

CONCENTRATION  
MONITORING OF  
FAB CHEMICALS IN  
CLEANROOM  
ENVIRONMENTS

**VAISALA**

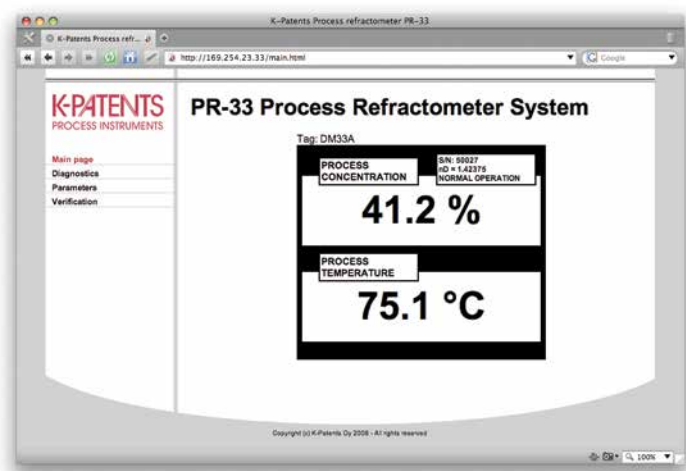


Vaisala K-PATENTS® Semicon Refractometer PR-33-S

# APPLICATIONS

The Semicon Refractometer PR-33-S monitors real-time the consistency of liquid chemical concentrations in the ultra-clean semiconductor fabrication processes and integrated process tools. Typical uses of the PR-33-S include:

- Preventing wrong chemicals or wrong concentrations from entering the process tool or the wet bench and thus helping to prevent expensive equipment damage and wafer scrap.
- Assisting in optimizing the etch process and in increasing the bath life of the etch solution.
- Increasing wafer throughput typically by up to 20%, and reducing cleaning chemical (e.g. EKC-265) consumption in the post etch polymer removal.
- Helping to achieve tight control of CMP slurries and better uniformity of the planarization process.



# MONITORED CHEMICALS

Acetic acid  $\text{CH}_3\text{COOH}$ , Acetone  $\text{CH}_3\text{COCH}_3$ , Ammonia  $\text{NH}_4\text{OH}$ , Ammonium fluoride  $\text{NH}_4\text{F}$ , Ammonium hydroxide  $\text{NH}_4\text{OH}$ , Ammonium sulphate  $(\text{NH}_4)_2\text{SO}_4$ , Citric acid  $\text{C}_6\text{H}_8\text{O}_7$ , Chromic acid  $\text{CrO}_3$ , Dilute Hydrofluoric acid DHF, Ferric chloride  $\text{FeCl}_2$ , Formic acid  $\text{HCO}_2\text{H}$ , Hydrofluoric acid HF, Hydrochloric acid HCl, Hydrogen peroxide  $\text{H}_2\text{O}_2$ , Isopropylalcohol IPA, Lactic acid  $\text{CH}_3\text{CHOHCOOH}$ , Magnesium chloride  $\text{MgCl}_2$ , Nickel chloride  $\text{NiCl}_2$ , Nitric acid  $\text{HNO}_3$ , Phosphoric acid  $\text{H}_3\text{PO}_4$ , Potassium hydroxide KOH, Sodium chloride NaCl, Sodium hydroxide NaOH, Sulphuric acid  $\text{H}_2\text{SO}_4$ , Tetramethyl-ammonium hydroxide TMAH  $(\text{CH}_3)_4\text{NOH}$ , etc.

Customized applications upon feasibility study.



Vaisala K-PATENTS® Semicon Refractometer PR-33-S

## REAL-TIME MONITORING

We are a company specialized in in-line liquid concentration measurements. We supply digital refractometers for thousands of industrial applications around the world.

The Semicon Refractometer PR-33-S is designed specifically for the cleanroom environments and integrated process tools in the semiconductor industry.

The PR-33-S monitors real-time the chemical concentrations and provides an Ethernet output signal and immediate feedback, if the chemical is not within the specifications. For example, low and high concentration alarms can be configured to increase bath life of costly chemicals and decrease the wafer scrap.

