VisiSens™ – 2D Mapping of Oxygen, pH & CO₂

- 2D read-out of luminescent sensor foils
- Contactless direct sensing or through transparent walls
- Visualize spatial and temporal analyte gradients
- Numerous measurement points in one image

www.PreSens.de/imaging
VisiSens™ – 2D Mapping of Oxygen, pH & CO₂
Functional Principle
We bring to light what’s inside...

Products Made in Germany

PreSens offers a broad range of sensor systems for end users in Bioprocess Control, Biological & Environmental Research, the Food & Beverage industry as well as other industrial applications.

We offer systems for
- Oxygen measurement in gases and liquids
- Non-invasive online pH, CO₂ and oxygen measurement
- Oxygen and pH sensors for single-use bioreactors
- Microsensors pH, oxygen and CO₂
- Process control in shake flasks incl. biomass monitoring
- Low-maintenance DO measurement for fermentation and bioreactor systems
- Online oxygen and pH measurement in disposables like multiwell plates and plastic bags
- Imaging solutions for 2D-mapping of oxygen-, pH-, and CO₂-distribution

Our product range is constantly expanding.

Company Profile

Based on research activities started in the 1980’s PreSens Precision Sensing GmbH was founded in 1997 as a spin-off from the University of Regensburg, Germany.

The company combines long-time experiences of different researchers in the fields of electronic engineering and sensor development. Right from the beginning, microsensor systems were sold to customers in life sciences. Already in its first decade of operation PreSens became one of the leading companies in the field of chemical optical sensor technology. Together with its partners it offers full service in Europe, America and Asia.

Service

Furthermore, we are developers and manufacturers of optoelectronic OEM sensor components for companies in the field of medical equipment and process control.

Is your application missing? Contact us and we find your customized solution!
...and work for the following industries.

Biotech & Pharma
Our Biotech & Pharma business field helps pharmaceutical companies such as Roche and DSM to improve their bioprocess development with PreSens sensors. With two decades of customer feedback our product development provides efficient solutions for your needs.

Food & Beverage
A cooperation with the market leader for beverage filling systems, Krones AG, Neutraubling, triggered our Food & Beverage business field in the late 1990’s. PreSens supplies sensors for checking the oxygen-tightness of packaging and special systems for determining the penetrability of oxygen in PET bottles at companies such as Nestlé, Heineken or Danisco.

Biology & Environmental
Our worldwide customer base in biological & environmental research has now grown to hundreds of users coming from the University of Alaska in Anchorage to the University of Wellington in New Zealand. For more than two decades we have delivered special sensor systems for various applications such as respirometry, or environmental monitoring.

Medical Research & Life Sciences
Our most recent business field arose from a cooperation with renowned medical technology manufacturers from the medical devices sector. PreSens supplies OEM parts, which are integrated into more complex medical systems. Microsensors, sensor spots, and imaging systems are applied in tissue engineering, microfluidics, and many other medical research fields.

Industry & Technical Applications
Robust probes with excellent long-term stability or sensors for contactless measurement find use in technical or industrial applications. Specially designed flow-through connectors for integration in pipes are already applied to monitor the oxygen content in liquids or gases. OEM sensor components can be designed to be integrated in customer systems.

Brewery
Bottling
Quality Control
Life Science Research
Surgery
Patient Care
QC
Fluorescent sensor foils combined with 2D read-out technology allow visualization of O₂, pH or CO₂ distributions in heterogeneous samples. For measurement, the sample surface is covered with the sensor foil, which translates the analyte content into a light signal. The sensor response is recorded pixel by pixel with a digital camera. With VisiSens™ spatial and temporal analyte changes can be monitored. VisiSens™ gives an overview over your sample area and allows you to freely choose the region of interest for investigation of spatial and temporal gradients.

- Read-out of O₂, pH or CO₂ sensor foils
- More than 100,000 measurement points within one recorded image
- USB-powered portable microscope detector unit
- Small to medium size field of view (2.1 mm² to 10.8 cm²)
- Image processing and evaluation software included
- Detect and quantify analyte hotspots
- Visualize spatial and temporal gradients
- Time-lapse analyte movies
Examples for Applications

O₂, pH and CO₂ Mapping in Sediments

O₂, pH, and CO₂ are key factors for microbial activity and various geochemical processes in sediments. They highly vary locally, e.g. at interfaces or different depths. Spatial and temporal analyte dynamics over long time periods can be visualized. Various regions can be compared within one measurement. VisiSens™ enables non-invasive 2D-mapping over cross-sections or on sample surfaces. The portable device can be used in lab and field.

