Polysilicon Production

Infrared Solutions for Photovoltaic Applications
Polysilicon Production Process (Siemens Process)

Application Description
Measurement and control is needed for the Chemical Vapor Deposition or CVD process (Siemens process) used to grow polysilicon rods. Rod temperature is measured to control the electric current needed to heat the polycrystalline rods to the proper temperature for uniform polysilicon growth. A typical reactor will require three temperature measurement points.

A secondary application is the measurement of the Silicon tetrachloride (STC) by-product of the polysilicon growth process in converter reactors during recycling of Trichlorosilane (TCS) for reuse in the polysilicon production process. A single measurement is required in the STC converter reactor.

Measurement Requirement
High performance infrared thermometers with variable focus, high resolution optics are typically required to properly target thin 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.

Recommended Solution
Ircon® Modline® 5 5R sensor with XP/ATEX housing
Polysilicon Production Process

Customer Benefits – the Value Sell!

■ 2-color measurement is insensitive to sight-path obstructions caused by deposition on reactor windows and the cloudy process environment inside the reactor.

■ Variable focus, high resolution optics simplifies sensor mounting and targeting, and provides accurate measurements, even on small diameter silicon rod targets that can move in the field-of-view. The location of the silicon rods can also vary from run to run, which necessitates a convenient means of adjusting the alignment and focus of the sensor.

■ Safety! ATEX/Class I, Div. II XP explosion-proof enclosures are directly compatible with the hydrogen reduction polysilicon processes (Siemens process).

■ Patented dirty window detector provides a real-time output of the reactor window cleanliness and allows optimal reactor maintenance and minimum reactor downtime.

■ Built-in sensor health check and field calibration capabilities reduces maintenance downtime.

Application Considerations

Variable focus, high resolution optics simplify sensor mounting and targeting. The polysilicon seed rods are small, ~ 7mm (.275 in) in diameter and can move several mm in the field-of-view early in the process cycle. Use of a ratio sensor provides accurate measurements with only a part of the rod in the field-of-view. The high optical resolution further simplifies the sensor mounting and alignment.

Ratio sensors must consider reactor window slope. The typical Siemens reactor will require the sensor to “see” through three windows: (1) the window of the Ircon/Raytek XP Housing, (2) an outer process chamber window and (3) an inner process chamber window. While the window materials can vary with chamber manufacturer, the outer windows are typically a borosilicate glass and the inner window is usually quartz (fused silica) or Pyrex. For applications where the window materials can be specified, fused silica is the best choice.

It is particularly important to note that some window materials have a significant window slope that can have an adverse impact on the accuracy of two color measurements. While quartz is quite good with high optical transmission and negligible slope, some borosilicate or “float glass” windows (typically used as an external chamber window), have transmission in the 60-75% range and a pronounced slope. This window slope, if not compensated for, can introduce significant measurement errors 50 – 150ºC (90-270ºF).

The solution to compensate for this window slope requires some application engineering to determine the optimal slope value to compensate for the window slope effects. This is typically done at the critical process set-point temperature. To do this most effectively, chamber window samples are required for the customers specific process chamber. The Ircon/Raytek applications team can analyze the window samples and prescribe the appropriate sensor slope values.

Competitive Considerations

The patented attenuation alarm output in the Modline 5R provides a real time output of reactor window cleanliness. This allows the user to optimize their chamber window cleaning/replacement schedule to minimize reactor downtime.

Built-in sensor health check constantly monitors the functioning of the Modline 5R sensor. The sensor can be configured to provide an alarm signal, if an operational problem is detected. Sensor error codes are displayed to simplify sensor troubleshooting.
Alternate Solutions

Marathon MR sensor with XP/ATEX housing
Provides many of the same benefits of the Ircon Modline 5R solution in a Raytek branded package

Marathon FA/FR
Customer Benefits
- A fiber optic solution is attractive in competitive situations where the user already has an installed base of reactors with fiber optic sensors.
- The small, lightweight optics head can be easily mounted to the process chamber viewport with minimal installation hardware.
- Long fiber optic cables (up to 22 meter/72 feet) allow electronics to be mounted outside the hazardous environment—No ATEX/XP Housing is required.

Marathon MM sensor with XP Housing (Recommended when users prefer a single color measurement solution)
Customer Benefits
- Remotely adjustable, variable focus, high resolution optics simplifies sensor mounting and targeting, and provides accurate measurements, even on small diameter silicon rod targets. The location of the silicon rods can also vary from run to run, which necessitates a convenient means of adjusting the alignment and the focus of the sensor.
- Video sighting option for remote viewing of the process environment/targeting of sensor

Application Considerations
Variable focus high resolution optics facilitate sensor mounting and targeting. The polysilicon seed rods are small, ~ 7mm (.275 in) in diameter and can move several mm in the field of view early in the process cycle. The high 300:1 optical resolution of the Marathon MM sensor further simplifies the sensor mounting and alignment.

Single color sensors must consider the transmission properties of the windows used in the process chambers. Since most Siemens process polysilicon reactors will require the use of an XP Housing, the sensor will need to “see” through a total of three distinct windows into the process environment: (1) the window of the Raytek XP Housing, (2) an outer process chamber window and (3) an inner process chamber window. While the window materials can vary with the chamber manufacturer, the outer windows are typically borosilicate glass and the inner window is usually quartz (fused silica) or Pyrex. For applications where the window materials can be specified, fused silica is the best choice.

To make accurate measurements with a single color Marathon MM sensor, the user must set the appropriate window transmission factor for the combined optical path. For a typical manufacturer’s reactor, this yields a combined transmissivity of approximately 0.39 (0.53 XP housing window X 0.8 soda lime external reactor window X 0.92 internal quartz reactor window).

Window contamination can also have an adverse affect on measurement performance with single color sensors. When using the MM sensor, the user must maintain the cleanliness of the internal reactor process window.

Competitive Considerations
The MM Video sighting option provides a remote method of target sighting that eliminates the need for the operator to spend excessive time in the hazardous process environment. In addition, the operators have a real time video image of the process environment to monitor the silicon growth process. Remotely controlled sensor focus capability allows the user to fine-tune the sensor focus without opening the XP housing or entering the hazardous process environment. Competitive products do not offer this capability.

Marathon field calibration software allows the user to do their sensor calibration/calibration check to minimize the expense and downtime of returning sensors to the service center for calibration.