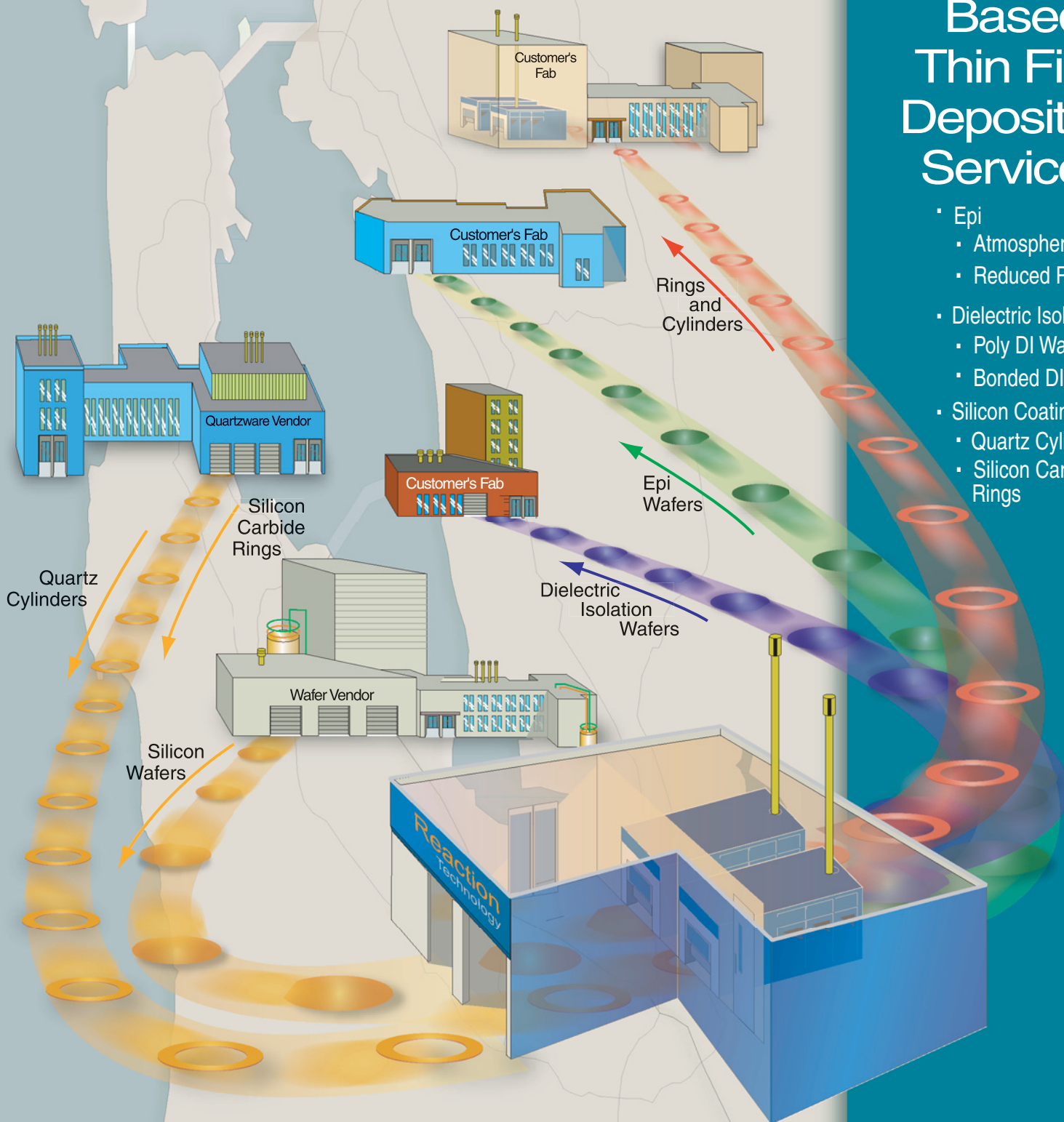


# Reaction Technology



## Silicon Based Thin Film Deposition Services

- Epi
  - Atmospheric
  - Reduced Pressure
- Dielectric Isolation (DI)
  - Poly DI Wafers
  - Bonded DI Wafers
- Silicon Coating
  - Quartz Cylinders
  - Silicon Carbide Rings