The concentration is determined by making an optical measurement of the solution's refractive index  $n_D$  and temperature. The advantage of this principle is that the same instrument can be used to measure any chemical.



Our extensive representative network offers technical support and field service in all industrialized countries worldwide.



No sampling or handling of hazardous chemicals in the laboratory. Better environmental performance and chemical waste management.

## DRIFT-FREE CALIBRATION

The PR-33-S has no calibration drift and needs no maintenance, adjustment or recalibration over time.

The sensor is factory calibrated to measure refractive index  $n_D$  and temperature  $T$  in standard units. Each sensor has identical calibration  $n_D=1.32...1.53$  (corresponding to 0-100% b.w.).

Because the sensors have identical calibration and each sensor gives Refractive Index  $n_D$  and temperature as output, the same instrument can monitor all kinds of liquid chemicals. Also all sensors can be freely interchanged without optical calibration or parameter changes.

Each sensor comes with a calibration certificate comparing a set of standard liquids to the actual sensor output. The calibration and accuracy can be easily verified on-site with certified refractive index liquids.



Fully digital instrument: No calibration drift and no maintenance, adjustment or recalibration over time.



Full measurement range  $n_D$  1.3200...1.5300 (equals to 0-100% by weight).



Accuracy is  $\pm 0.0002 n_D$  which corresponds typically to  $\pm 0.1\%$  by weight, e.g. for HCl in water.

## REMOTE FUNCTIONS

The PR-33-S consists of a Kynar® PVDF sensor and an Ethernet cable that any standard PoE switch can use for transmitting power to the sensor and data to a computer.

Via Ethernet it is easy to view real-time measurement data and diagnostics, and remotely alter instrument configuration settings without having to go to the cleanroom.



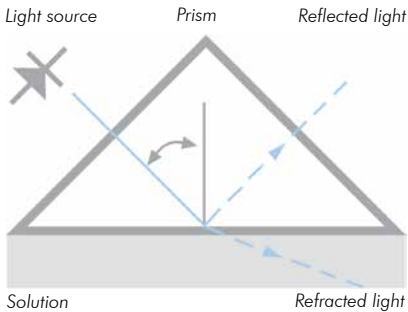
Any standard PoE switch can be used for transmitting power to the sensor and data to a computer.



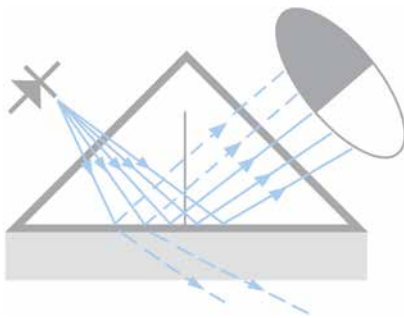
The communication is built on the standard UDP/IP protocols.

# DIGITAL MEASUREMENT PRINCIPLE

The light source sends light against the interface between the prism and the process solution, where the rays meet the surface at different angles.

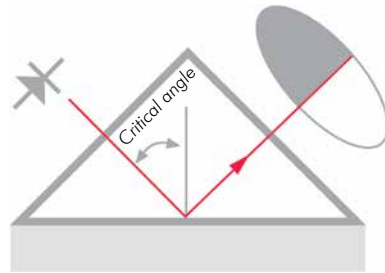


All rays coming to the surface below a certain angle, are totally reflected. The light coming to the surface at a higher angle is refracted into the process solution.



Thus an optical image with a dark sector and a light sector is created.

The angle corresponding to the shadow line is called the Critical Angle of Total Reflection. The Critical Angle is a function of the refractive index and hence the concentration of the solution.



A digital CCD-camera detects the optical image and the shadow line. The camera transforms the optical image point-by-point to an electrical signal. The exact shadow line position is located and converted to a reading in refractive index.

A built-in temperature sensor measures the temperature close to the interface of the process liquid. Then the refractive index and temperature are converted into concentration units.

A built-in diagnostics program ensures that the measurement is reliable.



The measurement is not influenced by particles, bubbles or impurities in the ppm range.



Fully automatic temperature compensation.

