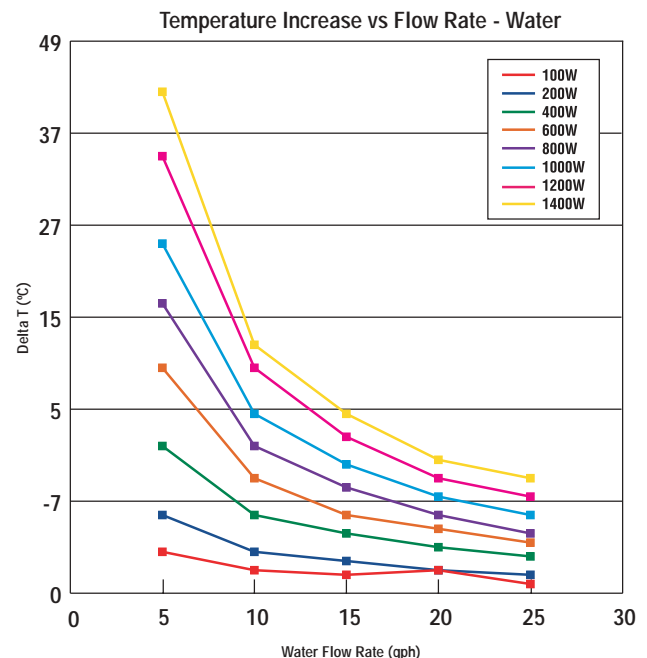
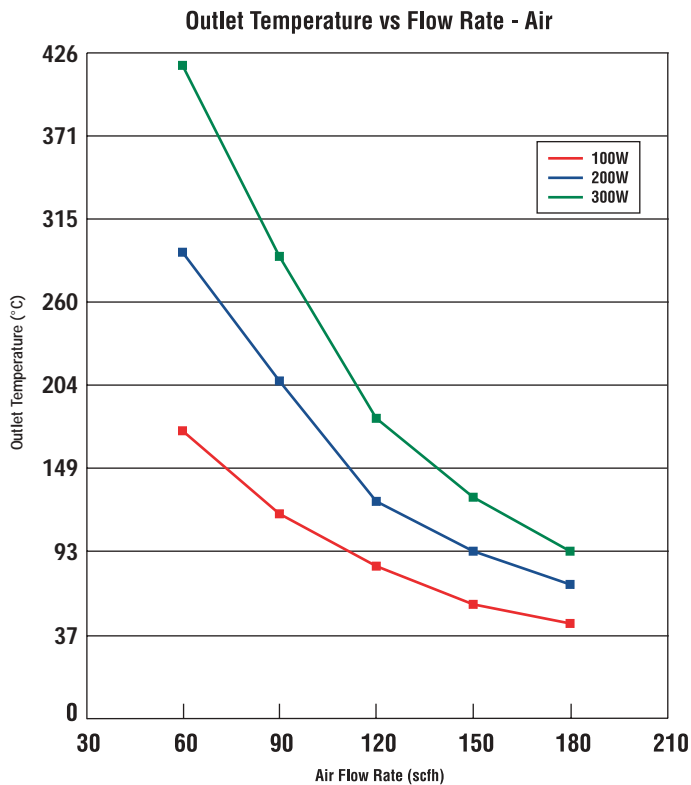
- Allows easy installation and use
- Eliminates additional parts and wiring
- Includes high limit internal sensor

High performance FIREROD® is used as heat source

- FIREROD® is agency approved
- Proven performance in air and liquid applications
- Stock units available for faster lead times