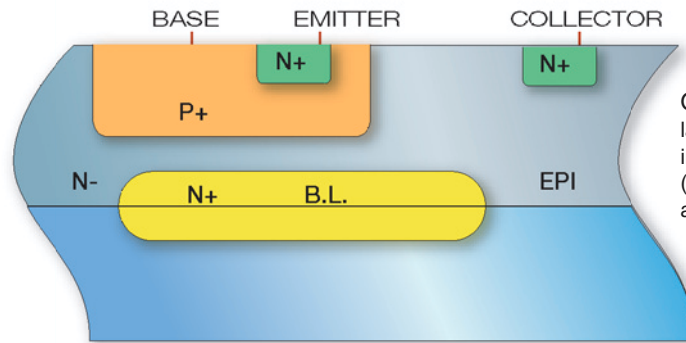
The largest Silicon Valley based thin film deposition services provider

# EPI WAFER OUTSOURCING SERVICES

## ABOUT EPI PROCESSING SERVICES

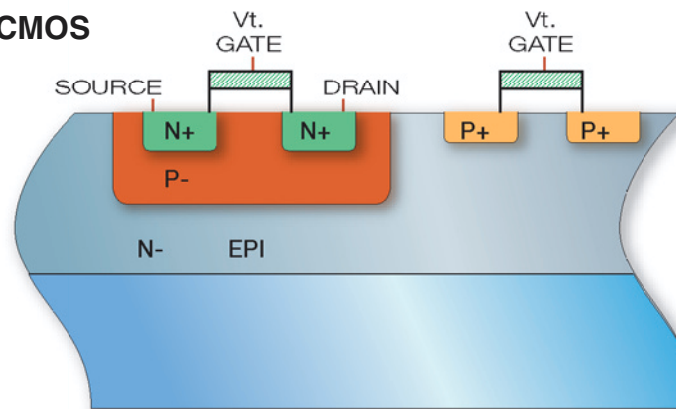
Semiconductor devices are manufactured by performing a complex series of process steps on a wafer, which is usually made of silicon. During those processes, several layers of conducting, semi-conducting or insulating thin films are formed on a silicon wafer. Precise and reliable control of the deposition of these films is vital to the ultimate performance and reliability of an individual device. Deposition of semiconductor and insulating thin films are produced by Chemical Vapor Deposition (CVD). In the CVD process, wafers are placed in a sophisticated reaction chamber (reactor), and a specially designed gas or vaporized liquid material is introduced to the chamber. A form of energy (e.g. heat or plasma) is then added to the reactor. This causes a thin film of material to be deposited on the surface of the wafer. CVD thin film processes are used to prepare the wafer surfaces with the desired uniformity of electrical and physical properties. One form of CVD based thin film deposition process is referred to as epitaxial or "Epi" deposition and is vital to both yield, performance and reliability of semiconductor devices. Specialty Epi wafers are used to manufacture semiconductor devices for applications such as automotive electronics, sensors, telecommunication circuits, analog power controls and robust application-specific integrated circuits, to mention a few.

### Bipolar



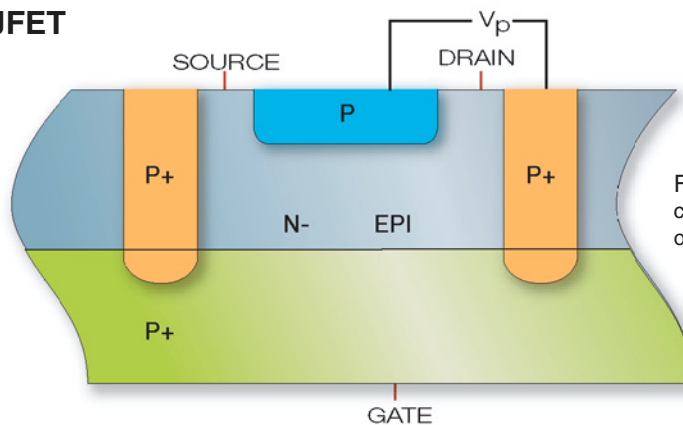
On bipolar devices an Epi layer prevents latch-up while improving breakdown voltage ( $B_v$ ) between the collector and emitter.

### CMOS



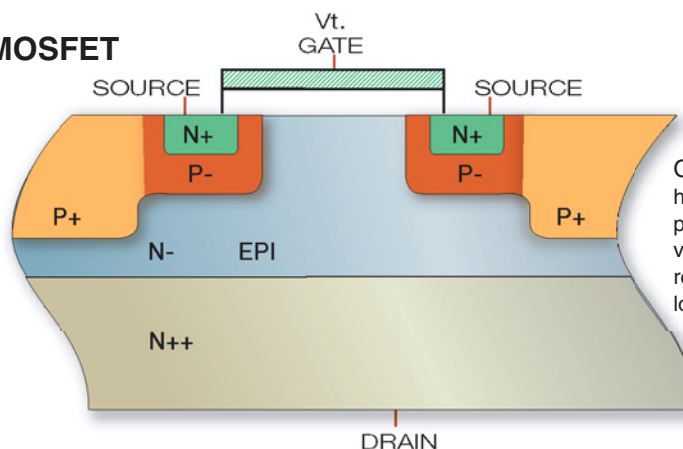
For CMOS, Epi improves breakdown voltage ( $B_v$ ), controls threshold voltage ( $V_t$ ), while preventing latch-up.

