



## **PV Cell Production**

Temperature Monitoring and Control



### **Process Sensors Offers Complete Solutions:**

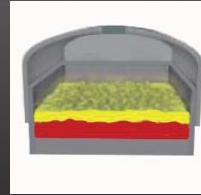
- **Directional Solidification Casting**
- **CdTe Cells — Thin Film Deposition**
- **Silicon Crystal Pulling**
- **CVD Siemens Process — Silicon Ingot Growing**
- **Polycrystalline Casting**
- **Radiant Heat Soldering**
- **Laser Weld Inspection**
- **CIGS Cells — Thin Film Deposition Process**

## SILICON CRYSTAL PULLING (CZOCHELSKI / FLOAT ZONE PROCESS)



Metis Series models MS single wavelength, and MQ 2 color ratio thermometer monitor the melt meniscus and susceptor to provide accurate temperature data for pulling rate control. Precision aiming and focusing is achieved through the use of focusable optics and advanced sighting capabilities such as through the lens, laser or video. Analog and digital outputs interface conveniently with control and data acquisition instrumentation.

## POLYCRYSTALLINE CASTING



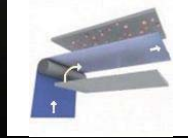
Metis Series model MQ, 2 color ratio thermometer, or model MS single wavelength thermometers, measure melt temperature with precision during the critical solidification phase to ensure the specified crystal orientation, size and homogeneity. The ratio measurement technique is not affected by partial obscuration of viewport sighting windows and vapors in the Infrared thermometers sight path.

## CVD REACTOR (SEIMENS PROCESS)



Metis model MQ, 2 color ratio thermometer in Class 1 Div I, Group B explosion proof housing with direct or fiber optic versions for hard to reach locations, provides the precise temperature measurement during deposition needed to ensure controlled growth rate and uniformity.

## CIGS CELLS – THIN FILM DEPOSITION



Metis model MS09 has a narrow band, short wavelength spectral response to minimize the effects of highly reflective, variable emissivity targets, such as are true of the aluminum and steel substrates encountered in CIGS thin film deposition process.

## IR Sensors for Glass, Photovoltaic (P

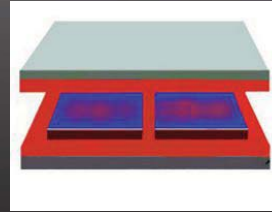
PSC Model Numbers	PSC Metis MQ11, MQ22	PSC Metis MS09, MI16, MI18	PSC Metis MY51	PSC Sirius SS09, SI16	PSC-CS-Laser-LT/2MH	PSC DT-40G / DT-44G	PSC DG-40N / DS-40N
Wavelength	1.45 ~ 1.8μ / 1μ	1μ / 1.6μ / 1.8μ	5μ	1.6μ / 1μ	1.6μ / 8-14μ	5μ	1.6μ / 1μ
Temperature Range	482 to 5792°F	248 to 5432°F	212 to 4532°F	482 to 3272°F	minus 58 to 2912°F	212 to 4532°F	482 to 4532°F
Accuracy	0.3% of reading +1°C	0.3% of reading +1°C	1°C + 0.5% of reading between measurement value & housing temperature	0.5% of reading +1°C	1% of reading / ± 0.3% of reading	0.6% of reading	0.5% of reading
Repeatability	0.1% of reading in °C +1°C	0.1% of reading in °C +1°C	0.1% of reading in °C + 0.2°C	0.1% of reading + 1°C	0.3% of reading + 2°C	0.5% of reading	0.1% of reading
Field of View	Up to 800:1	Up to 377:1	65:1 to 200:1	Up to 180:1	Up to 300:1	50:1	>100:1
Resolution	0.1°C/ 0.03°C	Analog; <0.1%,digital 0.1°C	Analog; <0.1%, Digital 0.1°C	0.1°C	0.1°C	0.1°C	0.1°C
Aiming Method	Through Lens, Laser or Video	Through Lens, Laser or Video	Through Lens or Laser	Laser	Dual Lasers - 4 wire	Laser or Green LED	Laser or Green LED
Focus Capabilities	Adjustable / Fixed	Adjustable / Fixed	Adjustable / Fixed	Adjustable	Fixed	Fixed	Fixed
Output	0 to 20mA, 4 to 20mA, RS232, RS485, Profibus	0 to 20mA, 4 to 20mA, RS232, RS485, Profibus	0 to 20mA, 4 to 20mA, RS232, RS485, Profibus	0 to 20mA, 4 to 20mA, RS232, RS485	4-20mA 2 Wire-Loop Powered with Digital communication	4-20mA / RS485	4-20mA
Response Speed	2ms adj. up to 10 sec.	1ms adj. up to 10 sec.	10 ms, 40 ms or 100 ms	5 ms adj. up to 10 sec.	10 ms /150 ms	60 ms / 30 ms	<10 ms adj. up to 10 sec
Accessories	Prot. Jacket / Cooling, Front cooling plate, Air purges, Swivel base mounts, cables, adjustable mounting brackets, right angle mirrors, scanning mirrors	Prot. Jacket / Cooling, Front cooling plate, Air purges, Swivel base mounts, cables, adjustable mounting brackets, right angle mirrors, scanning mirrors	Prot. Jacket / Cooling, Front cooling plate, Air purges, Swivel base mounts, cables, adjustable mounting brackets, right angle mirrors, scanning mirrors	Prot. Jacket / Cooling, Air purge, Sealed window assembly, cables, fixed or adjustable mounting brackets	Prot. Jacket / Cooling, Air purge, fixed or adjustable mounting brackets	Prot. Jacket / Cooling, Air purge, Sealed window assembly, cables, fixed or adjustable mounting brackets	Prot. Jacket / Cooling, Air purge, Sealed window assembly, cables, fixed or adjustable mounting brackets
Notes	2 Color Version sees through dirty windows, compensates for product emissivity (graybody)	Offered in both fiber and non-fiber optic versions	Sensor head ambient rating: 70°C	Sensor head ambient rating: 70°C	Sensor provides digital communication to allow set up of all IR sensor parameters. Sensor Head ambient rating: 85°C	Sensor head ambient rating: 70°C	Sensor head ambient rating: 70°C