Ideal solution for space-restricted applications

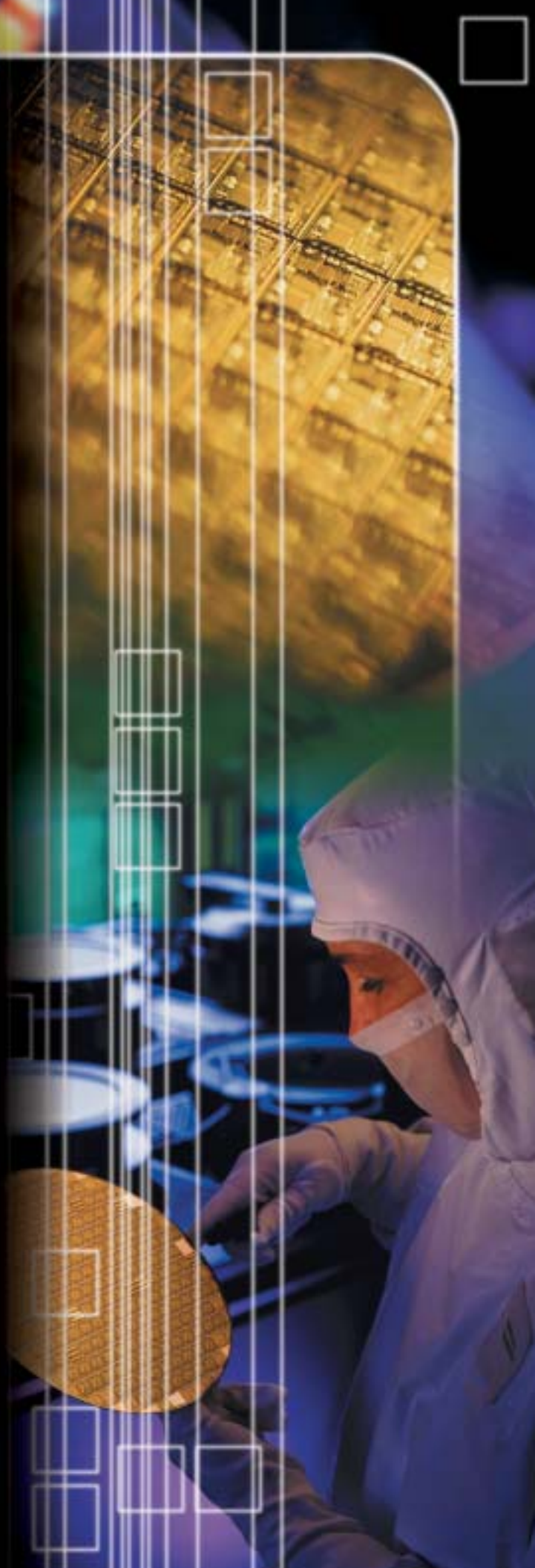
- Chamber is constructed from a standard pipe surrounding the heater
- Allows assembly to be placed in smaller vessels
- Operational to 80 PSI
- Versatile assembly options
- Inlets/outlets can be located according to customer specifications
- Chamber diameter and length can be varied according to application requirements
- Cost-effective assembly
- Replaceable heater
- Replaceable process thermocouple



Please be advised that these graphs only represent one version of this product.

Temperature Controllers and Connectivity

In addition to the best electric heater and temperature sensor designs, precise thermal control can only be accomplished with electronic temperature controllers having control algorithms optimized for a specific application. Watlow's family of single and multi-loop controllers and limits complete the thermal loop. Thousands of front-end wafer processing to back-end assembly applications have given Watlow the expertise to select the best control solution for applications. Our controllers not only provide precision closed loop control, but also provide a means to network the thermal aspects of the semiconductor process. Networking gives the process engineers a means to predict system performance changes and take corrective action before a significant drop in wafer yields can occur. Watlow temperature controllers support a process LAN through DeviceNet™ over CAN, Ethernet, Modbus™ or RS-235.



Connectivity Solutions

WAN



Controllers

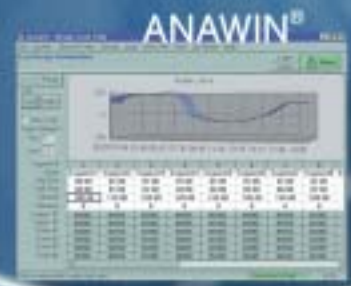


PDA

Software



WATVIEW



ANAWIN®



SERIES PD Browser

Enterprise

LAN



Gateways

Controller Product Connectivity Matrix

Watlow provides data and information through the use of open protocol standards. Multiple methods are supported allowing information to be delivered in the appropriate format for the intended end use. This includes web interfaces for people, industrial protocols for equipment, e-mail for pagers and XML for databases. As existing infrastructure and knowledge are leveraged in conjunction with widely adopted technology, greater value is delivered at a lower total cost.

