

Solar Market



Non-Contact Temperature Control in the Production
of Photovoltaic Cells and Modules

Infrared-Temperature Sensors

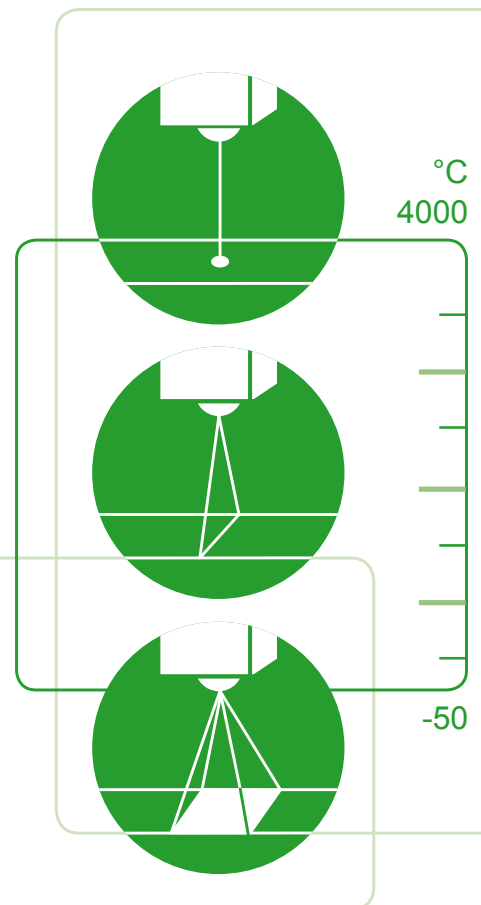
impac®

Thermal Imaging & Blackbodies

 **MIKRON®**

Controlling the production
process of:

Ingots & Wafers
Photovoltaic Cells
Photovoltaic Modules



Improving solar cell quality and yield

The solar industry is an expanding market with ever growing demands on the quality and performance of its products. Producers of solar cells are pushing to reduce the cost of solar energy to the level of traditional energy sources.

Reducing PV cost/watt by improving product performance and by increasing production throughput is a constant industry demand. Temperature measurement quality is decisive in improving process control and optimization enabling producers to meet tighter tolerances. Temperature measurement quality is therefore decisive in improving process control and optimization, as is adhering to ever tighter tolerances.

With over 50 years of experience, we offer you two product lines of non-contact temperature sensors which have already been successful with manufacturers for over 10 years.

impac[®] for pyrometry.

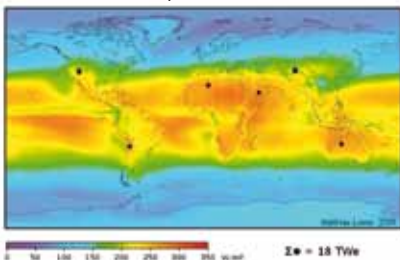
MIKRON[®] for thermography.

Our measurement instruments are suitable for virtually every step in the manufacturing of solar cells.

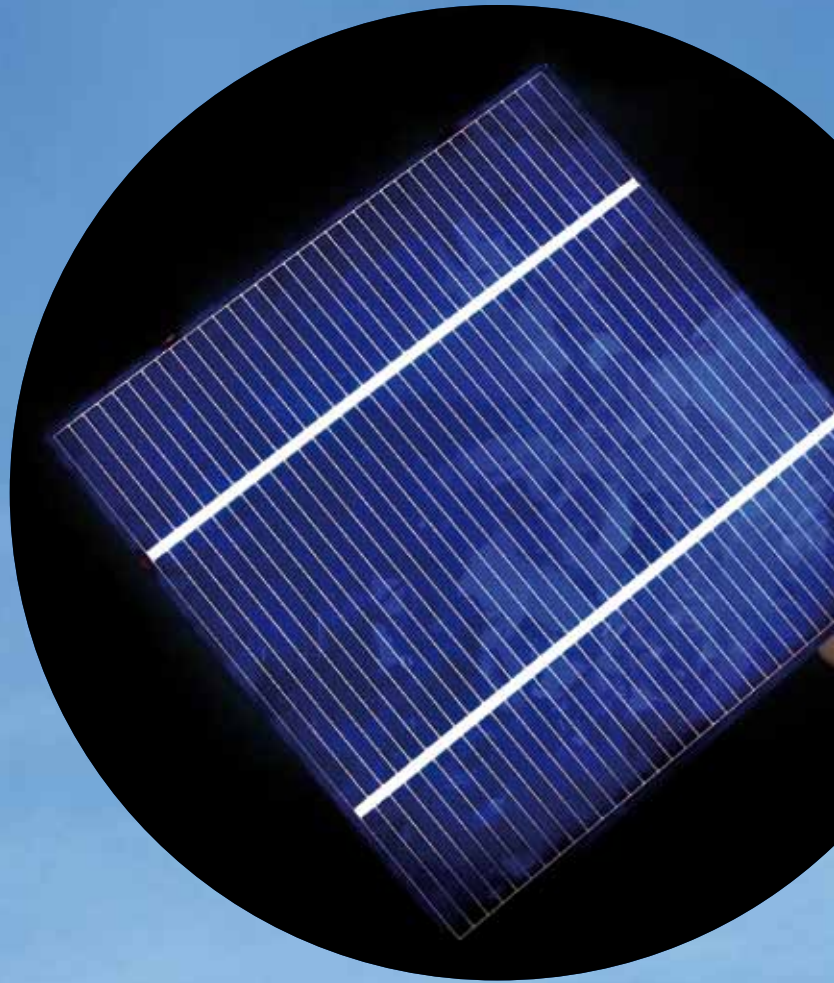
We know how critical the precise temperature measurement is to the production of solar cells, and we offer you:

