

# Solar Industry



## Infrared Solutions for Photovoltaic Applications



Photo courtesy of SCHOTT AG

Photo courtesy of Glos, Inc. Korea



## The Ircon®/Raytek® Solar Advantage

The two leading names in infrared (IR) noncontact temperature measurement, Ircon and Raytek, offer the industry's most complete line of infrared sensors, linescanners and process imaging systems. With nearly a century of combined experience in IR thermometry, we have the technical innovation necessary to meet the rapidly changing needs for temperature control in the growing solar industry.

Your process is unique and requires a customized solution. Our global sales team is ready and waiting to supply the right temperature measurement tools for your specific solar application process. From silicon and wafer production to photovoltaic cell and module manufacturing, we have the products you need at every step of your online process monitoring – even in hazardous and potentially explosive environments.

### Our Solutions

Ircon and Raytek infrared thermometers are designed for use in the solar industry, where monitoring and controlling temperature is critical to productivity and product quality.

Efficient temperature measurement is important in controlling the heating of silicon rods in polysilicon manufacturing. Proper temperature measurement of the silicon liquid used in the crystal pulling process for single crystal manufacturing helps insure wafer quality. Our explosion-proof housings provide additional safety for workers during hydrogen reduction processes. In PV cell manufacturing, high intensity lamp heated process chambers can be measured accurately. The use of thermal imaging can effectively detect cell interconnect defects in PV modules, as well as voids/bubbles in thin film coatings.

### Your Benefits

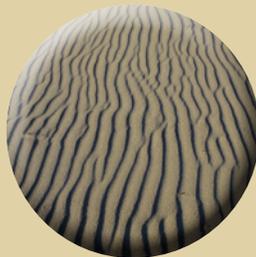
- Enhanced process control
- Increased productivity
- Improved product quality
- Reduced energy costs
- Minimized equipment downtime

### Major Applications

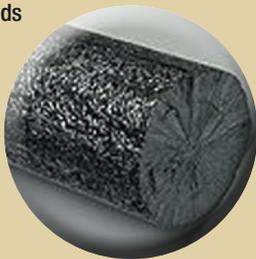
- Polysilicon production
- Single crystal silicon production
- Wafer polishing
- Photovoltaic cell manufacturing
- Thin film deposition/lamination
- PV module assembly
- Flat glass processing (float glass)
- Glass tempering
- Sapphire crystal growth

## The Photovoltaic (PV) Process

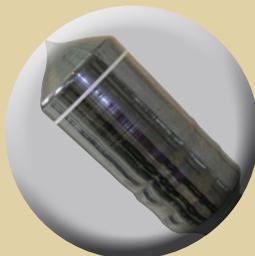
Beach Sand ( $\text{SiO}_2$ ) is converted to granulated Silicon (Si) using Oxygen reduction and distilled into highly purified  $\text{SiHCl}_3$  liquid.



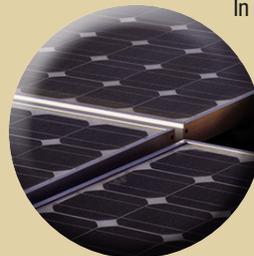
Polycrystalline Si rods for squared wafer production are grown using the Siemens Process of hydrogen reduction.



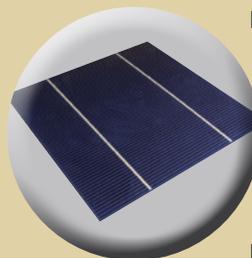
Single Crystal Si ingots are grown for round wafer production using a seed crystal and the Czochralski Process.



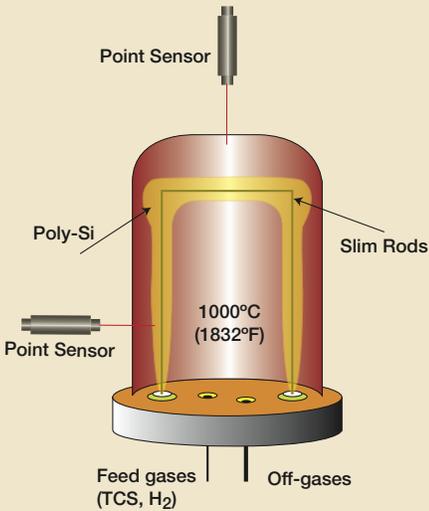
In PV module production, cells are placed on a glass or metal sheet and a layer of glass laminated on top for environmental protection. In thin film production, a polymer of glass, steel or flexible substrate is deposited on the solar panel prior to the protective glass layer.



