



*closing the loop on thermal solutions*

## **Semiconductor and Photovoltaic Manufacturing Equipment**



[www.durexindustries.com](http://www.durexindustries.com)

**Durex Industries** is the Semiconductor and Photovoltaic Equipment Industry's premier supplier of high performance radiant, convection, and conduction thermal solutions. Equipment used in manufacturing processes for transistors, memory devices, microprocessors, crystal silicon photovoltaic (PV) cells, and thin film PV cells all require thermal solutions. Knowing the importance of temperature, Durex continues to innovate and provide customer specific thermal solutions that are critical to next generation equipment and processes.

The best thermal solutions not only take into consideration the process temperature, but also understand the interaction of pressure, vacuum, radio frequency, time, flow, and chemistry. By providing solutions that include the entire thermal loop, Durex designs are the best available solution for your application.

## **Deposition and Etch Equipment**

**Semiconductor wafers** are commonly defined by the speed of the device, and small line width and spacing between transistors. **Photovoltaic (PV) cells** are defined by their efficiency in converting light into electricity and cost-per-watt. Processing semiconductor wafers and PV cells requires deposition of materials to create semiconductor junctions, interconnection of layers, and etching of photo-resist and line edges. Precisely controlling the temperature of the deposition and etch processes is critical to the performance of the device and increasing the product yield. ***Durex's proven technology platforms can be quickly customized to provide optimum performance in CVD, PECVD, LPCVD, plasma etch and other critical process equipment.***



### **In-situ Vacuum**

Critical process steps for CVD, PVD, etch, and ion implantation applications require elevated temperature in vacuum environments. Key specifications for the thermal solution include precision temperature uniformity, precision machining tolerances, material compatibility with the chemical or gas environment and a neutral source of contamination. Durex Industries has over 20 years of proven experience and capabilities for designing and manufacturing thermal solutions for the most demanding in-situ vacuum applications.

**Aluminum Pedestal Heaters** are the material of choice for most deposition and etch applications, because aluminum has excellent thermal conductivity and is inert to many process chemicals such as HF.

- Operating temperature < 450°C (842°F)
- Aluminum alloys 170.1, 319 or 356
- Perpendicularity < 0.1 mm
- Surface flatness to 0.005 mm
- Machined vacuum, lift pin, and other features
- Welding of dissimilar materials
- Integral cable and tubular heater assemblies
- Anodized aluminum and other coatings

**Special Material Pedestal Heaters** provide material compatibility in vacuum applications where aluminum cannot be used because of process temperatures greater than 450°C and or corrosive chemical environments.

- Operating temperature < 700°C (1292°F)
- Stainless steel (304 or 316), Inconel®, nickel...
- Mill groove heater assembly
- E-beam welded assembly
- Integral RTD or thermocouple assemblies