Spatial and Temporal Analyte Changes in Plants and Soil

O₂, pH and CO₂ play a crucial role in plant and soil processes, e.g. in photosynthesis, respiration, in rhizospheres or in microbiological processes. Metabolic processes can be monitored. This planar optical sensor technique allows non-invasive read-out through glass walls of rhizotrons. Studying metabolic activity of roots and determining the cultivation optimum is important for sustainable agriculture, e.g. for adjustment of water and fertilizer supply.

O₂ or pH in Cell Culture and Engineered Tissue

Cellular metabolism critically depends on local O₂ supply and pH values. Especially in 2D and 3D cell culture or engineered tissue, cells located in diffusion limited regions [e.g. in scaffolds or spheroids] can be subject to low oxygen levels and pH changes. Non-invasive, continuous 2D-mapping can be performed directly in the incubator under growth conditions. Furthermore, 2D analyte distributions in living samples can be visualized.

Non-invasive 2D Analyte Mapping in Microfluidics

VisiSens™ enables 2D visualization of important culture parameters inside microfluidic chips. You can continuously monitor in 2D, with high resolution at specific positions or over the whole chip surface in a non-contact read-out mode. Detect metabolic hotspots, record time-series, and monitor hypoxia, cellular growth, or O₂ supply inside the chip. You can gain new insights on metabolic activity and natural or artificially produced gradients.
**VisiSens™ – 2D Mapping of Oxygen, pH & CO₂**

**SPECS**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 O₂</td>
<td>0-100% a.s.</td>
<td>(0-20.9% O₂)</td>
</tr>
<tr>
<td>A2 pH</td>
<td>2.5 - 4.5</td>
<td>5.5 - 7.5</td>
</tr>
<tr>
<td>A3 pCO₂</td>
<td>0 - 1%</td>
<td>1 - 25%</td>
</tr>
</tbody>
</table>

**SET-UP**

- **Software**
  - Manual or automated picture capturing
  - Calibration
  - Image processing
  - Pseudocolor analyte maps
  - Time-lapse
  - Free choice of ROI

**EXEMPLARY RESULTS**

- **2D Read-Out**
- **Time Series**
- **Multiple ROI**
- **Gradients**

**VisiSens™ Detector Units**

The handheld cameras are the detectors to read out the fluorescent O₂, pH or CO₂ sensor foils. They are connected to a computer or laptop by USB. A focus control allows for various fields of view from microscopic to 3.6 x 3.0 cm².

**Sensor Foils**

The sensor foil can be attached directly on the sample or behind a transparent vessel wall. A sensor film translates the analyte content into a light signal. Foils are available for O₂, pH or CO₂. They can be cut in any desired size or shape.

**VisiSens™ AnalytiCal Software**

All VisiSens™ software uses the same user interface. They allow for controlling the image recording process and storage, and assist image processing and evaluation. Acquired images can be single images or automatically recorded time series.

**Adapter Tubes**

Tubes in different sizes can be attached to the VisiSens™ detector units to enable standardized measurement conditions, avoid ambient light coming from the sides and work at fixed fields of view.

*Is your application missing? Contact us and we find your customized solution!*
## Specifications