### JFET



For JFET devices, Epi is critical in the control of pinch-off voltage ( $V_p$ ).

### MOSFET



On MOSFET devices, the high resistivity Epi layer provides high breakdown voltages, while the low resistivity substrate provides low "on-resistance."

## TYPES OF EPI PROVIDED

Reaction Technology provides both thick and thin single crystal Epi layers on bare wafers of diameters ranging from 3 inches to 8 inches. As shown in the illustration, some of the silicon IC wafers such as Bipolar, or BICMOS have prior [buried] layers or patterns. Buried layer Epi deposition is a specialty of Reaction Technology.

## EPI SPECIFICATIONS

**Thickness:** *Single Crystal Epi: 0.5 to 150 microns with graded or stepped junctions*

**Resistivity:** *.002 to 150 ohm-cm*

**Diameter:** *3" to 6" diameter. 8" wafer processing for specific applications.*

**Layers:** *Single or multiple layers on bare or patterned wafers*

**Types:** *N, P, N+ or P+*

**Volume:** *Research lots (<25 wafers) to production volumes.*

## Silicon Coating Services

Reaction Technology supplies polysilicon coating services for silicon carbide and quartz products for use in single wafer and cluster tool RTP, CVD, EPI, and Etch chambers. The polysilicon coating extends the life of parts such as bell jars, isolation chambers, liners, rings, shower heads, gas distribution plates, robot blades, etc which are exposed to highly corrosive chemicals in the semiconductor manufacturing process. Extending the cycle that the machines can be run without downtime for maintenance is a major payback for the investment in poly coating of the ceramic components.

## TYPES OF DI WAFERS PROVIDED

As shown in the illustration to the right, Reaction Technology provides two technologies to create dielectrically isolated (DI) single crystal areas on the wafer surface: 1) Poly DI Wafer Technology and 2) Bonded DI Wafer Technology. Both techniques are provided on bare wafers with diameters ranging from 3 inches to 6 inches.

## DI WAFER SPECIFICATIONS

**Thickness:** *Polycrystalline Silicon: up to 750 microns of polysilicon*

**Diameter:** *3" to 6" diameter wafer processing for specific applications.*

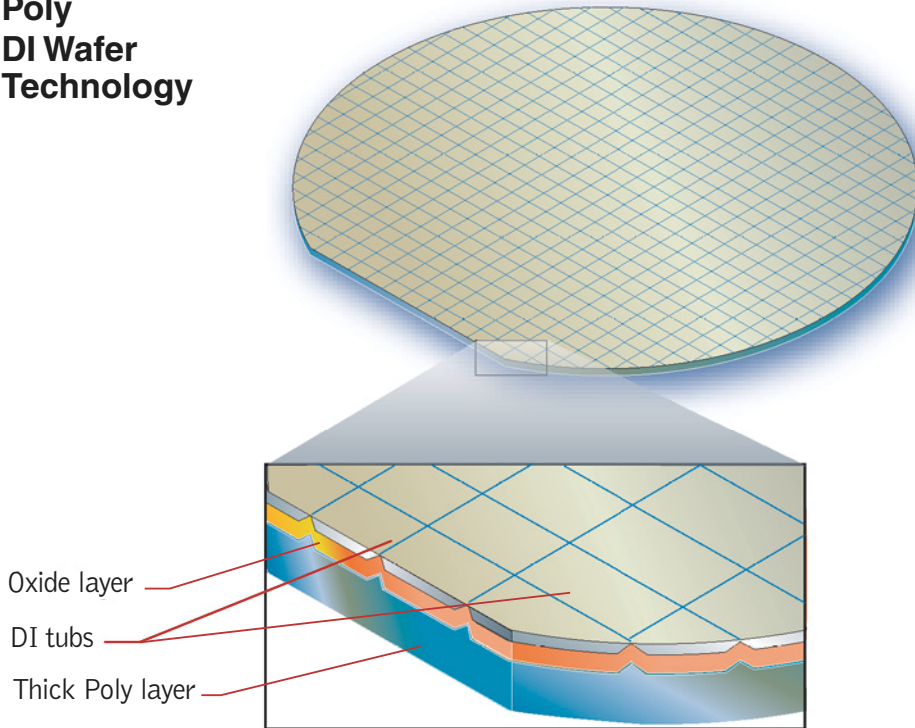
**Volume:** *Research lots (<25 wafers) to production volumes.*