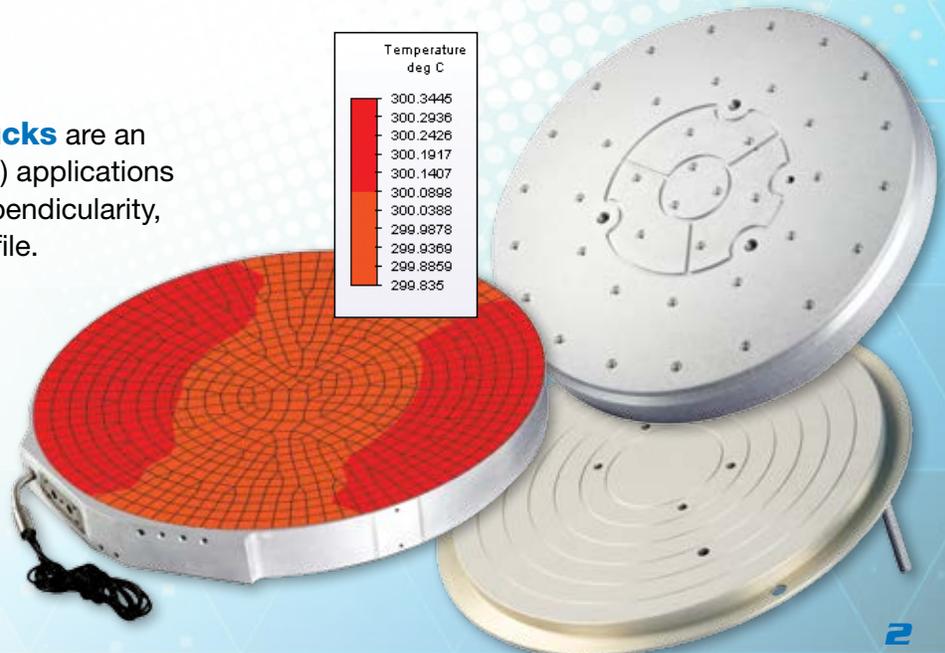


**Cast Vacuum Chamber Heaters** are designed to optimize temperature profile in a vacuum chamber. Uniform process temperature improves etch and deposition rates and uniformity.

- Three dimensional cast aluminum assemblies
- Operating temperature < 450°C (842°F)
- Aluminum alloys 170.1, 319 or 356
- Precision machining of vacuum and other features
- Integral RTD or thermocouple sensors

**Durex Cast Aluminum Wafer Chucks** are an industry standard for wafer probing (test) applications maintaining temperature uniformity, perpendicularity, and flatness throughout the thermal profile.

Achieving consistent and precision temperature uniformity is a direct result of Durex's thermal modeling (FEA) design tools and propriety manufacturing processes.





## **SENTINEL® Heater and Insulation Systems**

Durex Industries' SENTINEL Heater and Insulation Systems is a turnkey thermal solution for PECVD, LPCVD, MOCVD, ALD, plasma etch and other vacuum applications. Low vapor pressure gas delivery lines need to be held at a temperature higher than the gas vaporization point in order to prevent condensation that will affect process yields. Vacuum exhaust lines remove the vapor phase bi-products from the semiconductor process. Sublimation occurs when the vapor phase materials cool in a vacuum line. By heating the forelines, vacuum lines, and vacuum pumps, sublimation of ammonium chloride ( $\text{NH}_4\text{Cl}$ ), nitrides ( $\text{NH}_3$ ) ( $\text{NH}_4\text{Cl}$ ) and other potentially hazardous materials can be substantially reduced.



## **SENTINEL Features and Benefits**

### **Foam Insulation Systems**

- Reduces total energy consumption
- Meets SEMI touch-safe guidelines

### **Heater Temperature**

- Elevates gas temperature above vapor condensation or sublimation phase
- Extends life of valves and vacuum pumps

### **Form-Fit Heater Construction**

- Reduces potential for particle build-up in cold sections
- Optimum process performance and tool up-time

### **Structured Silicone Rubber Heaters**

- Ideal for straight, elbows, tees, and less complex stainless steel 3-D dimensions
- Easy retrofit existing silicone rubber heater solutions

### **Hybrid Silicone Rubber Heaters**

- Reduces system cost by combining the heater constructions for a specific plumbing system
- Optimizes temperature uniformity for components that require tighter temperature tolerances
- Reduces thermal system complexity



## HALO® Temperature Controller

Durex Industries' HALO process temperature controllers are an integrated thermal solution combining temperature control, integrated high limit control, heater current sensing, visual alarm indication, high/low temperature alarm, digital I/O, Graphical User Interface (GUI), and RS 485/Modbus® communications. The HALO controller represents a new convergence of technologies that improves thermal system performance while substantially reducing costs of ownership.

The HALO Temperature Controller and SENTINEL Gas and Pump Line Heaters are a superior thermal solution for semiconductor applications. Internally, one HALO temperature controller can monitor the performance and control the temperature of multiple heaters with up to 10 amp resistive loads. Integrated current sensor monitoring of each heater provides engineers with a visual HALO indication of a heater or wiring failure.



