

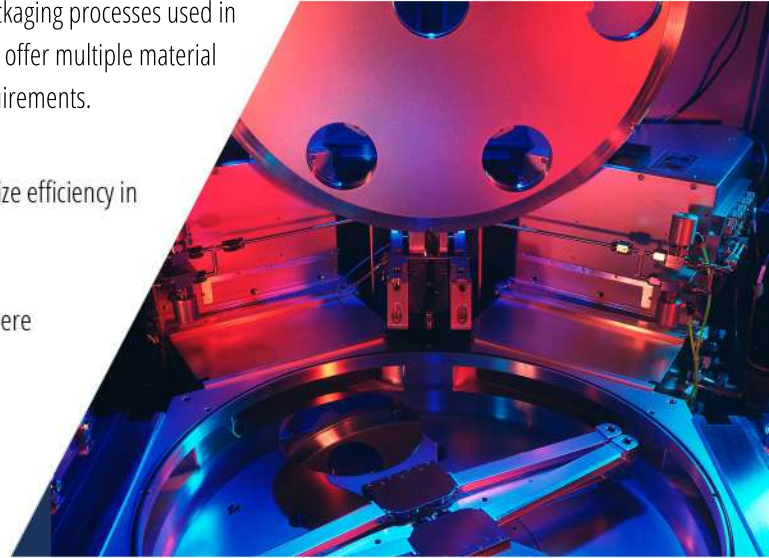
## FRALOCK HEATERS FOR SEMICONDUCTOR MANUFACTURING

Fralock provides custom-engineered heaters for critical in-chamber, testing, and packaging processes used in a variety of both front and back-end semiconductor manufacturing applications. We offer multiple material types, providing you with options to choose the ideal material solution for your requirements.

**Ceramic Heaters** are designed for extremely rapid heating and cooling to maximize efficiency in production.

**Polyimide Heaters** provide high flexibility in shape and design for operation where thermal uniformity in narrow spaces is needed for wafer fabrication.

**Stainless Steel Heaters** are formulated with a Borosilicate glass dielectric layer which enables high temperature generation and robust electrical connections for lower costs.



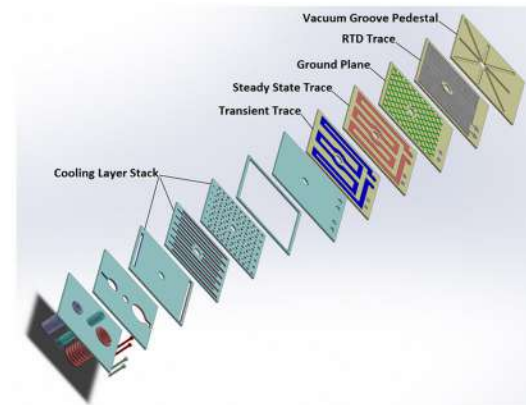
### Heater Types and Properties

Heater Type	Temperature Range	Material	Structural Formats	Power Density	Relative Cost
Ceramic AlN	Up to 650°C	AlN Tungsten	Platens or tubular	Small format 2KW/sq in 300 mm 10- 15kW Pending configuration	\$\$\$
Flexible Polyimide	-269°C to +220°C	Bonded Polyimide Layers	Flat, formed to most surfaces	40 W/sq in	\$
Stainless Steel/Glass	Up to 450°C	Borosilicate Glass, Stainless Steel	Platens or tubular	40 kW/sq in	\$\$

### CERAMIC HEATERS

Fralock Ceramic heaters are made using high thermal conductivity Aluminum Nitride (AlN) ceramic with embedded Tungsten resistance heating traces, providing tailored power input to achieve your temperature transition goals.

Extremely rapid heating in excess of 300°C/sec is made possible because the coefficients of thermal expansion of Aluminum and Tungsten are the equal ( $4.3 \times 10E-6$  Co). Integrated channel structure and low density AlN ceramic provide quick cooling rates, from 300°C to room temperature in a just few seconds.