Controller	EIA/TIA-485 –Modbus™ RTU	EIA/TIA-232 –Modbus™ RTU	EIA/TIA-422 –Modbus™ RTU	Modbus™ IrDA via IRCOMM	IrDA wireless	Ethernet – Modbus™ TCP/IP	DeviceNet™ on Canbus	Ethernet – NAFEM Protocol	FTP	HTTP
SERIES SD31	X									
SERIES SD Controller	X			X	X					
SERIES SD6C_D							X			
SERIES SD Ramping	X			X	X					
SERIES SD6R_D							X			
SERIES SD Limit	X			X	X					
SERIES SD6L_D							X			
SERIES 96	X	X								
SERIES 96_AA	X	X								
SERIES 97	X	X								
SERIES 981/982	X	X	X							
SERIES 988/989	X	X	X							
SERIES 998/999	X	X	X							
SERIES F4P	X	X								
SERIES F4S	X	X								
SERIES F4D	X	X								
SERIES PDS						X			X	X
SERIES PDD						X			X	X
MICRODIN	X	X								
SERIES N7	X	X						X	X	
EM GATEWAY						X			X	
CDN GATEWAY							X			
CLS200	X	X								
MLS300	X	X								
SERIES D8							X			
CAS200	X	X								
CPC400	X	X								
PPC-2000	X	X								
SERIES DX Transmitter							X			

Connectivity capabilities periodically change. Contact Watlow for the latest information.

Modbus™ is a trademark of
Schneider Automation
Incorporated.

DeviceNet™ is a trademark of Open
DeviceNet Vendors Association.

Controllers

DIN-A-MITE® Power Controllers

Watlow's DIN-A-MITE® family of power controllers is a turnkey assembly that includes SCR control, heat sink, wiring and a touch-safe exterior all in one package. The burst fire output option gives tool designers the ability to improve the stability of a thermal system in fast responding tools like RTP and LPCVD. Faster and more frequent switching will also increase the life of heaters by reducing temperature overshoot on a heater element.

Features and Benefits

DIN-rail or standard panel mount

- Versatile, quick and low-cost installation
- Compact size reduces panel space; less cost

Touch-safe terminals

- Isolates the isothermal measuring block from ambient airflow

Compact, universal package

- Increased safety for installer/user

Faster switching with solid state

- Saves energy and extends heater life



SERIES SD Controllers

The SERIES SD family of PID temperature controllers utilizes today's advanced technology to provide superior value, benefits and accuracy. The features and performance offered by SERIES SD controllers make them ideally suited for a broad range of semiconductor applications in temperature and process control.

Features and Benefits

Watlow's INFOSENSE™ sensor technology

- Thermal sensing technology improves sensor accuracy by a minimum of 50 percent

Watlow's patented User Defined Menu System

- Allows the user to assign up to 20 parameters in the operations menu
- Improves operational efficiency

"Save and Restore" feature for user settings

- Allows the user to save individual or factory settings
- Eliminates the need to contact the OEM or factory to restore settings

DeviceNet™ on CAN

- ODVA and Semiconductor SiG compliant

Controllers

SERIES PD Controllers

Watlow's SERIES PD controllers utilize embedded Ethernet technology to provide convenient, economical means for setting up and viewing key process variables such as temperature, pressure and humidity. Available in single or dual versions, the DIN-rail mounted SERIES PD controllers offer up to four control/alarm outputs, as well as a digital/current transformer input associated with each channel.

Features and Benefits

Ethernet connectivity

- Convenient, easy-to-use operator interface
- Simplified process monitoring

DIN-rail sub panel mounting

- Quick, economic installation

Watlow INFOSENSE™ sensor technology

- INFOSENSE technology improves sensor accuracy by a minimum of 50 percent



SERIES D8 Controllers

The Watlow SERIES D8 is a powerful line of controllers that combines performance and flexibility with compact design. Compliance with the ODVA and Semiconductor SIG standards means this controller is easy to integrate into systems with DeviceNet™ on CAN (Controller Area Network).

Features and Benefits

DeviceNet™ on CAN

- Open protocol that is easily integrated with other DeviceNet™ components

PID control of up to eight loops

- Precision control of multiple temperature zones
- Minimal panel space per loop and reduced installation time

Flexible, easy-to-use

- Easy setup with menu guided, full-text prompts
- Context-sensitive, on-screen help saves time

SERIES SD Limit Controllers

The SERIES SD limit controllers come with the Factory Mutual (FM) agency approval and meet SEMI S2 requirements. Temperature limits provide redundant over-temperature protection to enhance safety on tools and in wafer fabs. Electronic limit controllers provide fast response to changes in process temperature. When combined with the appropriate sensor design the limit controller will react to changes in temperature in critical locations on a tool.