## HALO Features and Benefits

### HALO 360° Visual Alarm Indication

Visual alarm indication in remote locations

### Graphical User Interface (GUI)

Easy set up and monitoring of system parameters

### Integrated 10 Amp Power Switching

Enables thermal systems with up to 10 amps of parallel wired heaters

### Integrated Over Temperature Limit

De-energizes heaters if over temperature event occurs

### Integrated High and Low Current (I) Sensor

Monitors heater health of parallel wired heaters up to 10 amps

### Integrated Process And Alarm Sensor Inputs

Accurately measures process temperature and monitors heater health

### High/Low Temperature Alarm Relay

Switch closure for external alarm device

### Selectable Temperature Control Algorithms

Stable process temperature control

### Ramp/Soak Programming

Program up to 8 time and temperature process steps

### Agency Approval

UL

### Universal Power Supply: 85 To 265 VAC, 50/60 Hz

One control meets global line voltage requirements

### Universal Mounting Bracket

Flexible vertical or horizontal mounting options

**Mobilize and maximize your control power with HALO!**

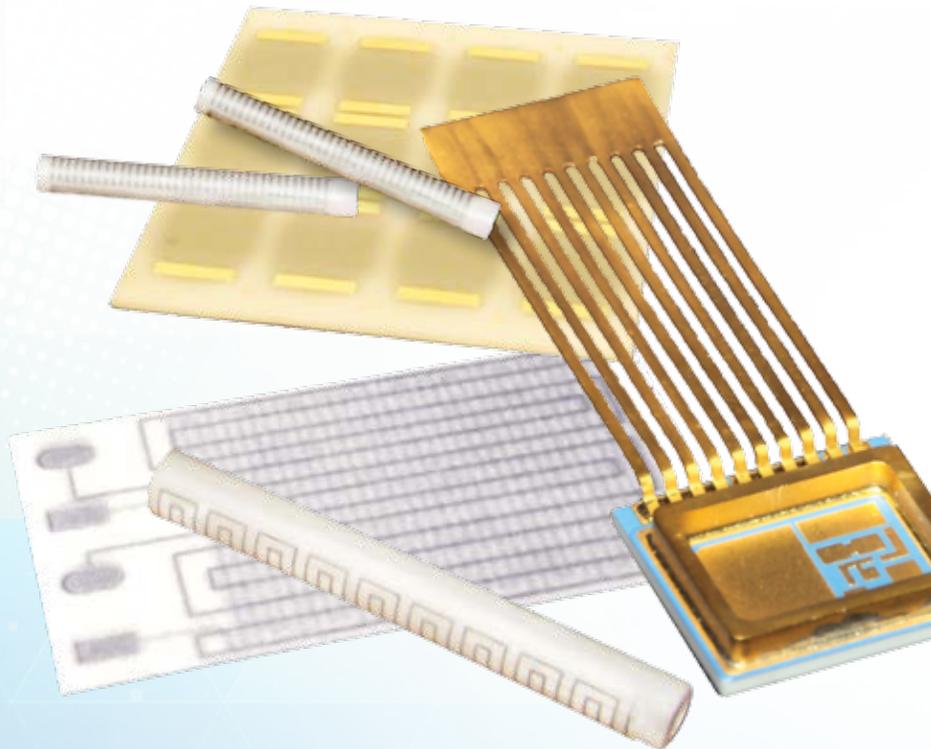


## **Rapid Fire™ Aluminum Nitride (AlN) Heaters**

Durex industries' Rapid Fire aluminum nitride (AlN) ceramic heater solutions combine the thermal conductivity of aluminum and dielectric strength of specialty ceramics with physical properties similar to stainless steel. Additionally, a tungsten (W) RTD Sensor is integrated into the multi-layer heater construction to provide maximum control of this high watt density heater. New levels of machine design and thermal performance can be achieved through the excellent thermal, dielectric and physical properties of AlN heaters.