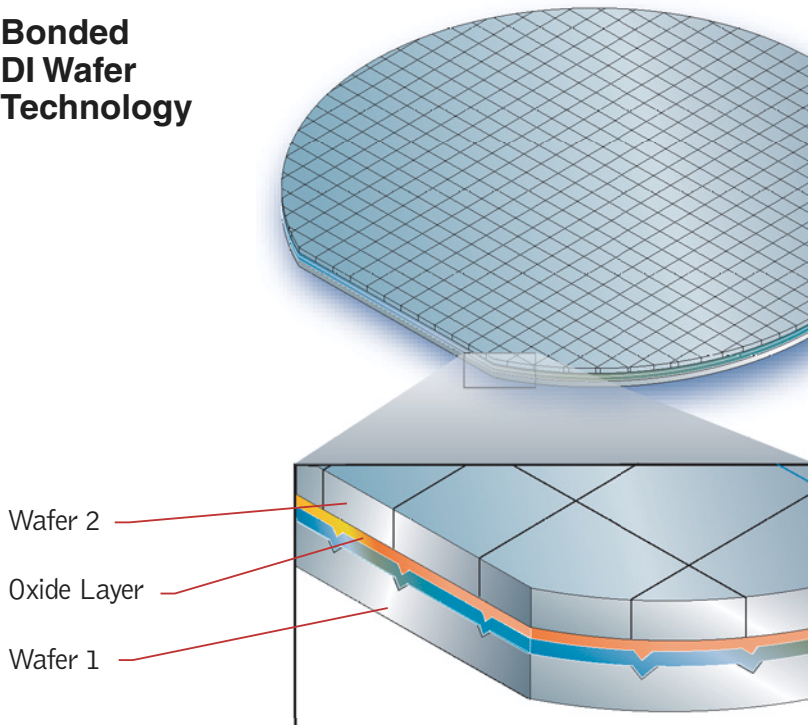
# DI WAFER OUTSOURCING SERVICES

## ABOUT DI WAFER PROCESSING SERVICES

### Poly DI Wafer Technology



### Bonded DI Wafer Technology



DI wafers are used in the manufacture of semiconductor devices where high voltage breakdowns and radiation hardness is desired. It is sometimes desirable to create dielectrically (DI) isolated areas on silicon wafers. These areas are known as "tubs" and are created by using either: 1) thick Poly DI Wafer Technology, or 2) Bonded DI Wafer Technology.

Precise and reliable control of the deposition of the polysilicon layer and the dielectrically isolated tubs is vital to the ultimate performance and reliability of the individual device. Deposition of the polycrystalline silicon is produced by Chemical Vapor Deposition (CVD). This CVD based thin film poly deposition process is referred to as "Poly" deposition and is vital to the yield, performance and reliability of semiconductor devices.

## Company Profile

Founded in 1991, Reaction Technology is the largest provider of Epitaxial Silicon (**Epi**) and Polycrystalline Silicon (**Poly**) outsourcing services in the Silicon Valley. The company is financially stable and committed to on time delivery of all products within specification. Reaction Technology is ISO 9002/2000 certified and applies continuous improvement techniques and statistical process control to enhance uniformity and quality of customer's products. The company focuses on providing both Reduced Pressure (**RP**) and Atmospheric Pressure (**AP**) silicon epitaxy (**Epi**) services for semiconductor manufacturers. In addition to Epi processing, Reaction Technology provides 1) Dielectrically isolated (**DI**) wafers and 2) Silicon coatings for quartz cylinders and silicon carbide rings for use in single wafer and cluster tool semiconductor processing.

*Founded  
in 1991*

*ISO  
9002/2000  
Certified*

## The Value of Wafer Outsourcing

Outsourcing of thin film deposition semiconductor processing can be an important business strategy for a semiconductor manufacturer. This is true regardless of the volatile semiconductor industry cycle. During cyclical downturns in demand, outsourcing can allow a semiconductor manufacturer to reduce operating costs by temporarily idling in-house capacity while maintaining both throughput and quality. During boom periods, outsourcing can provide extra capacity on a regular or periodic basis. A third benefit of outsourcing is to provide backup production capability in the event of a sudden and unexpected loss of internal capability.