Controller Products Agency Compliance, Recognitions or Approvals

Global guidelines for product safety and EMI compliance vary with geographic region as local regulations change to meet the growing environmental challenges. Watlow views compliance with global safety guidelines as essential to supplying components and subsystems. By selecting components that meet agency requirements, equipment engineers save time and money involved with extensive testing of uncertified components. Most Watlow standard temperature controllers meet CE guidelines for EMI, have UL® recognition and meet SEMI S2 guidelines for safety. Meeting the guidelines of all three agencies are critical to supplying semiconductor equipment in Asia, Europe and North America.

Controller	UL®	c-UL®	UR	c-UR	CSA	CE	FM	NSF	VDE	IP65	ANSI Gas Appliance	SEMI S2 Compliance
SERIES SD31	X	X			X	X		X		X		X
SERIES SD Controller	X	X			X	X		X		X		X
SERIES SD Limit	X	X			X	X	X	X		X		X
SERIES SD DeviceNet™	S	S			S	S	S	X		X		X
SERIES SD Ramping	X	X			X	X		X		X		X
SERIES 96	X	X				X				X		X
SERIES 97						X	X			X		X
SERIES 981/982			X	X		X				X		X
SERIES 988/989			X	X		X				X		X
SERIES 998/999			X	X		X				X		X
SERIES F4P	X	X				X				X		X
SERIES F4D	X	X				X				X		X
SERIES F4S	X	X				X				X		X
SERIES PD Single	X	X			S	X						X
SERIES PD Dual	X	X			S	X						X
MICRODIN			X	X	S	X						X
SERIES CV			X	X	S	X					X	X
SERIES CF			X	X	S	X					X	X
SERIES LV			X	X	S	X	X				X	X
SERIES LF (potted)			X	X	S	X	X				X	X
MINICHEF 2000 (F2)			X	X		X		X			X	X
SERIES N7			X	X	S	X		X				X
EM GATEWAY						X						
CLS200	X	X				X						X
MLS300	X	X				X						X
TLM-8	X	X				X	X					X
CAS200	X	X				X						X
CPC400	X	X				X						X
PPC 2000	X	X				X						X
DIN-A-MITE® A	X	X				X						X
DIN-A-MITE B	X	X				X						X
DIN-A-MITE C	X	X				X						X
DIN-A-MITE C throughwall	X	X				X				X		X
DIN-A-MITE D	X	X				X						X
SERIES CZR			X		X	X			X			X
POWER SERIES	X	X				X			X			X

X = Approved S = Submitted July 7, 2003

Agency approvals periodically added. Contact Watlow for latest information.