# SENSOR MOUNTING

Vertical line



Horizontal line

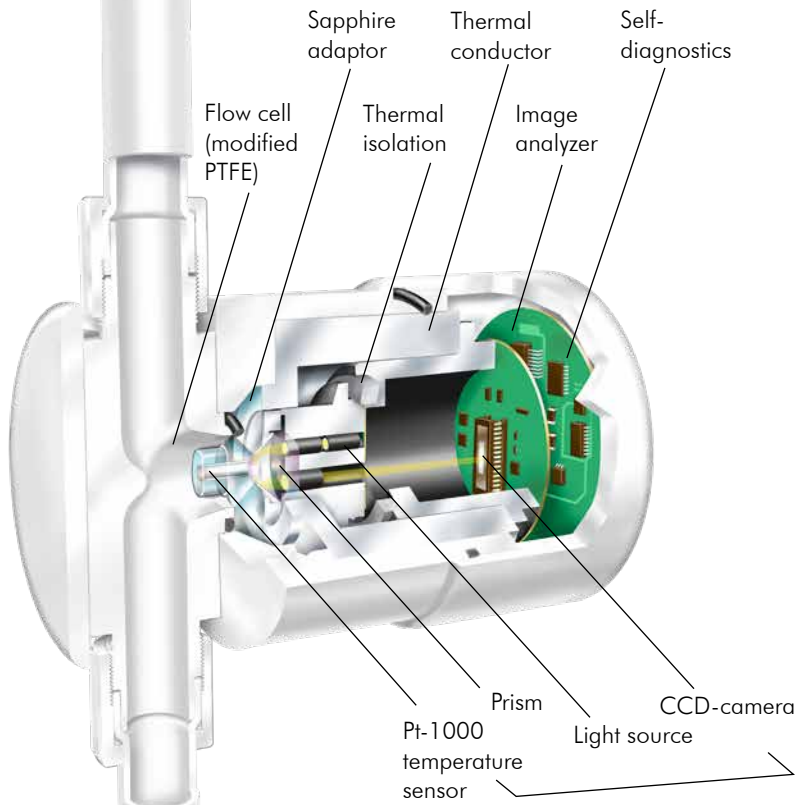


The PR-33-S has a compact metal-free construction that allows integration in a process tool or in an ultra-clean cabinet.



PR-33-S needs only a small footprint area.

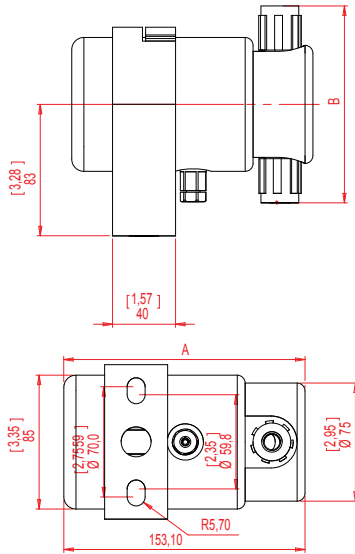
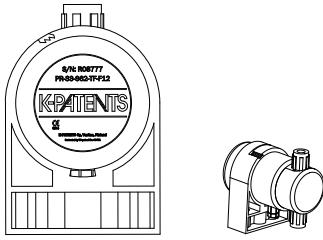
# DESIGN



The PR-33-S utilizes the CORE-optics (Compact Optical Rigid Element) module that is isolated from the sensor body. The integral probe type temperature sensor responds fast to the changes of the process liquid temperature. The CORE-optics protect the measuring components from any influence of pressure, flow or temperature changes.

# SPECIFICATIONS

SENSOR PR-33-S



Refractive Index range, standard:	Full range, $n_D = 1.3200 \dots 1.5300$ (corresponds to 0...100% b.w.), Sapphire H73 prism
Refractive Index range, option:	$n_D = 1.2600 \dots 1.4700$ , Sapphire H74 prism (for Hydrofluoric acid HF)
Output units:	$n_D$ / R.I. (Refractive Index) / Conc% / g/l
Accuracy:	R.I. $\pm 0.0002$ (corresponds typically to $\pm 0.1\%$ b.w.). Repeatability $\pm 0.0001$ (corresponds typically to $\pm 0.05\%$ b.w.).
Speed of response:	1s undamped, damping time selectable up to 5 min
Patented CORE-Optics:	No mechanical adjustments and digital measurement with 3648 pixel CCD element, 589 nm wavelength (sodium D-line) light emitting diode (LED), built-in Pt-1000 temperature sensor (linearization according to IEC 751)
Temperature compensation:	Automatic, digital compensation
Instrument verification:	NIST traceable calibration, verification with standard R.I. liquids and the documented procedure (ISO 9000)

