Semiconductor and Photovoltaic Manufacturing Equipment
High Performance Thermal Solutions

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 the best available solution for your application.

**Durex Industries Capabilities**

**Design**
- Conduction, radiation and convection heat transfer expertise
- CAD/CAM and solid modeling
- Finite Element Analysis (FEA) thermal system modeling
- R&D laboratory and qualification systems
- Rapid prototyping
- Mechanical and electronic design
- Structural mechanics

**Manufacturing**
- CNC equipment for repeatable precision machining
- Lapping machines for smooth flat surfaces
- E-beam welding
- Brazing (torch and vacuum braze)
- Class 1,000 cleanroom
- Special coatings such as anodizing, electroless nickel and Teflon®
- Chemical cleaning and packaging
- High purity gas tube welding (class 100)

**Validation Test**
- Temperature uniformity
- Structural characteristics and analysis
- Coating performance
- Digital X-ray
- Electrical and mechanical tests

*closing the loop on thermal*
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 photoresist 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.

High Performance • Fast-Reacting

A hallmark of working with Durex Industries is our system for interfacing with our customer’s engineering teams to provide rapid prototyping of new designs. Fast prototyping helps Durex customers to validate design options faster and deliver winning solutions to their customers.
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 design 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 > 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

In-situ Vacuum Application:

Major semiconductor and PV process steps are performed in low to ultra high vacuum environments and process temperatures. Temperature uniformity of the wafer or PV cells is critical to the production process. Optimizing temperature uniformity typically requires radiant heating of the wafer with a pedestal heater assembly and conduction heating of the vacuum chamber’s boundary areas including walls, ports, showerheads, and other parts.

A CVD equipment manufacturer’s specifications required precision temperature uniformity across the wafer surface, and for the heating and sensing components to be compatible with the gases and chemicals used in the wafer process, such as hydrofluoric acid (HF). By understanding the boundary environment within the vacuum chamber and using in-house Finite Element Analysis (FEA) Durex Industries designed an HF compatible aluminum pedestal heater with integral thermocouple sensors. Additionally, as a vertically integrated supplier, Durex was able to substantially reduce the prototype lead-time.
**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.
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

Aluminum Tubular Heaters are the preferred integral heater solution for many aluminum pedestal and heated part assemblies. Material compatibility between the heater and aluminum housing reduces potential for movement of the element due to thermal cycling.

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 or Incoloy®
- Vacuum feed through fittings
- High dielectric strength magnesium oxide (MgO)
- Moisture resistant, high temperature end seals
Atmospheric Application:

Surrounding a vacuum chamber in an atmospheric environment gas delivery and exhaust pump lines are heated to optimize the temperature of the gasses and reduce preventative maintenance cycles. There are also wet etch and clean process steps that are enhanced by heating the liquids and gasses. Durex’s application specific thermal solutions reduce equipment design time and costs.

Gas Line and Abatement Heating Applications:

Delivering gases to the vacuum chamber at a precise temperature prevents condensation and helps optimize the deposition and etch processes. Elevating the temperature of the abatement system reduces sublimation of materials that could result in reduced yield and increased preventative maintenance.

A manufacturer of LEDs using phosphorus in the deposition process scheduled a preventative maintenance (PM) cleaning of the exhaust lines every 6 weeks. Since phosphorus is flammable, the fire prevention team was on site during every PM. The manufacturer installed pump line heaters from the vacuum chamber to the scrubber. The result is that the manufacturer has substantially extended the time between PMs saving cost and reducing hazardous risk of fire.

**Gas and Pump Line Heaters** are turnkey solutions that reduce condensation from the gas cylinder to a vacuum chamber, and sublimation of nitrides and other materials in the exhaust lines from the vacuum chamber to the scrubber.

- Standard designs for regulators, filters, mass flow controllers (MFC) and piping
- Clean silicone rubber heater construction
- Process temperatures to 200°C
- Integrated temperature assemblies
- Meets SEMI safety guidelines
- Integrated high limit protection

**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 Ω RTD assemblies
Control Consoles are an integrated turnkey single or multi-loop temperature and power control solution mounted in an electrical enclosure that simplifies system design.

- PID temperature control stabilizes thermal profile
- SSR solid state switching
- High limit control for safety
- Electrical enclosure with connectors that mate with gas and pumpline heaters

Wafer Cleaning and Drying: Following deposition, doping, and plasma etch process steps, wafers and PV cells may require cleaning and drying solutions that reduce potential for any residue that might contaminate subsequent process steps.

Durocast® Circulation Heater Technology integrates combinations of tubular heaters, circulation tubes, cooling tubes, temperature sensors and electrical enclosure. This turnkey solution may be used to heat gasses, solvents, and liquids used in cleaning and drying process steps.

High Purity Teflon® Protected Heaters and Sensors reduce the potential of metal particulates contaminating the wet process chemistries.

316L Immersion Heaters represent a high purity tubular heater technology used in cleaning steps for many PV cell applications.
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
- UL recognitions

**Cartridge Heater Assemblies**, because of their high watt density and small size, are the preferred solution for wire and die bonding applications. RTD and thermocouple sensors are integrated into the heater for process or limit control.
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 120,000 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 9001/2008 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.