Design Services

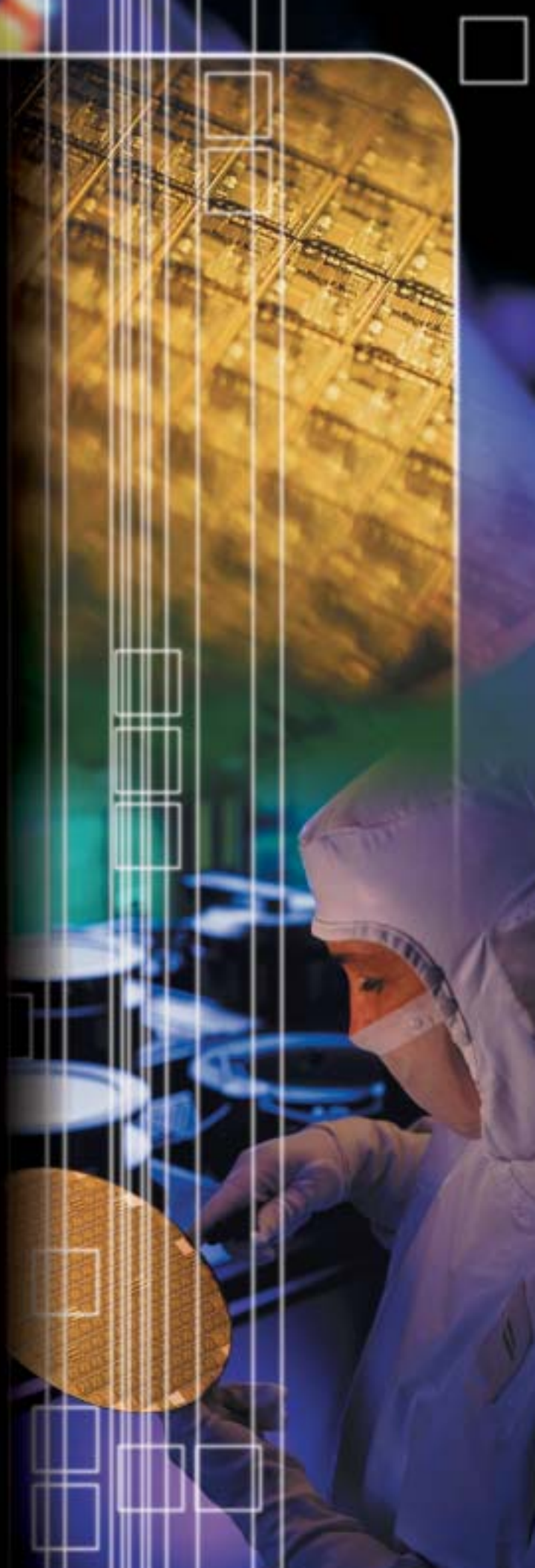
The complexity of semiconductor tool designs and processes combined with economic reality has created an environment where businesses need to identify and focus on their core competency while partnering with companies that have complementary skills. Watlow's core competency is thermal applications expertise and delivering innovative designs for complex thermal challenges. Thermal applications expertise as a core competency is the ability to understand system thermodynamics and semiconductor process requirements. In addition to thermal expertise, Watlow has a project management expertise that has proven to accelerate projects and deliver a working model on the first iteration.

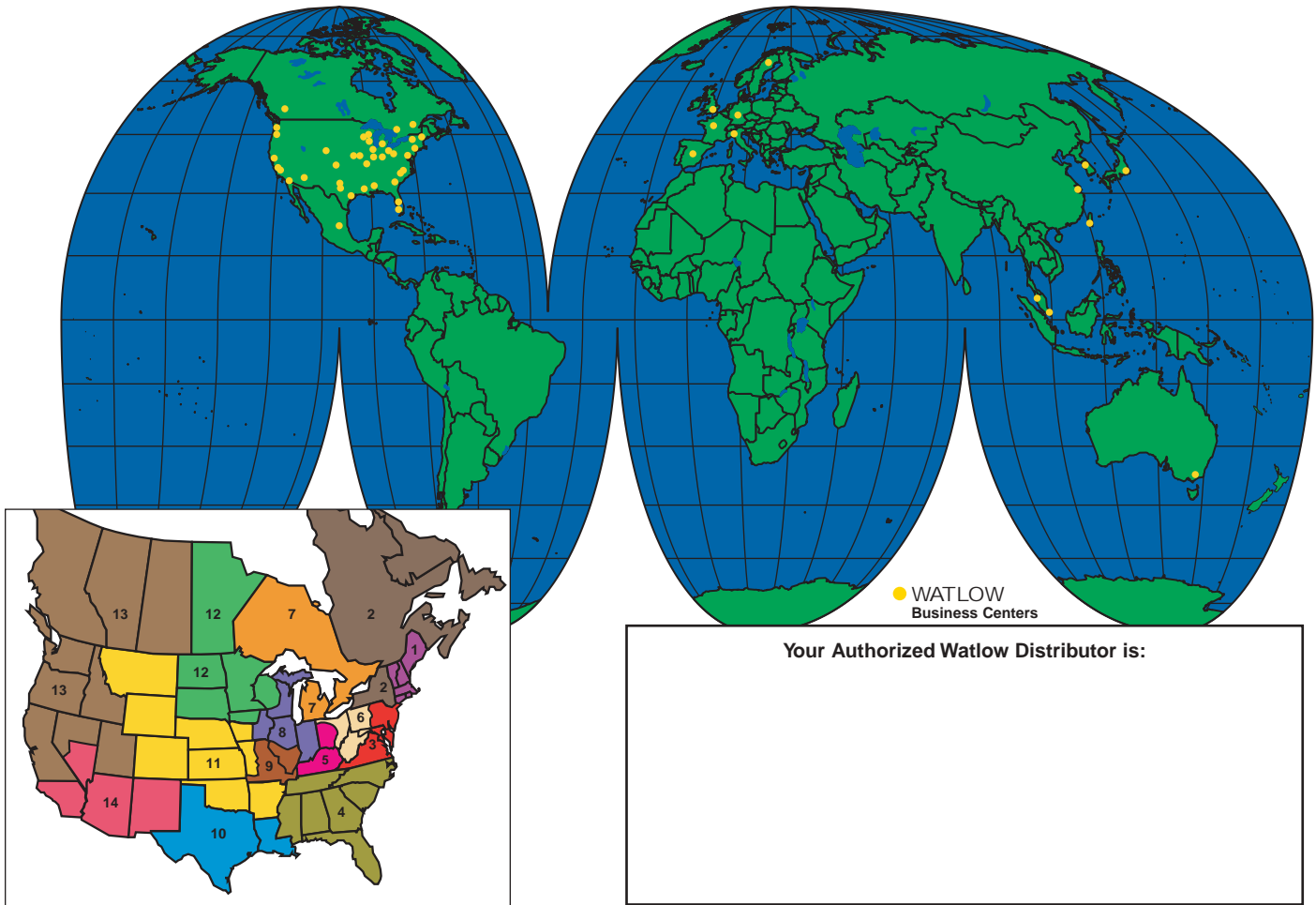
Single Iteration, Watlow's engineering services division, specializes in developing custom thermal products that enable manufacturers to achieve the near-impossible.