- Long standing experience with solar applications.
- A broad product range of high quality instruments for non-contact temperature measurement.
- Extensive consultation to solve your individual measurement task.
- Worldwide support on site via our network of LumaSense offices, subsidiaries and sales representations.

Solar irradiance map



Source: www.ez2c.de/ml/solar_land_area





Our Solutions

... stand for rugged, modern and reliable technologies. We have more than 50 years of experience integrating temperature measurement sensors into production processes.



Our Solutions

... contain detailed knowledge of your specific requirements. LumaSense Technologies understands your challenges and works with you to overcome them.



Our Solutions

... include first class support and consultation. Our global experience enables manufacturers to quickly improve their process control and avoid unproductive iterations.

How can we help you?



Monocrystalline, Polycrystalline and Thin Film Cells for the Solar Industry

The IMPAC and MIKRON product lines provide non-contact temperature measurement for process control for the production of monocrystalline, polycrystalline and thin film cells.

Our wide product range in infrared temperature measurement enables both an improvement in product quality as well as a more effective process control for all current manufacturing processes in the solar industry.

The figures below illustrate the possible uses of our products. Due to our large selection of measurement instruments for varying applications we can deliver the optimum solution for your measurement task.



Fig. 1 : Polycrystalline Casting (Vacuum Melting Furnace)

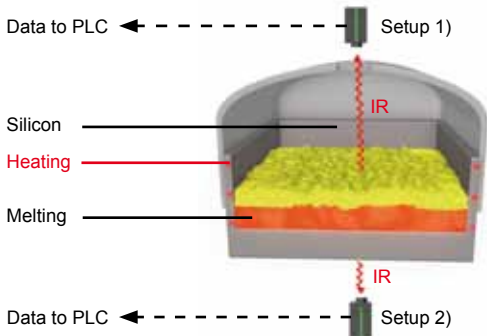


Fig. 2 : CVD Reactor (SIEMENS Process)

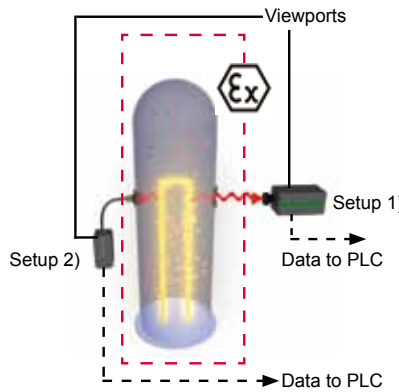
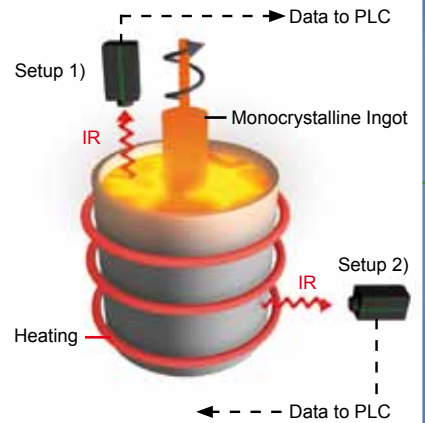


Fig. 3 : Monocrystalline Silicon (Czochralski Process)



Process Step Polycrystalline Casting (Fig. 1)

Process Task Meticulous control during solidification of the molten silicon into the polycrystalline silicon cast is critical to achieve the desired crystal size and homogeneity.