PV cell manufacturing continues with ingots that are cut into wafers and trimmed. Anti-reflective and metallic/electrical contact coatings are applied. The cell is fired and contact paste is printed on the front.



## Polysilicon Production (Ingot/Wafer Production)



### Application description

Direct measurement of the poly crystalline silicon rods inside a Siemens process CVD reactor vessel to control the electrical current used to heat the silicon rods. Also, measurement of the Silicon tetrachloride (STC) by product of the polysilicon growth process in converter reactors to recycle Trichlorosilane (TCS) for reuse in polysilicon production.

### Measurement requirement

High performance infrared thermometers with variable focus, high resolution optics are required to properly target the polysilicon rods, as the reactors provide limited and variable optical access. Also, the sensors must not be affected by the process environment or from the gradual build-up of contamination on the process reactor windows.

### Icon/Raytek solution

Modline<sup>®</sup> 5, Marathon MR and FR high performance, 2-color ratio thermometers provide the perfect solution.

- 2-color measurement is insensitive to sight-path obstructions – deposition on reactor windows and cloudy process environment inside the reactor.
- Patented dirty window detector provides a real-time output of the reactor window cleanliness and allows optimal reactor maintenance and minimum reactor downtime.
- Variable focus, high resolution optics simplifies sensor mounting and targeting, and provides accurate measurements, even on small diameter silicon rod targets.
- Modline 5, Marathon MR sensors with ATEX/Class I, Div. II explosion proof enclosures are directly compatible with hydrogen reduction polysilicon processes.
- Built-in sensor self calibration/field calibration capabilities reduces maintenance and reactor downtime.

## Single Crystal Silicon Production (Ingot/Wafer Production)

### Application description

Direct measurement of silicon crystal solidification during the process of pulling ingots of single crystal silicon.

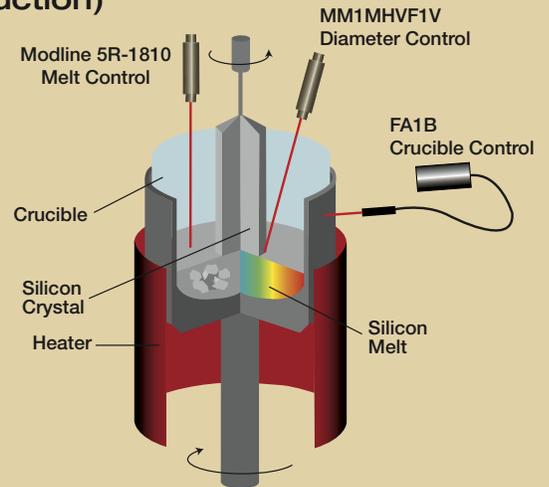
### Measurement requirement

High performance infrared thermometers with variable focus and high resolution optics provide the small measurement spot required to precisely measure the silicon liquid/solid freeze point and properly control the crystal pulling process. Other related process variables measured include silicon melt and crucible temperatures.

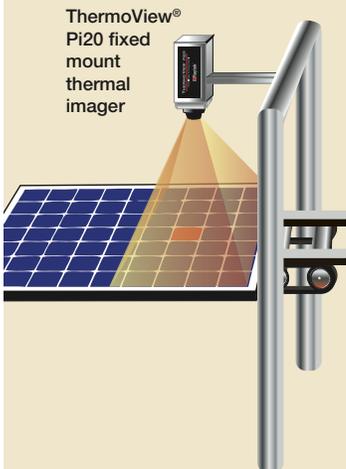
### Icon/Raytek solution

Modline 5, 5R, Marathon MR and Marathon MM with integrated video camera are high performance, short wavelength single color and 2-color ratio thermometers, offering critical features for this application.

- Variable focus, high resolution optics provide a very small measurement spot size at the silicon liquid/solid interface, which is necessary for controlling the crystal pulling process.
- Integrated video camera allows for real-time video output of the process environment.
- Built-in sensor self calibration/field calibration capabilities reduces maintenance requirements and reactor downtime.