<table>
<thead>
<tr>
<th></th>
<th>Oxygen (blue)</th>
<th>pH (red)</th>
<th>CO₂ (green)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SF-RPSu4</td>
<td>SF-LV1R</td>
<td>SF-HP5R</td>
</tr>
<tr>
<td><strong>Specifications</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Measurement range</td>
<td>0 - 100 % air saturation (0 - 20.9 % O₂)</td>
<td>pH 2.5 - 4.5</td>
<td>pH 5.5 - 7.5</td>
</tr>
<tr>
<td>Response time (t&lt;sub&gt;90&lt;/sub&gt;)**</td>
<td>Gas phase: &lt; 8 sec.</td>
<td>&lt; 30 sec.</td>
<td>&lt; 30 sec.</td>
</tr>
<tr>
<td>Size of sensor foil***</td>
<td>40 x 40 mm&lt;sup&gt;2&lt;/sup&gt; to 100 x 150 mm&lt;sup&gt;2&lt;/sup&gt;</td>
<td>40 x 40 mm&lt;sup&gt;2&lt;/sup&gt; to 100 x 100 mm&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Number of sensing points within one image**</td>
<td>300,000</td>
<td></td>
<td></td>
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<tr>
<td>Measurement temperature range</td>
<td>From + 5 °C to + 45 °C</td>
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<td></td>
</tr>
<tr>
<td><strong>Properties</strong></td>
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<td></td>
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</tr>
<tr>
<td>Compatibility</td>
<td>Aqueous solutions, ethanol (max. 70 % v/v), methanol (max. 10 % v/v), pH 2 - 10</td>
<td>Aqueous solutions, pH 2 - 9, ethanol (max. 10 % v/v)</td>
<td>Aqueous solutions, pH 2 - 9, ethanol (max. 10 % v/v), pH 4 - 9</td>
</tr>
</tbody>
</table>

### Device

- **Camera chip**: Enhanced Color CMOS
- **Image resolution**: 1.3 megapixel (1280 x 1024 pixels)
- **Magnification**: 10-fold to 220-fold, depending on adapter tube used
- **Field of view**: ~ 1.6 x 1.3 mm<sup>2</sup> to ~ 3.6 x 3.0 cm<sup>2</sup>; typically ~ 1.2 x 1.0 cm<sup>2</sup>
- **Output**: 15 fps live video preview [no storage] and 0.5 fps full-resolution picture storage [png]
- **Number of LEDs**: 8
- **Dimensions**: Length 10 cm, diameter 3.8 cm
- **Material**: ABS housing, All-aluminum housing
- **Digital interface**: USB 2.0, high speed USB transmission

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*VisiSens™ is no approved medical device

**Typical data which may strongly differ with adapting the imaging set-up to specific needs

*** Standard product size; sensor foils can be cut with e.g. scissors into desired size or shape
VisiSens™ TD – Modular O$_2$, pH and CO$_2$ Mapping System

2D Contactless Read-out System for High Resolution, Large Area, Multi-parameter or Multi-spot Sensing of O$_2$, pH and CO$_2$

VisiSens™ TD enables simultaneous 2D read-out of optical O$_2$, pH and CO$_2$ sensor foils within one set-up. Planar sensors for one or more analytes are placed on the sample area or in different cavities and the fluorescent sensor signals are read out pixel by pixel with a camera. Fields of view from mm$^2$ up to 30 cm x 25 cm are possible. VisiSens™ TD gives an overview over your sample area and allows to freely choose the region of interest for investigation of spatial and temporal gradients or simultaneous read-out of multiple sensor signals. The modular system can be customized according to the user’s requirements.

- Three analytes – one system
- Read-out of oxygen, pH and CO$_2$ sensor foils
- Multiple sensor types combinable in one field of view
- Variable sensor and measurement geometry
- No analyte consumption or electric potential
- Read-out through transparent vessel walls
- Customized 2D sensor systems
- 12-bit detector
- Adaptable field of view, microscopic, 6 x 4 cm$^2$ or up to 30 x 25 cm$^2$
- Single- and multi-analyte operation modes
- Time-lapse slide shows of recordings

Is your application missing? Contact us and we find your customized solution!
Examples for Applications

Visualizing Analytes over Large Sample Surfaces
The VisiSens™ TD images large areas and gathers information on spatial and temporal analyte changes, e.g., in large scale pH and CO₂ imaging of root-soil interactions within rhizotrons or while analyzing biogeochemical processes in sediments. It is also well suited for applications in sensitive processes, e.g., metabolic activity of living samples or tissue engineering, where O₂ gradients over a cross section of a 3D graft can be monitored.

Multi-sample and Multi-sensor Read-out
Large fields of view enable analyte value recording in multiple samples simultaneously with free choice of measurement geometry. Even different sensor ranges can be combined. The fluorescent sensor foils can be mounted at the bottom of transparent vessels, plates or vials containing different samples and placed next to each other, e.g., in a small rack. One image taken from the bottom contains the information on analyte concentrations in a group of samples.