IMPAC/MIKRON-Solution Highly accurate 2-color ratio infrared thermometer with optional video output for fast and reoccurring temperature measurements.
Setup 1) Measuring the melt temperature **Ref.*: Series 5**
Setup 2) Controll heat output **Ref.*: Series 5**

Customer Benefits Best possible temperature readings for material crystallization. Optimum process monitoring based on fully digital sensor architecture.

Silicon Ingot Growth "CVD / Siemens Process" (Fig. 2)

Temperature of deposition surfaces must be measured precisely to control growth process and uniformity of growth inside reactor.

Very stable 2-color infrared thermometers in an explosion proof housing for process safety.
Setup 1) For easy accessible objects **Ref.*: Series 770 incl. explosion proof package**
Setup 2) For difficult accessible objects **Ref.*: Series 50**

Excellent and fast silicon temperature measurement combined with process safety. Restricted mechanical sensor integration solved by robust fibre optics.

Silicon Crystal Pulling "Czochralski Process" (Fig. 3)

1) Determine silicon melt temperature and assure correct crystallization process.
2) Control of heating system to optimize energy efficiency and crystallization process.

Highly accurate narrowband or 2-color infrared thermometer with video output for fast temperature measurement.
Setup 1) Measurement of melt temperature **Ref.*: Series 5**
Reliable and easy to integrate infrared thermometer for temperature monitoring and PLC control.
Setup 2) Control of heating system **Ref.*: Series 200**

Best possible temperature readings for material crystallization. Perfect application monitoring based on fully digital sensor architecture.
Fast non-contact temperature control of the heating system.
Compact, best price sensor for excellent device integration.

Steps in Photovoltaic Manufacturing

PV Module Production

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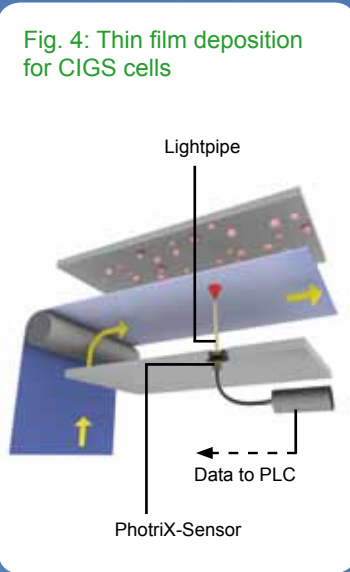


Fig. 4: Thin film deposition for CIGS cells

Thin film deposition for CIGS cells (Fig. 4)

Control of the correct material composition in the deposit layer based on temperature parameters.

Provide accurate, non-contact temperature measurement of shiny, low emissivity metal, such as stainless steel, or polymers webs on which the material is deposited.

Ref.*: Series PhotriX for metals. Series 5 and Series 140 for polymers.

Enable measurement and control of temperature on low emissivity materials.

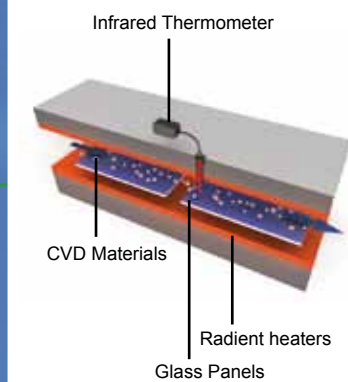
Continuously assure product quality & process stability.

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PV Cells

Fig. 5: Thin film deposition



Thin film deposition for CdTe cells (Fig. 5)

Accurately measure and control temperature during deposition onto glass substrates. Process must be repeatable in vacuum reactor and support high-volume production.

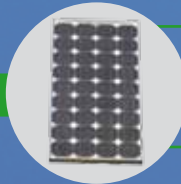
Infrared thermometer and integration accessories (windows and vacuum flanges) designed for and proven in glass measurements.

Ref.*: Series 200 or Series 5 or Series 140

Produce consistent quality and desired film quality by leveraging production proven solutions from the glass industry.