### **Rapid Fire AlN Advantages**

- Thermal conductivity equivalent to aluminum for fast and uniform thermal response
- Watt density higher than any metal or ceramic heater technology for concentrated heat in a small area
- Integrated RTD sensor for optimum heater temperature control
- Dielectric strength eliminates need for magnesium oxide (MgO) insulation layer used in metal heaters
- Heater temperature up to 1000°C (1832°F) for high temperature applications
- Low porosity non-stick surface reduces potential for process contamination
- Chemically inert to most acid environments
- High mechanical strength, hardness and wear resistance for industrial applications



**Heater Sheath Material Thermal and Physical Properties\***

	Aluminum Nitride AlN	96% Alumina Al <sub>2</sub> O <sub>3</sub>	Silicon Nitride Si <sub>3</sub> N <sub>4</sub>	Aluminum Al	Stainless Steel 304	Description
Thermal Conductivity (W/K·m)	180	30	40	180	12	Thermal Conductivity is a measurement of a material's ability to conduct heat: higher value = faster more uniform heat transfer
Coefficient of Thermal Expansion (x10 <sup>-6</sup> /°C)	4.3	10.2	3.2	23.6	5.8	Coefficient of Thermal Expansion (CTE) is a measurement of material expansion resulting from change in temperature: lower value = less material expansion
Heat Capacity (J/g·K)	0.78	0.88	0.71	0.9	0.5	Heat Capacity is amount of heat required to raise temperature of a material one degree centigrade: higher value = less energy to heat material
Density (g/cm <sup>3</sup> )	3.26	3.75	3.25	2.7	8	Density is the measurement of a material's weight to volume: lower value = less weight and fast heating
Vicker Hardness (GPa)	11.2	15.7	13.9	0.11	1.26	Vicker Hardness is a measurement of the physical hardness of a material: higher value = harder material
Young's Modulus of Elasticity (Gpa)	322	370	290	69	180	Young's Modulus of Elasticity is the ratio of a material's uniaxial stress over uniaxial strain : higher value = less tensile strength
Flexural Strength (Mpa)	350	400	610	276	520	Flexural Strength is the measurement of a material's bend or fracture strength: higher value = better material flexibility
Dielectric Strength (V/m) @ 25°C	16 x 10 <sup>6</sup>	18.1 x 10 <sup>6</sup>	13 x 10 <sup>6</sup>	N/A	N/A	Dielectric Strength is a measurement of a material's electrical insulation resistance: higher value = better electrical insulation

\* Property values reflect typical performance and can vary by adding alloys and / or process procedures.

**AIN Heater Capabilities**

- Thermal conductivity equivalent to aluminum for fast and uniform thermal response
- Watt density: up to 2000 W/in<sup>2</sup> (310 W/cm<sup>2</sup>).
- AIN thermal conductivity: 190 W/mK
- Rapid ramp rate: 0-400°C (32 to 752°F) in less than 2 seconds
- Atmospheric and inert gas environments applications
- Complex and 3 dimensional geometries
- Thickness: 0.05 in. to 0.200 in (1.27 mm to 5.08 mm)
- Size: Up to 10.25 in<sup>2</sup> (66.13 cm<sup>2</sup>)
- Encapsulated tungsten (W) RTD sensor
- Surface metallization

**Advanced Ceramic Heaters are small in size but Mighty in Power!**

## **cable | tubular heaters**

**Cable (Coil) Heaters** are high temperature corrosion and oxidation resistant heaters that can be manufactured in small diameters and formed into geometries that optimize the thermal profile of a heated part.