## Thin Film Deposition/Lamination/Testing (PV Modules)



### Application description

Measurement of the temperature distribution in the polymer films laminated between the glass sheets that form the substrate and top surface of the solar panel.

Early detection of cracked or broken solar cells and defective electrical connections caused by poor solder joints.

### Measurement requirement

A high resolution thermal image of the entire panel surface allows proper tuning of the ovens used in the lamination process. Non-uniform temperature profiles or improper process temperatures can lead to voids or delaminations, as well as poor PV module performance and failure.

A thermal image taken after current is input to the module shows variations in temperature that can result from the inadequate or irregular flow of electricity.

### Raytek Solutions

#### ThermoView™ Pi20 High Performance Thermal Imager and DataTemp® DTPi Software

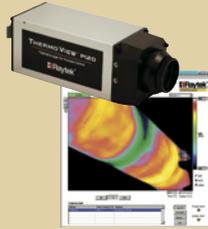
has the potential of detecting not only the defective cells quickly and accurately, but also determining the failure of electrical connections.

- Multiple temperature ranges, lens options, and onboard Ethernet.

#### GS150 Process Imaging System

with complete image capture and analysis software provides a 3-5 micron spectral response, allowing the linescanner to see through the glass panel and measure the process temperature of the underlying film.

- High resolution–1024 measurement points per scan line and 150 lines/sec. scan rate provide an exceptionally high resolution image of the panel to detect the smallest process anomalies or defects.



### Raytek ThermoView™ Pi20

Rugged thermal imaging camera designed for industrial process control applications.

- Thermal imaging for moving or stationary targets
- DataTemp® DTPi thermal imaging software
- Temperature Range: -40°C to 2000°C (-40°F to 3632°F)
- Onboard Ethernet
- Full complement of accessories

### Raytek MP150

Infrared linescanner provides a continuous thermal image of moving targets and web based processes.

- Temperature Range: 20 to 1200°C (68 to 2192°F)
- High resolution 1024 temperature points per scan line
- Fast 150 Hz scan rate
- Ethernet connectivity with OPC server support



### Raytek Marathon MR

High performance, infrared ratio (two-color) thermometer

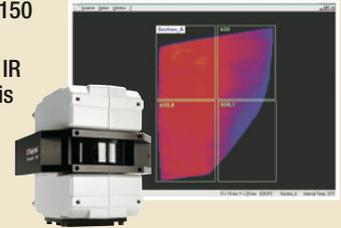


- 1.0 micron spectral response
- Temperature Range: 600 to 3000°C (1112 to 5432°F)
- High resolution optics
- Laser or through-the-lens target sighting
- Patented dirty window detector
- RS485 digital communications with software

### Raytek GS150 System

■ Uses the high performance MP150 infrared linescanner

- Complete software solution for IR image capture and data analysis
- Ethernet connectivity with OPC server support



### Ircon Modline 5

High performance, short wavelength infrared thermometer

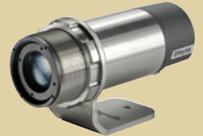


- 0.85 to 2.8 micron spectral response
- Temperature Range: 50 to 3000°C (122 to 5432°F)
- High resolution optics (D/240)
- Laser or through the lens target sighting
- Patented dirty window detector

### Raytek Marathon MM

High performance thermometer

- Wide range of spectral responses available
- Temperature Range: -40 to 3000°C (-40 to 5432°F)
- High resolution optics
- Through-the-lens, laser or video target sighting
- RS485 digital communications with software



### Ircon XP Explosion Proof Enclosure

■ Compatible with Ircon Modline 5 and Marathon MR/MM thermometers

- Class I, Div. II rated
- FM/ATEX instrument housing



### Raytek Marathon FR

High performance, infrared fiber-optic ratio (two-color) thermometer

- 1.0 micron spectral response
- Temperature Range: 500 to 2500°C (932 to 4532°F)
- Rugged fiber-optic cable
- High resolution optics
- Laser target sighting
- Patented dirty window detector
- RS485 digital communications with software



## The Worldwide Leader in Noncontact Temperature Measurement

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