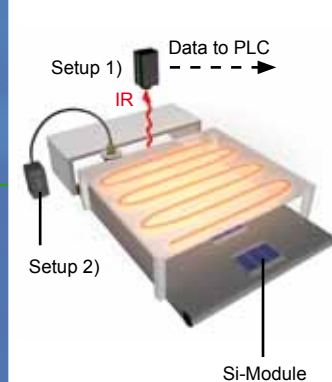
PV Module Connection

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Modules

Fig. 6: Soldering



Soldering by radiant heating (Fig. 6)

Reduce cycle times and minimize thermal exposure of the photovoltaic cell.

Deliver standard infrared thermometer and excellent PID controller package to assure fast feedback loop control.

Setup 1) For objects which are easy to access.

Ref.*: Series 140 with PI 6000 controller

Setup 2) For objects which are difficult to access.

Ref.*: Series 140 with fibre optics and PI 6000 controller

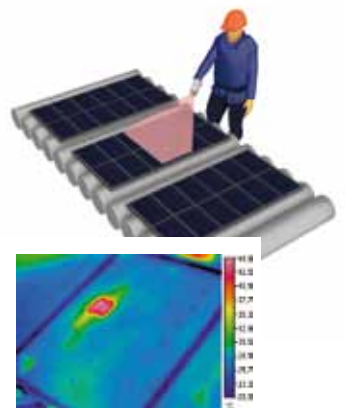
Fast and automatic control of process. Tuned application package with essential PID controller from single source supplier.

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Systems

Fig. 7: Quality control of packaged modules



Heat image

Quality control of packaged modules (Fig. 7)

Assure best possible module functionality prior to shipment.

Deliver portable thermal imaging unit for in-field checks.

Ref.*: Thermal Imaging

Supply thermal imaging components and system packages for online process control.

Ref.*: Thermal Imaging

Prompt and easy recognition of defective modules to improve quality management.

Uncooled measurement systems with appropriate functionality.

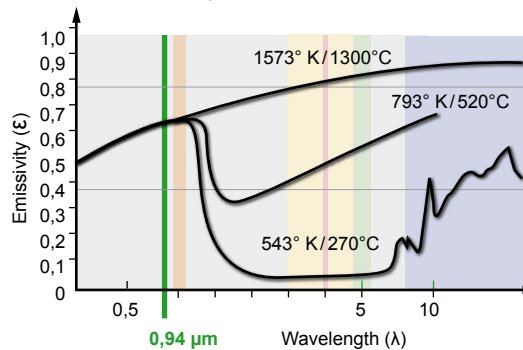
Wide variety of thermal imagers with protective enclosures.

**see product details at the end of brochure*

Product examples

Our products offer literally hundreds of different non-contact temperature measurement instruments for almost all industrial applications. Through our long standing experience in the field we have developed a wide portfolio of high quality products for the solar industry.

Silicon emissivity over infrared spectrum



The "silicon" wavelength: 0.94 μm

Silicon is one of the most difficult materials for non-contact temperature measurements. Not only the emissivity curve strongly varies over the infrared spectrum, also each curve intensity depends on the silicon temperature.

To achieve highly repeatable temperature readings, IMPAC sensors interpret 0.94 μm narrow-bandpass filters and calibrate them into the device.

At this particular wavelength the emissivity of silicon is constantly high and independent of the material temperature.



Series 5

2-color ratio infrared thermometer for emissivity independent temperature measurement

- Temperature Ranges: 600 ... 3000°C
- Wavelength: 0.97 μm and 1.05 μm
- Exposure Time (t_{90}): < 10 ms
- Target sighting by built in laser targeting, through lens sighting or video camera



Series PhotriX

Most accurate short wavelength infrared thermometer with unmatched low temperature capability

- Temperature Ranges: 30 ... 2400°C
- Wavelength: 0.7 ... 1.65 μm
- Response Time(t_{90}): 1 μs
- Lens, fiber optics and/or sapphire lightpipe



Series 200 / Series 300

Compact loop wired process sensor with linear 4 ... 20 mA output

- Temperature Ranges: 650 ... 2500°C
- Wavelength: 0.8 ... 1.1 μm
- Response Time(t_{90}): 10 ms
- Sighting: LED targeting light



Series 140

Highly accurate and fast unit for objects which are difficult to access

- Temperature Ranges: 100 ... 750°C
- Wavelength: 2 ... 2.6 μm
- Exposure Time (t_{90}): 1.5 ms
- Fiber optics with laser targeting



Series 770 incl. explosion proof package Highly stable 2-color infrared thermometer with beam-splitter architecture.