- Operating temperature < 650°C (1200°F)
- 304, 316 stainless steel or Incoloy®
- Diameter < 0.40 inches (10.16 mm)
- Voltage to 240V
- Paralleled coil resistance wire for applications to 1000 inches
- Series resistance wire for applications > 1000 inches
- High ductility for forming geometries
- Integrated thermocouple sensors



**Standard Tubular Heater Assemblies** are used in radiant heating applications and as integral conduction heaters in heated part assemblies.

- Operating temperature to < 900°C (1652°F)
- 304, 316 stainless steel, Incoloy®, or aluminum
- Vacuum feed through fittings
- High dielectric strength magnesium oxide (MgO)
- Moisture resistant, high temperature end seals



## Assembly Packaging and Test Applications

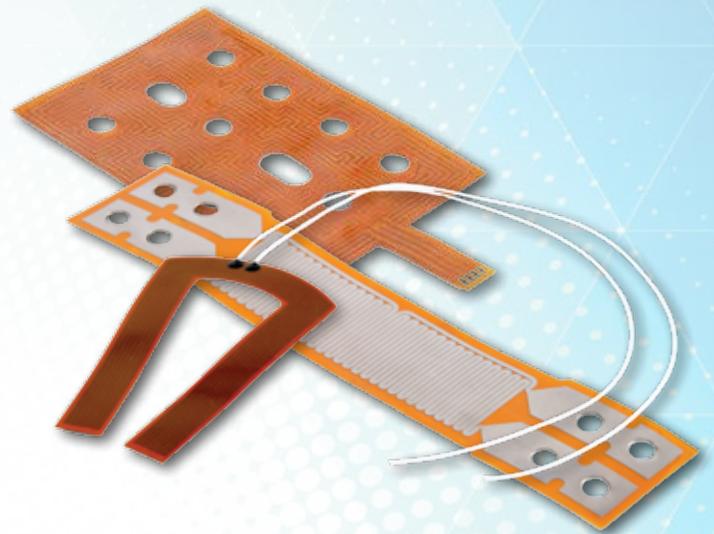
Completed wafers are tested at cryogenic and elevated temperatures to identify and sort the semiconductor devices for their performance characteristics. The wafers are then sliced into individual die. Leads are attached and the devices are packaged before a final performance test. Temperature is a critical variable in most of the process steps.

**Polyimide Heaters and integrated Assemblies** represent a thermal solution for application requiring precision temperature profiles at lower process temperatures. By supplying a thermal assembly that has been optimized for an application, Durex can assure that part-to-part performance will meet the semiconductor equipment specifications. Polyimide heater solutions are commonly used in wafer testing, dry etch, and other applications.

- Process temperature 200°C (392°F)
- Kapton® or silicone rubber materials
- Moisture and chemical-resistant
-  recognitions

**RTD or Thermocouple Sensor Assemblies,** used in semiconductor and PV processes, require knowledge of thermodynamics and the application's environment. Durex sensor assemblies are designed to be robust and provide the highest degree of accuracy and repeatability.

- Single or multipoint sensor assemblies
- NIST traceable calibration on refractory thermocouple materials
- 100, 1000, and 2000  $\Omega$  RTD assemblies



## 1/8 Inch Magnum cartridges

**Durex Industries' 1/8th Inch (3.175 mm) Cartridge Heater** was developed for Original Equipment Manufacturers (OEMs) that required a small high power thermal solution. Typical applications include injectors used in a gas chromatograph, ion sources used in mass spectrometer, lead attachment in die bonders and other applications requiring a high watt density in a small area.

This miniature cartridge heater is designed with a thin 304 stainless steel wall for fast temperature response, and is swaged for low internal temperatures and longer life. Additionally, Durex' proprietary magnesium oxide (MgO) compaction process assures the highest possible dielectric strength. 1/8th Inch Cartridge Heaters can be used in applications up to 1000°F (538°C). Custom heaters can be designed in lengths up to 12 inches (305 mm), 750 watts and voltage from 5 to 240 VAC.