*Expanded view of a rectangular heater*

	Aluminum Nitride	Tungsten
Density - g/cc	3.36	19.3
Linear Coefficient of Expansion per °C	$4.3 \times 10^{-6}$	$4.3 \times 10^{-6}$
Thermal Conductivity (RT) - W/mK	180	170

Exceptional thermal uniformity and seamless transfer of temperature is achieved due to matched coefficients of thermal conductivity

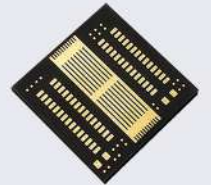
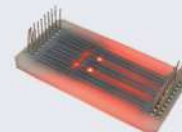
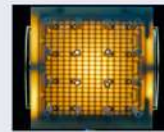
## Applications Include

Front-end:

- High-temperature showerhead heaters with integrated gas flow to chamber
- Pedestal wafer heater to 650°C with and without remoted connections
- Cylindrical formats for heated nozzles, plasma generation

Back-end:

- Burn-in testing
- Class testing
- Chip stacking - thermal compression bonding



## FEATURES AND BENEFITS

- Multiple zones of heater and sensor traces in various levels
- Multiple resistance temperature detectors (sensors) focusing on specific locations
- Tungsten traces are fully integrated and chemically bonded into the AlN microstructure
- Tunable resistivity tungsten inks from 8-80 mOhm/square provide rapid resistance tuning for new product introduction
- Ground plane shielding
- Thin substrates: Flat, round or any geometry can be CNC milled
- Robust reliability, proven with millions of cycles in the field
- Complex geometry: venting, through blind features, and internal channels
- For Wafer Pedestal heaters:
  - Large Format sizes up to 380mm diameter
  - Integral stem using patented pressure-less bonding
  - Multi-zone heater and temperature sensor capability
  - Internal gas delivery passages available



## ALL-POLYIMIDE HEATERS

Fralock's polyimide heaters are manufactured with fully encapsulated traces using Fralock's Adhesiveless Laminate Technology, and are more efficient, thinner, lighter, and far more durable than any comparable product on the market. Polyimide heaters offer superior performance and durability for applications in wafer fabrication equipment.

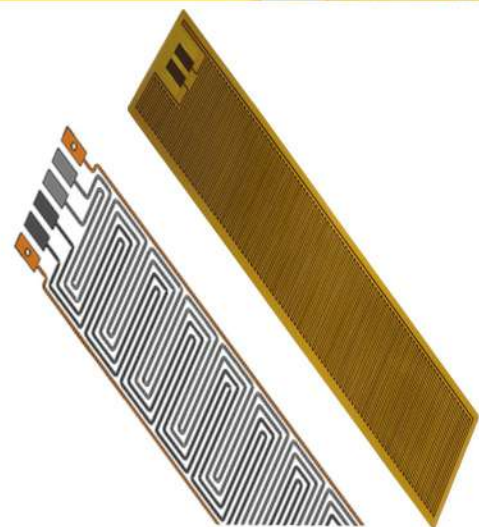


## Applications Include

- Gas delivery heating for non-flat requirements
- Gas box heating
- Wafer pedestal heaters for sub 250°C requirements
- Wafer Fabrication Precision Heaters (high wattage, rapid response)

## Features and Benefits

- High bond strengths that exceed substrate properties
- Flammability Rating, UL® 94V0
- Flexible construction – can be folded, wrapped, or crumpled without affecting performance
- Lightweight – constructions as thin as 0.0762 mm (0.003")
- Multi-layer and multi-zone (many, independently controlled, zones of heater traces across the entire surface)
- Excellent Temperature range -269°C to +220°C
- Very low out-gassing
- Uniform and or tunable heat distribution



## STAINLESS STEEL HEATERS

We offer unique heaters engineered using a specialty formulated glass with the same coefficient of expansion as stainless steel. This provides superior adhesion and lifetime during thermal cycling. This glass is used as a dielectric platform to print a resistance circuit, which is covered again in glass.

## Applications Include

- Sub 450°C low cost applications
- Load lock and wafer transfer wafer heaters

## Features and Benefits

- Superior dielectric glass layers for lifetime reliability
- Trace resistance customization through the ratio of silver/palladium and/or line width to achieve a desired resistance
- Flat and tubular configurations - various shapes and sizes can be fabricated
- Robust electrical connections
- Ground plane shielding
- Thin substrates: Flat, round or any geometry can be CNC milled
- Robust reliability, proven with millions of cycles in the field
- 300 and 400 series stainless steels