Capabilities include:

- Developing creative ideas to improve the thermal performance of your product
- Reinforcing your market position with innovative, patentable designs
- Offering insight into emerging heating, sensing and control technologies
- Providing the expertise to reducing the development risk and improving time to market

**Single
Iteration**
Better Thermal Products Faster.





Watlow Products and Technical Support Delivered Worldwide

North American Technical Support & Sales Offices

Region 1	
New England	603-882-1330
Region 2	
New York, Upstate	716-438-0454
Quebec/Atlantic Canada	450-433-1309
Region 3	
Maryland/Virginia	215-345-8130
New York/New Jersey/Philadelphia	215-345-8130
Region 4	
Atlanta	770-972-4948
Birmingham	205-678-2358
Charlotte	704-573-8446
Nashville	615-264-6148
Orlando	407-351-0737
Raleigh/Greensboro	336-766-9659
Tampa/St. Petersburg	407-647-9052

Region 5	Cincinnati	513-398-5500
Region 6	Cleveland Pittsburgh	330-467-1423 412-322-5004
Region 7	Detroit Ontario	248-651-0500 905-979-3507
Region 8	Chicago Indianapolis Wisconsin, North Wisconsin, South	847-458-1500 317-575-8932 920-993-2161 262-723-5990
Region 9	St. Louis	314-878-4600
Region 10	Austin Dallas Houston	512-249-1900 972-620-6030 281-440-3074
Region 11	Denver Kansas City Tulsa	303-798-7778 913-897-3973 918-496-2826

Region 12	Minneapolis, Manitoba	952-892-9222
Region 13	Portland Sacramento San Francisco Seattle Western Canada	360-254-1009 707-425-1155 408-434-1894 425-222-4090 604-444-4881
Region 14	Los Angeles Phoenix San Diego	714-935-2999 602-795-7712 714-935-2999
Asian Technical Support & Sales Offices		
Australia	+61 (39) 335-6449	
China	+86 (21) 6277-2138	
Japan	+81 (03) 5403-4688	
Korea	+82 (02) 575-9804	
Malaysia	+60 (4) 641-5977	
Singapore	+65 6773-9488	
Taiwan	+886 (0) 7-288-5168	

European Technical Support & Sales Offices	
France	+33 (01) 3073-2425
Germany	+49 (0) 7253-9400-0
Italy	+39 (02) 458-8841
Sweden	+46 31 7014959
United Kingdom	+44 (0) 115-964-0777
Spain	+34 916 759 192
Latin American Technical Support & Sales Office	
Mexico	+52 (442) 217-6235