### Specifications

#### Electrical:

- Minimum Volts: 5V
- Maximum Volts: 240V
- Maximum Wattage @ 240V: 744W \*Depends on wire watt density
- Maximum Amperage @ 240V: 3.1A
- Wattage Tolerance: +10/-15%

#### Mechanical Sheath Material:

- Standard: 304 Stainless Steel
- Optional: Inconel®

#### Mechanical Dimensions:

- Diameter: 0.122 inch (3.10 mm) +/- 0.002 (0.05 mm)
- Length Minimum: 0.75 inch (19.05 mm)
- Length Maximum: 12 inch (304.8 mm)
- Length Tolerance to 4.5 inch (114.3 mm): +/- 0.94 inch (2.4 mm)
- Length Tolerance > 4.5 inch (114.3 mm): 3.0%

#### Heater Sheath Temperature:

- 1400°F (760°C)



### Advantages:

#### Proprietary Swaging Process

- Higher operating temperature
- Higher heat transfer
- Robust heater design
- Longer heater life

#### Proprietary MgO Compaction

- Higher dielectric strength
- Faster thermal response

#### Miniature Size and Low Mass

- Better heat transfer
- Quicker response time
- Longer life due to lower internal temperature

## Solar Photovoltaic Thermal Solutions

**PV Cells** are manufactured using a series of deposition, doping, etch and metallization processes on substrates that may be crystalline silicon wafers (cSi), glass, metal, polymer or other materials. PV cost-per-watt, efficiency, life, and other performance characteristics are directly related to substrate material and thin film materials used to form the cells. Packaging of the PV cells into arrays and modules includes string and lamination steps. Like semiconductor wafer processing, most PV process steps require precision temperature solutions. Major differences between cSi and the other PV substrates is size of the material and whether the cells are manufactured with single, batch, or continuous process flows. Most PV processes require large area radiant and conduction heating solutions.

**Radiant Heating Panels** are designed for thermal precision and robustness in large sizes for conveyor furnace, roll-to-roll (web) furnaces and single piece vacuum chambers. The cable (coil) or tubular heater layout is optimized for the equipment design and specified temperature profile.

- Dimensions < 2.5 sq meters (26.91 sq. ft.)
- Operating temperature < 700°C (1292° F)
- Stainless steel reflective panel
- Vacuum flanges
- Integrated RTD or thermocouple sensor assemblies



**Conduction Heating Panels** are designed and manufactured in large dimensions using either cast aluminum heater technology or mill groove heater assemblies with top and bottom plate welded or mechanically fastened to insure heater placement.

- Cast aluminum dimensions to < 2.5 sq meters (26.91 sq. ft.)
- Stainless steel dimensions < 2.5 sq meters (26.91 sq. ft.)
- Operating temperature < 700°C (1292°F)
- Perpendicularity < 0.1 mm (0.0004 in.)
- Surface flatness to 0.5 mm (0.02 in.)



**Vacuum Feedthrough Fittings** are precision brazed or welded as integrated components in cable, cartridge and tubular heater assemblies, and RTD and thermocouple sensor assemblies



## ***About Durex Industries***

Founded in 1980 by Ed Hinz, CEO & President, Durex Industries is a privately owned thermal solutions company specializing in electric heaters, temperature sensors, and temperature controls. Durex's 145,000 sq. ft. business, engineering, and manufacturing center is conveniently located 25 miles northwest of Chicago in Cary, Illinois.

Since our founding, providing customers with reliable products and excellence in all aspects of the business have been the hallmark of Durex and the basis of our name. "Dur" means durable and "ex" means excellence. Durex Industries, an ISO 9001 registered company, supplies engineering and manufactures thermal solutions for most global industrial equipment markets, including food service, life sciences, packaging, photovoltaic, plastics, process, and semiconductor. Our focus on lean design, manufacturing, and business systems continues to provide customers with the best design and product value in our industry.



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