

# LAND

## AMETEK®

*NON-CONTACT TEMPERATURE  
MEASUREMENT SOLUTIONS FOR  
THE SOLAR AND SILICON INDUSTRIES*

### APPLICATION NOTE

The manufacture of silicon products for the photovoltaic and electronics industries requires accurate, reliable temperature measurements to ensure consistent quality and process efficiency. This is increasingly important as demand for these products grows.

AMETEK Land is able to deliver a range of technologies to meet the unique demands of these production processes, helping to increase productivity, reduce costs and improve product quality.



## THE SOLAR AND SILICON INDUSTRIES

After oxygen, silicon is the second-most abundant element in the Earth's crust. It is crucial to two of the most rapidly growing industries, solar power and semiconductor-based electronics.

Solar power depends upon photovoltaic cells – silicon-based devices which convert light directly into electricity. These cells require high-quality, uniform silicon crystals in either polycrystalline or monocrystalline structures.

Monocrystalline silicon is the more efficient material for photovoltaic cells, but is more expensive to produce in large quantities than polycrystalline silicon, so the latter is more frequently used for solar cells.

Since polycrystalline silicon – often referred to as polysilicon – is less

efficient at converting light to electricity, good product quality is essential to its effectiveness.

Temperature measurements in the reactor during the manufacturing process help control the uniformity of the crystalline structure, supporting product quality.

Polysilicon can also be cast into ingots, which require monitoring during cooling and solidification.

The higher cost of monocrystalline silicon production means that increasing efficiency and reducing waste product by temperature monitoring can have significant benefits for manufacturers.

A temperature measurement solution is also advantageous when

photovoltaic cells are assembled together to form a module.

Solder reflow processes are used to connect the cells, so techniques which ensure heating and connection are homogenous across the module will support process efficiency.

As the world leader in the design and application of infrared temperature measurement solutions for industry, AMETEK Land provides a range of non-contact technologies to support these applications.

For more than 70 years we have supported many different industries, providing an effective foundation for these key measurements in the developing solar and silicon production industries.

# POLYSILICON REACTORS

Polysilicon is the key component in most photovoltaic solar power cells. Typically, the Siemens process, which is based around chemical vapour deposition (CVD), is used to manufacture polysilicon. This process requires continuous, accurate temperature monitoring and control at the reactor stage to ensure consistent product quality.

Firstly, silicon is converted to trichlorosilane (TCS) in a fluidised-bed reactor. Then the TCS, which has a boiling

point of 32 °C (89.6 °F) is distilled to reach the required purity. Lastly, the TCS is broken down in a CVD reactor with a reducing atmosphere at around 1000 °C (1832 °F) and producing thick rods of highly pure polysilicon.

The CVD reactor environment is challenging for measurement instruments, as the temperatures are extremely high and the surrounding atmosphere may be occasionally hazardous. In North America, this may

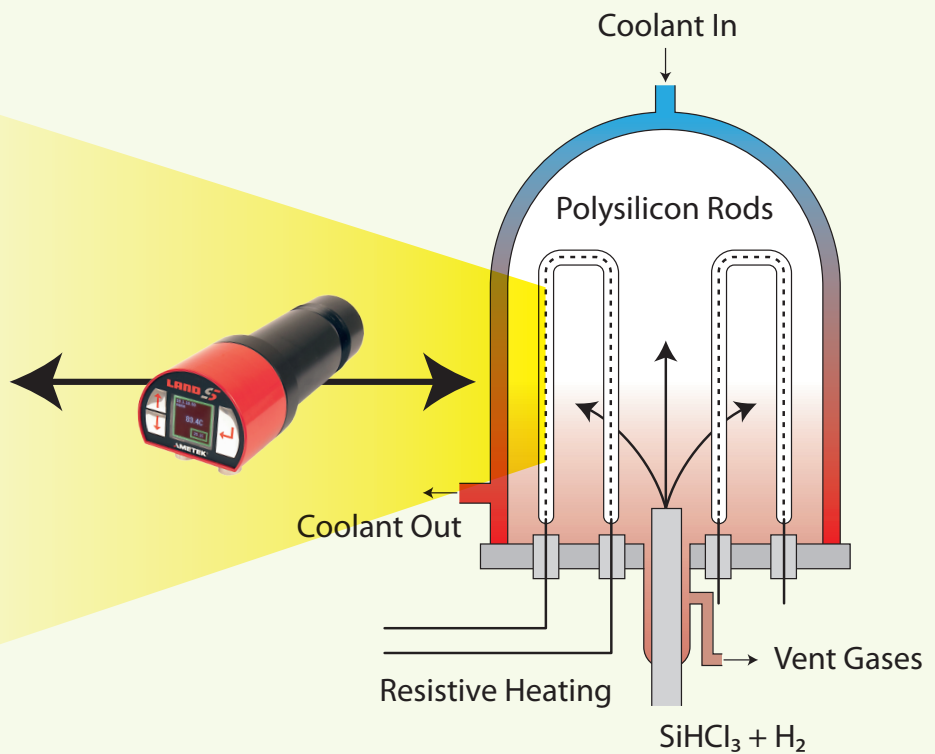
require the use of Hazloc-certified sensors.