Three Different Analytes with one Device
The modular set-up is applicable for imaging oxygen, pH, and CO₂ sensor foils with one system and in one field of view. It visualizes spatial and temporal changes of analyte concentrations. The combined information on distributions of several analytes can give valuable insight in metabolic activity or chemical processes inside samples, e.g., when investigating complex processes in cell culture, or tissues, in root systems, or when phenotyping crop plants.

Microscopic Analyte Imaging – TD MIC Configuration
VisiSens™ TD can be equipped with microscope optics for measuring analyte gradients with very high spatial resolution. The VisiSens™ TD MIC can be used, e.g., to monitor spatial and temporal changes of O₂ of cross-sections of multicellular tumor spheroids. The system is compact and fits into an incubator to monitor analyte changes under cell culture conditions over days.
VisiSens™ – 2D Mapping of Oxygen, pH & CO₂

**SPECS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
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<tbody>
<tr>
<td>O₂</td>
<td>0 - 100% a.s.</td>
</tr>
<tr>
<td>pH</td>
<td>2.5 - 4.5</td>
</tr>
<tr>
<td>pCO₂</td>
<td>0 - 1%</td>
</tr>
</tbody>
</table>

**MODULAR SET-UP**

- Variable Field of View
- Multi-sensor Set-up
- Multi-analyte Set-up
- Sensor Array

**APPLICATION**

- **VisiSens™ TD Basic System**
  - The basic imaging device consists of a 12-bit detector with integrated light sources and mode operation units. It is prepared for reading out O₂, pH and CO₂ sensor foils, even simultaneously in one experiment. The modular concept allows to choose the modalities that are required for the specific application.

- **Sensor Foils**
  - Sensor foils for O₂, pH and CO₂ in different measurement ranges are available in up to 15 x 10 cm² size. They are placed directly on the sample or inside transparent vessels and read out contactless. A sensitive layer converts the analyte content into a light signal.

- **VisiSens™ Scientifical Software**
  - VisiSens™ TD includes a modular control and evaluation software. One can choose between different operation modes from single- to multi-analyte modes. Snapshots or automatic time series recordings are possible.

- **Customized VisiSens™ TD**
  - VisiSens™ TD offers a broad range of possible modifications with different lenses, light sources, and operation modes. Various accessories allow to further customize the system according to the specific experimental needs.

Is your application missing? Contact us and we find your customized solution!
Specifications