## RADIANT HEAT SOLDERING – TABBING MACHINE



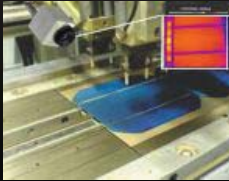
Process Sensors' Model PSC-CS-Laser-LT thermometer with built-in dual lasers provides pinpoint sighting and can be used in a 2 wire loop powered configuration. The 4-20 mA linear output signal integrates easily into recording and process control instrumentation. A built-in peak picker is provided for intermittent, moving targets.

## CdTe CELLS – THIN FILM DEPOSITION



Thermometer Compact Series models DT40-G or DT44-G sensors precisely measures the glass substrate surface temperature during deposition. The Metis model MP23 or PSC-SSS-Laser 3M series have the capability to measure the temperature of the deposition / TECO coating through the glass substrate.

## LASER WELD & ELECTRICAL BIAS INTERCONNECT TESTING



Process Sensors' model PSC-PI on-line camera provides a real time picture of thermal gradients that indicate defective welds and faulty interconnects. Interchangeable lenses and Windows based software facilitate data acquisition and automatic control functions. The compact size of the PSC-PI camera is ideal for use in test station configurations and tight locations.

## DIRECTIONAL SOLIDIFICATION CASTING



Process Sensors Metis model MS thermometers accurately measures the temperature of the molten silicon and insures that the liquid / solid phase change has occurred to initiate the next step in the process. The pyrometer is used to measure temperature and provide feedback to control power to the heaters. This insures that the growth process is optimized.