AMETEK Land has wide experience in supplying products which make critical temperature measurements in and around the Siemens process. Fibre-optic technology keeps the electronics away from the harmful operating conditions of the CVD reactor, while the non-contact measurement system does not interfere with the process, and so avoids any risk of contamination.

## SIEMENS PROCESS



Temperature measurement data from the SPOT pyrometer



## RECOMMENDED PRODUCT: *SPOT R100 PYROMETER*



FIXED SPOT  
PYROMETERS

## SINGLE-SPOT

### ADVANCED SINGLE-SPOT RATIO PYROMETER

Single-spot, non-contact infrared pyrometers, optimised for a wide span of temperature ranges and process requirements.



# SPOT R100 RATIO FO

Designed for easy, one-person installation, SPOT pyrometers provide an accurate standalone temperature measurement solution, with no separate signal processor required. They offer Ethernet, Modbus TCP/IP, 4-20 mA analogue outputs and alarm outputs.

The R100 FO model is a fibre-optic ratio thermometer which combines the signal from two detectors, measuring in the range 550 to 1800°C (1022 to 3272°F). Flexible fibre-optics allow the optic head to be mounted in a hostile environment with the detector and other electronics kept several metres away.

With models using a variety of operating wavelengths and temperature ranges for different process requirements, the SPOT range can deliver accurate stable measurements quickly, reducing maintenance time and enabling faster process adjustments.

## SPOT PYROMETER WITH FIBRE-OPTIC ATTACHMENT

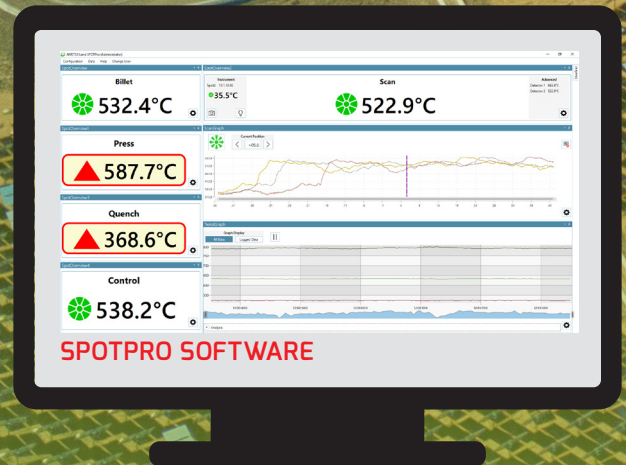


## FEATURES

- Self-contained single-sensor solution
- Range of digital and analogue communications
- Local and remote motorised focus control
- Easy plug-and-play installation

## BENEFITS

- Fibre-optics keep electronics away from hostile conditions
- No separate processor required
- Scratch-resistant sapphire protection window
- Faster, more accurate measurements
- Integrated webserver and Modbus TCP/IP – Industry 4.0 ready



# POLYSILICON INGOT CASTING

Polysilicon rods produced through chemical vapour deposition are usually broken up and cast into ingots by being heated until molten then poured into moulds. These ingots can then be machined into the desired shape.

The quality of the ingot, determined by achieving the desired crystal size and homogeneous structure, depends upon the uniformity of cooling. This requires accurate temperature monitoring throughout the ingot solidification process.

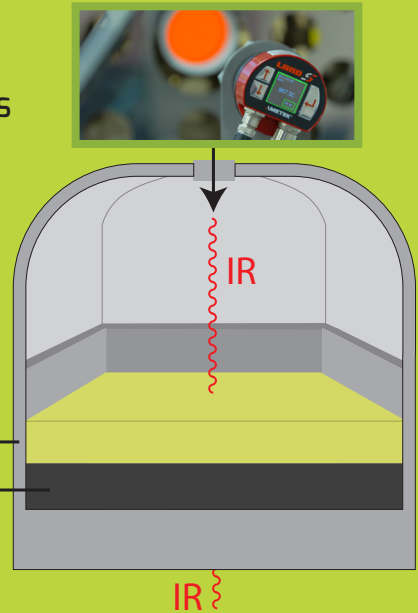
AMETEK Land's non-contact infrared SPOT pyrometer, Near Infrared (NIR) thermal imager and advanced software processing techniques provide high-resolution data about absolute temperature, the rate of temperature change, temperature distribution, and uniformity.

These specifically engineered solutions were developed to ensure a high-quality polysilicon structure in the ingot prior to them being sawn into wafers.