**Oxygen (blue)**

<table>
<thead>
<tr>
<th>SF-RPSu4</th>
<th>SF-LV1R</th>
<th>SF-HPSR</th>
<th>SF-CD2R*</th>
<th>SF-CD1R</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specifications</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measurement range</td>
<td>0 - 100 % air saturation</td>
<td>pH 2.5 - 4.5</td>
<td>pH 5.5 - 7.5</td>
<td>0 - 1 % pCO₂ at atmospheric pressure</td>
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<tr>
<td></td>
<td>[0 - 20.9 % O₂]</td>
<td></td>
<td></td>
<td>(1013.15 hPa)</td>
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<tr>
<td>Response time (t₉₀)**</td>
<td>Gas phase: &lt; 8 sec.</td>
<td>&lt; 30 sec.</td>
<td>&lt; 30 sec.</td>
<td>&lt; 3 min.</td>
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<tr>
<td>Limit of detection***</td>
<td>0.03 % air saturation</td>
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<tr>
<td>Precision (temporal)****</td>
<td>± 0.02 % air saturation at 0 % air saturation</td>
<td>± 0.01 pH at pH 4</td>
<td>± 0.01 pH at pH 7</td>
<td>± 0.02 % CO₂ at 0.15 % CO₂</td>
</tr>
<tr>
<td></td>
<td>± 0.1 % air saturation at 100 % air saturation</td>
<td></td>
<td></td>
<td>± 0.01 % CO₂ at 0.8 % CO₂</td>
</tr>
<tr>
<td>Precision (spatial)*****</td>
<td>± 1.5 % air saturation at 0 % air saturation</td>
<td>± 0.1 pH at pH 4</td>
<td>± 0.1 pH at pH 7</td>
<td>± 0.08 % CO₂ at 0.15 % CO₂</td>
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<tr>
<td></td>
<td>± 3 % air saturation at 100 % air saturation</td>
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<td>± 0.08 % CO₂ at 0.8 % CO₂</td>
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<tr>
<td><strong>Properties</strong></td>
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<tr>
<td>Compatibility</td>
<td>Aqueous solutions, ethanol [max. 70 % v/v], methanol [max. 10 % v/v], pH 2 - 10</td>
<td>Aqueous solutions, pH 2 - 9 ethanol [max. 10 % v/v]</td>
<td>Aqueous solutions, pH 4 - 9 ethanol [max. 10 % v/v]</td>
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<tr>
<td>General sensor temperature working range</td>
<td>from + 5 °C to + 45 °C</td>
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<tr>
<td><strong>System Components</strong></td>
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<tr>
<td>Hardware</td>
<td>O₂</td>
<td>pH</td>
<td>CO₂</td>
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<tr>
<td>VisiSens TD Basic System*</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Big Area Imaging kit*</td>
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<td>x</td>
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<td>TD MIC Configuration*</td>
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<td>VisiSens ScientifiCal*</td>
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<tr>
<td>Imaging Modality O₂*</td>
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<tr>
<td>Imaging Modality pH*</td>
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<td>Imaging Modality CO₂*</td>
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<td>Mixed dual or triple modes*</td>
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<td>SF-RPSu4</td>
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<td>SF-LV1R</td>
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<td>SF-CD1R</td>
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<td>SF-CD2R*</td>
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<td>Mounting Rack*</td>
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<td>Sensor Plate Tubus Adapter*</td>
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<td>Resolution Test Chart*</td>
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<tr>
<td>Plates with Integrated Sensor Foils*</td>
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</tbody>
</table>

* Prototype component; please contact our service team!

** Typical data which may strongly differ with adapting the imaging set-up to specific needs

*** Typical data of LOD of a defined ROI (> 6,000 pixels) over time in dark lab conditions at 20 °C, FoV 8 cm x 6 cm

**** Typical data of temporal variation in a defined ROI (> 6,000 pixels) over time in dark lab conditions at 20 °C, FoV 8 cm x 6 cm

***** Typical data of spatial standard deviation in defined ROI (> 6,000 pixels) in dark lab conditions at 20 °C, FoV 8 cm x 6 cm
## Product Matrix

<table>
<thead>
<tr>
<th>Sensor (p. 15-16)</th>
<th>DU01</th>
<th>DU02</th>
<th>DU03</th>
<th>O₂</th>
<th>pH</th>
<th>CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF-RPSu4</td>
<td>x</td>
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<td>SF-HPSR</td>
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<td>SF-LV1R</td>
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<td>SF-CD1R</td>
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<td>SF-CD2R</td>
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<td>Self-adhesive Sensor Foils</td>
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### Hardware (p. 17-18)

<table>
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<tr>
<th>Hardware</th>
<th>DU01</th>
<th>DU02</th>
<th>DU03</th>
<th>O₂</th>
<th>pH</th>
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<tbody>
<tr>
<td>VisiSens TD Basic System</td>
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<td>VisiSens TD Big Area Imaging Kit</td>
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<td>TD Micro-Configuration</td>
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### Software (p. 15-17)

<table>
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<th>pH</th>
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### Accessories (optional)

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<th>Accessories</th>
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Product Range

VisiSens™ Oxygen

Detector Unit DU01
USB powered and portable 2D detection device for oxygen imaging

Oxygen Sensor Foil SF-RPSu4
Fluorescent sensor foil for oxygen imaging from 0 – 100 % air saturation

Software VisiSens™
AnalytiCal 1
Software for measurement control and evaluation of oxygen images

VisiSens™ pH

Detector Unit DU02
2D read-out device for pH sensor foils

pH Sensor Foil SF-HP5R
Fluorescent sensor foil for measurements in a range of 5.5 – 7.5 pH

Software VisiSens™
AnalytiCal 2
Software for measurement control and evaluation of pH images

CaliPlate for SF-HP5R
Calibration helper; 10-well plate equipped with pH sensor foil SF-HP5R

pH Sensor Foil SF-LV1R
Fluorescent sensor foil for measurements in low pH range from 2.5 – 4.5 pH

CaliPlate for SF-LV1R
Calibration helper; 10-well plate equipped with pH sensor foil SF-LV1R
VisiSens™ CO₂

Detector Unit DU03
USB powered and portable 2D detection device for CO₂ imaging

CO₂ Sensor Foil SF-CD1R
The CO₂ sensor foil SF-CD1R has a measuring range of 1 – 25 % CO₂ and is suitable for measurements in liquids or samples with a constant relative humidity of 100 %.