*Incremental  
Capacity*

*Fast  
Turnaround*

*Contingency  
Capability*

## The Reaction Technology Reactor Outsourcing Program

Reaction Technology offers a Reactor Outsourcing program that allows customers to free-up valuable cleanroom space for higher value processes while converting 100% of Epi costs to variable costs. After a customer is completely comfortable with Reaction Technology's quality and service levels, the customer's Epi equipment is acquired by Reaction Technology and placed in the Reaction Technology facility for appropriate compensation. Reaction Technology agrees to supply Epi wafers at contract pricing. A double-barreled savings often occurs from this program. Not only do customers with both single wafer and batch reactor equipment have two utilization curves to worry about, but they often run wafers with lower uniformity requirements on single wafer reactors [which is not needed] instead of running them on more cost efficient batch reactors. The table to the right illustrates a hypothetical single chamber reactor that could have been outsourced for substantial operating profit savings over the 4 year period shown.

**Outsourcing Savings for One (Underutilized) Single Chamber Reactor**

Calendar Year	150 mm Substrates			
	2000	2002	2003	2004 (est.)
Single Chamber Reactor Wafer Capacity	72,000	72,000	72,000	72,000
Reactor Utilization	60%	30%	40%	45%
Wafers produced per year	43,200	21,600	28,800	32,400
Cost/Wafer In House	\$33	\$54	\$40	\$37
Cost/Wafer through RTI <sup>1</sup>	\$32	\$32	\$32	\$32
Savings/Wafer through RTI	\$1	\$22	\$8	\$5
<b>Operating Profit Savings through outsourcing to Reaction Technology</b>	<b>\$43.2K</b>	<b>\$475.2K</b>	<b>\$230.4K</b>	<b>\$162.0K</b>

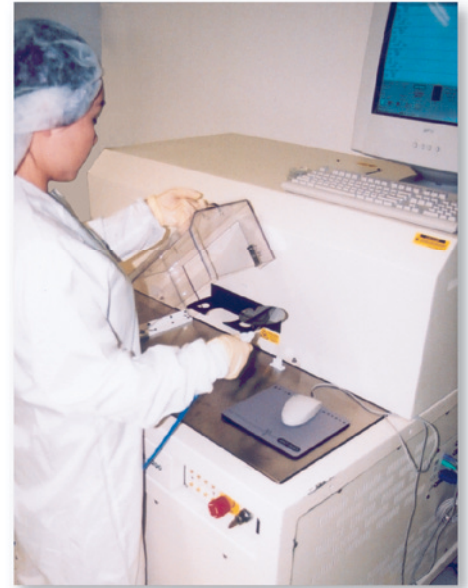
<sup>1</sup>This example assumes RTI pricing of \$34/wafer for single chamber processing, and \$24/wafer for batch processing and that 20% of the customer's workload can be run with batch processing, i.e., a weighted average cost of \$32/wafer.

## Metrology

Epitaxial layers are thoroughly inspected in-house to assure specification adherence and quality using the following techniques and methods:

*All product are tested to customer standards using ISO 9002/2000 certified processes*

- Thickness measurement by Fourier transform infrared (**FTIR**)
- Resistivity measurement by computerized mercury probe (**Hg**)
- Measurement of thickness and resistivity for single and multiple layer devices using spreading resistance profiles (**SRP**)
- Resistivity of N/P and P/N structure measured by four point probe (**4PP**)
- 100% visual inspection using high intensity white light ( **Black Box** )
- For continuous process improvement, the application of statistical process control (**SPC**) to the manufacturing process



## e-business Initiative

Like many of our customers, Reaction Technology has a long-term objective of evolving to an e-business-corporation by automating and integrating data-sharing with business processes and IT systems to external customers and business partners. The goal of this initiative is to update and deliver information vital to customer operations in near real time. When completed, the Reaction Technology e-business Initiative system will allow customers to electronically transmit purchase orders and invoices, determine shipping and or buffer inventory status, and receive data on an order's adherence to specifications. The company currently uses an automated bar code based workflow-tracking system that was designed to streamline internal business processes and eliminate human error.



## ISO 9002/2000 Certification Program

Since 2001 Reaction Technology achieved ISO 9002 certification for the manufacturing process. ISO 9002 certification continued into to the present as the company implemented statistical process control (**SPC**). These highly rigorous manufacturing disciplines help create consistent high quality product for our customers.

*Reaction Technology's LPE  
Epi reactor and an operator  
loading / unloading a  
susceptor.*

## Regulatory Compliance

Regulatory compliance is critically important in both the City of Sunnyvale, City of San Jose and the City of Santa Clara for life safety support, and security.