## MULTICRYSTALLINE SILICON DIRECTIONAL SOLIDIFICATION PROCESS



Crucible  
Silicon



## RECOMMENDED PRODUCT:



# SPOT R100 PYROMETER



FIXED SPOT  
THERMOMETERS

# THE CZOCHRALSKI PROCESS

Monocrystalline silicon is used in large quantities by the photovoltaic industry, yielding an extremely high light-to-electricity conversion efficiency when used in solar cells.

It is also an essential component for the production of integrated circuits, of the type used in computers, mobile phones and televisions.

This form of silicon is obtained through the Czochralski process, a method of crystal growth that can be used to obtain single crystals of semiconductors, metals and salts.

High-purity silicon is melted in a cylindrical crucible at very high

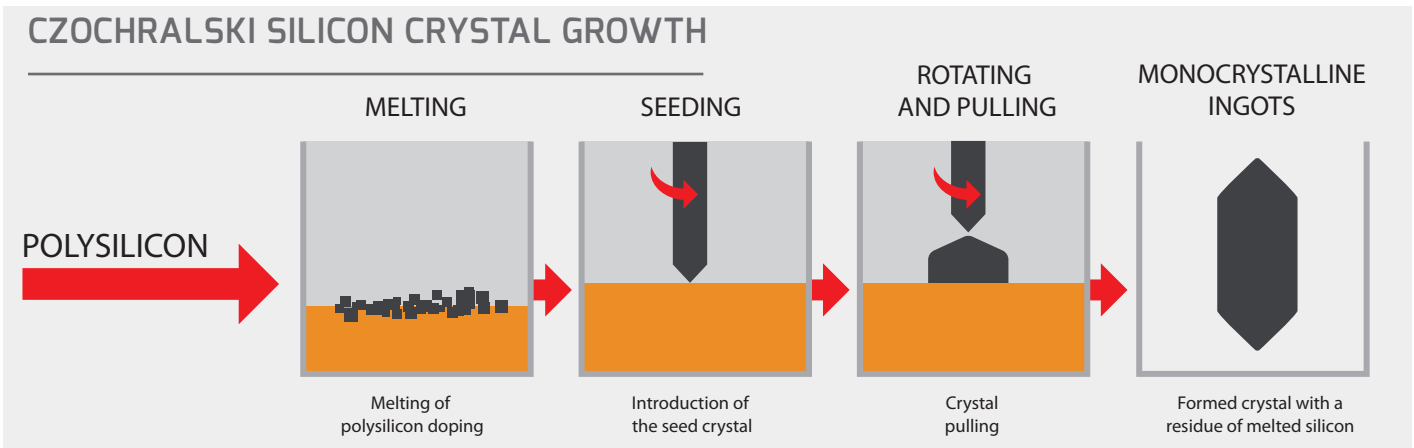
temperatures (typically 1425 °C, or 2597 °F). Impurities such as boron or phosphorus can be added to affect the silicon's electronic properties, changing it into p-type or n-type silicon.

A rod-mounted seed crystal is dipped into the molten silicon, then pulled upwards while rotating slowly – this creates a large, single-crystal cylindrical ingot. Efficiency and quality depend on monitoring of the temperature, pulling rate and speed of rotation for the ingot during the process. Control of the diameter is typically based on the meniscus shape formed between the seed crystal and the melt.

AMETEK Land provides highly accurate near-infrared measurement solutions, using single-point pyrometers and thermal imaging cameras to resolve areas as small as 0.013 x 0.013mm.

Digital image processing means that the liquid/solid boundary can be accurately monitored during the process, without the need for careful aiming and avoiding spurious measurements from misaligned or defocused pyrometers.

Flexible software tools support the unmatched measurement performance to provide a complete monitoring package for this application.



## RECOMMENDED PRODUCT: **NIR**



The NIR is a highly accurate near-infrared fixed thermal imager producing high-definition thermal images for detailed temperature measurements. Flexibility is key to this product, with AMETEK Land's advanced radiometric technology delivering accurate process temperature data for a variety of applications.

Designed to ensure consistent product quality and enhanced process safety, the imager transmits thermal data to a PC via a Gigabit Ethernet connection. Advanced software support provides flexible, application-specific thermal analysis.