CO₂ Sensor Foil SF-CD2R
This sensor foil is for measurements in low CO₂ range of 0 – 1 %; it is suitable for measurements in liquids or samples with a constant relative humidity of 100%.

Software VisiSens™ AnalytiCal 3
Software for measurement control and evaluation of CO₂ images

Accessories

Adapter Tube 1
Standard adapter tube that comes with the VisiSens™ detector units; typical field of view of ~ 12 x 10 mm²

Adapter Tube 2
Adapter tube for VisiSens™ detector units with typical field of view of ~ 1.7 x 1.3 mm²

Adapter Tube 4
Adapter tube for VisiSens™ detector units with typical field of view of ~ 36 x 30 mm²

VisiSens™ AnalytiCal 4 Software
Software for measurement control of up to three different VisiSens™ detector units

Is your application missing? Contact us and we find your customized solution!
VisiSens™ TD

VisiSens™ TD Basic System
Modular imaging detector unit that can be equipped with various imaging modalities for read-out of $O_2$, $pH$ or $CO_2$ sensor foils

Oxygen Sensor Foil SF-RPSu4
Fluorescent sensor foil for oxygen imaging from 0 – 100 % air saturation

VisiSens™ ScientifiCal Software
VisiSens™ TD Software for measurement control and evaluation of recorded data; the modular software offers various operation modes from single- to multi-analyte modes.

pH Sensor Foil SF-HP5R
Fluorescent sensor foil for measurements in a range of 5.5 – 7.5 pH

CaliPlate for SF-HP5R
Calibration helper; 10-well plate equipped with pH sensor foil SF-HP5R

pH Sensor Foil SF-LV1R
Fluorescent sensor foil for measurements in low pH range from 2.5 – 4.5 pH

CaliPlate for SF-LV1R
Calibration helper; 10-well plate equipped with pH sensor foil SF-LV1R

CO$_2$ Sensor Foil SF-CD1R
Fluorescent sensor foil SF-CD1R for the range of 1 – 25 % $CO_2$ suitable for measurements in liquids or samples with a constant relative humidity of 100%

www.PreSens.de/imaging
VisiSens™ – 2D Mapping of Oxygen, pH & CO₂

Is your application missing? Contact us and we find your customized solution!

CO₂ Sensor Foil SF-CD2R
Low CO₂ range (0 – 1 %) sensor foil; suitable for measurements in liquids or samples with a constant relative humidity of 100 %

Self-adhesive Sensor Foils
O₂ and pH sensor foils are also available with self-adhesive backside for easy sensor implementation

VisiSens TD Mounting Rack
Rack for mounting camera detector and light sources in various modifications

Big Area Light Sources
Mixed excitation light sources for read out of 8 x 6 cm² to a max of 30 x 25 cm² field of view

24-Well O₂ or pH Plates
24-well plates with integrated sensor foils for O₂ or pH; read-out of all wells in one image possible; beta-irradiation service offered.

96-Well O₂ or pH Plates
96-well microtiterplates with integrated sensor foils for O₂ or pH; read-out of all wells in one image possible; beta-irradiation service offered.

VisiSens™ TD MIC Modification
Optics and excitation light source for microscopic O₂ imaging
Notes
Discover the complete PreSens portfolio

Bring to light what’s inside.

PreSens comes from PRECISION SENSING and offers:

- precise and simple measurement of $O_2$, pH, CO$_2$ and biomass
- systems for Pharma, Biotech, Food & Beverage, Biological & Environmental Research, Technical or Industrial Applications and Medical Devices
- sensors thinner than a hair, non-invasive and online
- optimum advice and support
- more than 1,000 items in stock
- prompt delivery worldwide

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