## V), Silicon & GaAs Wafer applications

PSC DGF-40N / DSF-40N Fiber Optic Models	PSC DSF-30/34 Fiber Optic Model	PSC-SSS-G5	PSC-SSS-P7	PSC-SSS-1MH/2MH	PSC-SSS-Laser-G5	PSC-SSS-Laser-1M/2MH	PSC-PI Thermal Imaging Camera
1.6μ / 1μ	1μ	5.2μ	7.9μ	1.6μ / 1μ	5.2μ	1.6μ / 1μ	7.5 to 13μ
482 to 4532°F	1112 to 3272°F	212 to 3002°F	32 to 932°F	482 to 3272°F	212 to 3002°F	482 to 3272°F	minus 4 to 1652°F
0.5% of reading	0.3% of reading	1% or ± 2°C	1% of reading or ± 1.5°C	0.3% of reading +2°C	1% of reading or ± 1°C	0.3% of reading +2°C	2 % of reading or ± 2°C
0.1% of reading	0.1% of reading	0.5% or ± 0.5°C	0.5% of reading +0.5°C	0.1% of reading + 1°C	0.5% of reading + 0.5°C	0.1% of reading + 1°C	0.5% of reading
Up to 107:1	>100:1	20:1	10:1	Up to 75:1	Up to 75:1	Up to 330:1	Up to 956:1
0.1°C	0.1°C	0.1°C / 0.2°C	0.5°C	0.1°C	0.1°C / 0.2°C	0.1°C / 0.2°C	0.1°C
Laser	N/A	Laser accessory	Laser accessory	Laser accessory	Dual Lasers	Dual Lasers	2D thermal image
Adjustable	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Adjustable
4-20mA	4-20mA / RS485	0 to 20mA, 4 to 20mA, RS232, RS485,USB, T/C, Ethernet, 0/5, 0/10VDC, relays,Profibus	0 to 20mA, 4 to 20mA, RS232, RS485,USB, T/C, Ethernet, 0/5, 0/10VDC, relays,Profibus	0 to 20mA, 4 to 20mA, RS232, RS485,USB, T/C, Ethernet, 0/5, 0/10VDC, relays,Profibus	0 to 20mA, 4 to 20mA, RS232, RS485,USB, T/C, Ethernet, 0/5, 0/10VDC, relays,Profibus	0 to 20mA, 4 to 20mA, RS232, RS485,USB, T/C, Ethernet, 0/5, 0/10VDC, relays, Profibus	USB or Ethernet Connection, SDK, 0-10VDC camera output
<10 ms adj. up to 10 sec.	<10 ms adj. up to 10 sec.	80 ms/120 ms	150 ms	1 ms	80 ms/120 ms	1 ms	125 frames per second, Adjustable
Prot. Jacket / Cooling, Air purge, Sealed window assembly, cables, fixed or adjustable mounting brackets	Prot. Jacket / Cooling, Air purge, Sealed window assembly, cables, fixed or adjustable mounting brackets	Protective Jacket / Air purge, fixed or adjustable mounting brackets, Close focus lens, right angle mirror.	Protective Jacket / Air purge, fixed or adjustable mounting brackets, Close focus lens, right angle mirror.	Protective Jacket / Air purge, fixed or adjustable mounting brackets, Close focus lens, right angle mirror.	Prot. Cooling Jacket, Air purge, fixed or adjustable mounting brackets	Prot. Cooling Jacket, Air purge, cables, fixed or adjustable mounting brackets	Air purge, Cooling Jacket, Tripod mount, I/O modules, PC Touch Screen Display, multiple 4-20mA outputs, multiple relays & variety of lenses
Fiber optic lens ambient rating: 250°C	Fiber optic lens ambient rating: 250°C	Sensor head ambient rating: 85°C	Sensor head ambient rating: 85°C	Sensor head ambient rating: 100°C / 125°C	Sensor head ambient rating: 85°C	Sensor head ambient rating: 85°C	Sensor head ambient rating: 0 to 50°C

# ***PROCESS SENSORS CORPORATION — YOUR MOST COMPREHENSIVE, SINGLE SOURCE FOR INFRARED NON-CONTACT TEMPERATURE SENSORS, THERMAL IMAGING CAMERA SYSTEMS AND BLACKBODY CALIBRATION SOURCES.***

Production of photovoltaic (PV) cells is growing at an unprecedented rate in response to the increasing use of this technique to generate electric power from sunlight. The need to find competitive sources of electrical power as an alternative to fossil fuels is also creating pressure to increase the efficiency of the PV cell.

While research is focusing on newer, more efficient types of photo devices, such as the “Glitter” cell, practice has shown that the cost effectiveness of established production methods can significantly be improved by increasing the yield and improving quality through precise temperature measurement and control.

With over 15 years of instrument manufacturing and application engineering experience, Process Sensors Corporation is uniquely positioned to serve the temperature measurement needs of the PV Cell manufacturing industry. The company’s range of IR Temperature sensors and Thermal Imaging Cameras have specifications selected for optimum measurement performance in each application. The products are supported globally by expert application engineers who provide comprehensive, turnkey, temperature measurement solutions.



Metis Series



Sirius Series



PSC-CS-Laser



40 Series



DSF 30/34 Series



PSC-SSS



PSC-SSS-Laser



PSC-PI Thermal Camera

## **IR THERMOMETER CALIBRATION AND TRACEABILITY**

Although Process Sensors IR thermometers are designed for long-term stability, it is good practice to check them periodically against an unambiguous reference source. The only such source at temperatures higher than the melting point of ice is a blackbody furnace. Properly designed blackbody calibrators avoid errors due to variable emissivity and reflected energy. Properly certified, they provide calibration traceability to certified laboratories and national standards. Such traceability is invaluable for supporting product quality assurance. Process Sensors’ non contact infrared temperature sensors are reliable and optimized in terms of accuracy, based on stringent calibration standards.

## **APPLICATIONS**

The preceding information is intended to help in the selection of temperature sensors for particular manufacturing and testing applications. Brochures for each sensor are available on request or can be downloaded from [www.ProcessSensorsIR.com](http://www.ProcessSensorsIR.com).

Process Sensors application engineers will assist you in selecting the optimum sensor for your specific application measurement needs.

## **PROCESS SENSORS CORPORATION**

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