### FEATURES

- High-resolution thermal images
- Robust housing for harsh environments
- Range of temperature and field-of-view options
- Simple installation and ease of use

### BENEFITS

- Detailed temperature information
- Optimum process control
- Flexible configuration for a range of applications
- Powerful software support

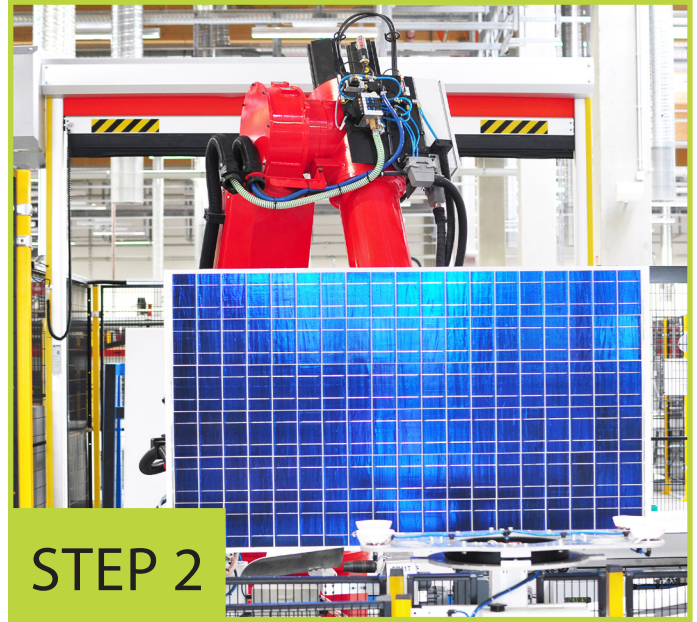
# PHOTOVOLTAIC MODULE ASSEMBLY



## STEP 1

There are two basic steps to assemble a photovoltaic module. Firstly, a number of photovoltaic cells (typically between 20 to 80 cells) are connected electrically using stringing ribbon. The ribbon is dipped into, or sprayed with, flux, and solder reflow is used to connect the cells.

Secondly, the connected cells are placed on a substrate – usually glass – and joined together, by soldering, before a second substrate (again, glass is usual) is placed on top and the module is sealed. The module is then tested for efficiency before use.



## STEP 2

AMETEK Land's LSP-HD infrared linescanner provides an ideal measurement solution for the analysis of large, moving, flat areas. If the areas of analysis are stationary, an ARC Imager solution can be used as an alternative.

LSP-HD offers market-leading resolution and speed, resulting in highly detailed and informative thermal images that allow detection of even the smallest defects.

Using onboard processing and optional analogue process I/O, the LSP-HD instantly provides processed data to plant computers, allowing the control and fine-tuning of heating parameters.

## RECOMMENDED PRODUCT: *LSP-HD 61*



Highly-homogeneous and designed to operate in harsh environments, the LSP-HD range of linescanners uses high-quality optics to produce high-definition thermal images at unrivalled scan speeds, for outstanding process control.

All LSP-HD scanners feature rugged sapphire protection windows that resist scratches, acids and solvents. They also have a robust scanner assembly with only one moving part, and a die-cast housing with water-cooling and air purging.

The LSP-HD 61 is optimised for temperature measurements in the range 50 to 400 °C (122 to 752 °F), providing scanning of 1000 sample points at speeds up to 150 scans per second. Plug-and-play industrial Ethernet connection provides real-time processed data, allowing module assembly problems to be identified and analysed quickly. This can be extended further with the AMETEK Land Landscan Windows Control and Analyse (WCA) software which can support up to eight linescanners simultaneously.

### FEATURES

- High-resolution, homogeneous thermal imaging optical system
- Operates in hot, dusty industrial environments
- Easy installation with single Ethernet cable
- Range of data output formats

### BENEFITS

- Real-time thermal displays for accurate results
- Industry-leading scan speeds
- Detects even the smallest temperature differences
- Installation costs significantly reduced

# AMETEK LAND SOLUTIONS FOR THE SOLAR AND SILICON INDUSTRIES



Our in-house service centres provide after-sales services to ensure you get the best performance from your system. This includes technical support, certification, calibration, commissioning, repairs, servicing, preventative maintenance and training. Our highly trained technicians can also attend your site to cover planned maintenance schedules and repair emergency breakdowns.

## SPOT Pyrometers

Fully-featured, high-performance pyrometers for fixed, non-contact infrared spot temperature measurements and a range of process requirements.



## NIR IMAGER

A high-precision, focusable fixed thermal imaging camera producing high temperature measurements in a wide range of applications.



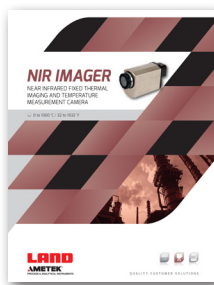
## LSP-HD 61

Ethernet-controlled compact infrared linescanner, designed to produce advanced thermal imaging in moving processes.

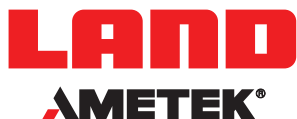


## ARC IMAGER

Using AMETEK Land's cutting-edge, high-resolution radiometric technology, the flexible, option-rich ARC produces detailed thermal images with unrivalled precision.



DOWNLOAD THE BROCHURES AT: [WWW.AMETEK-LAND.COM](http://WWW.AMETEK-LAND.COM)



### CONTACT US