- Temperature Ranges: 750 ... 2000°C
- Wavelength: 2 ... 2.6 μm
- Response Time(t_{90}): 7.5 ms
- incl. adapted optics



Series 50

Universal temperature unit for small spot sizes.

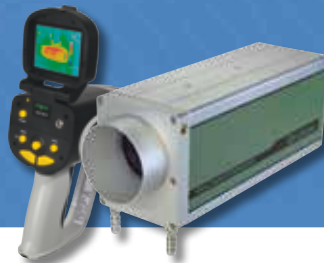
- Temperature Ranges: 400 ... 1300°C
- Wavelength: 0.94 μm
- Exposure Time (t_{90}): < 1 ms
- Fiber optics with spot sizes from 0.45 mm incl. laser targeting



Series KLEIBER Highspeed

Ultra high-speed sensor with built-in laser filter for small objects

- Temperature Ranges: 160 ... 1000°C
- Wavelength: 1.58 ... 2.5 μm
- Response Time(t_{90}): 6 μs
- LED targeting light



Thermal Imaging

Portable inspection unit for in-field optimization or process cameras for quality control purposes

- Temperature Ranges: - 40 ... 500°C optional up to 3000°C
- Wavelength: Depending on application
- Frame rate: 5 ... 60 Hz
- Reporting software or online control packages



PI 6000 controller

Simple PID controller for digital infrared thermometer with easy, guided setup

- Programmable via PC software
- Sampling time: 250 μs
- Automatic PI self optimising
- 9 individual controlling programs storable



Our contribution to your success



Global presence – local strength

Our representatives located around the globe and our branch offices in key regions respond directly to your business needs in local languages.

Telephone support and on-site service by our field application engineers ensure the implementation of successful measurement solutions.



Expertise through experience

As a leading company in infrared temperature measurement with decades of tradition and expertise, our solutions deliver added value to our customers' success.

Highly qualified employees, together with state-of-the-art technologies guarantee highest possible product quality.



Total solutions from one company

We use extensive existing know-how to develop new, innovative products and solution packages for almost any industry.

We offer comprehensive all-in-one temperature measurement solutions for a wide variety of photovoltaic production steps.



Comprehensive customer support

We are at your side with comprehensive service, starting from your initial enquiry right through to installation and aftercare of your IMPAC or MIKRON products.

Our detailed consultation is part of our success and yours.

Company Information



LumaSense Technologies is a global provider of temperature and gas sensing solutions to clean technology, energy, industrial and medical markets. We design, manufacture and market sensors for industry, research and original equipment manufacturers (OEMs). A common technology theme in our sensors is the use of infrared (IR) light to provide robust, accurate sensors for demanding environments, applications and customers.

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Specifications and content are subject to change without notice.

TEMPERATURE MEASUREMENT



Infrared Thermometry

Non-contact measurement of temperatures from -50 to 4000 °C for precise measurement of industrial and research targets. Impac offers the world's broadest product line with specific wavelengths for many applications, software for integration, and protective enclosures for mounting in harsh industrial environments. www.impacinfrared.com



Thermal Imaging & Blackbodies

Fixed-installation and portable thermal imaging solutions for process control, diagnosis and remote monitoring applications. Mikron thermal imagers offer full system solutions with realtime process control software, I/Os, and robust protection and mounting hardware. www.mikroninfrared.com



Explosion-proof Refinery Sensors

Extremely robust infrared sensors for temperature measurement in refinery applications, such as sulfur recovery units, and flare monitoring. www.mikroninfrared.com



Fiber-optic Temperature Measurement

Non-metallic temperature sensors for accurate contact measurement in harsh environments from -100 to 330 °C. Luxtron sensors are ideal for high-voltage power equipment, RF and MRI medical application, and industrial processes using RF, microwave, and voltage bias. www.lumasenseinc.com

GAS ANALYSIS



Gas Monitoring

Highly precise gas concentration monitors for PPB level measurements in research, process control and environmental monitoring using photoacoustic spectroscopy technology. www.lumasense.dk



OEM Gas Sensing

Non-dispersive infrared (NDIR) and dispersive infrared (DIR) gas benches for concentration measurements in OEM devices in environmental, automotive and medical markets. www.lumasenseinc.com