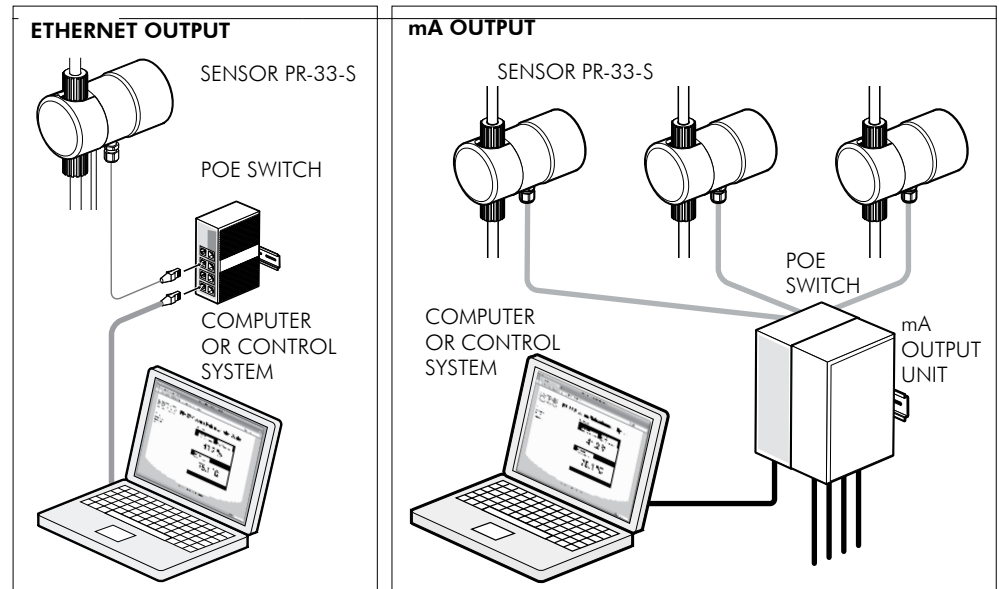
<b>SENSOR PR-33-S:</b>	
Sensor wetted parts:	Modified PTFE, prism gasket modified PTFE prism Sapphire, O-ring Kalrez, adaptor Sapphire
Sensor housing:	Ultra-pure Kynar® PVDF
Process connection:	Flare fittings or Nippon Pillar Super 300 Type fittings; fitting sizes 1/4 inch, 1/2 inch, 3/4 inch or 1 inch
Process temperature:	-20°C (-4°F)...85°C (185°F)
Ambient temperature:	-20°C (-4°F)...45°C (113°F)
Sensor protection class:	IP67, Nema 4X
Sensor weight:	1.2 kg (2.6 lbs)
Fieldbus and industrial Ethernet connectivity:	Through Fieldbus converter to Modbus/TCP, Modbus RTU and Ethernet/ IP networks
Power consumption:	max. 1W
Ethernet connection:	10/100Base-T Ethernet
Remote functions:	Remote access with a web browser, data acquisition through UDP/IP
Patents:	US Patents US6067151 and US6760098B2, German Patent DE19855218
Sensor cable:	FEP-covered Ethernet cable between sensor and PoE switch; cable type Cat 5e Ethernet with RJ-45 connector, cable length 10 m (33 ft), PVDF sensor cable gland

**OPTIONS:**

IEEE 802.3af compliant PoE switch (4+2 ports, 24Vdc/48Vdc input); Power supply unit for the PoE adapter (84-264 Vac); Ethernet to mA output unit (2 x 4-20 mA)

**ORDERING INFORMATION:**

- Sensor process connection and fittings size
- Measurement range
- Properties of process solution
- Process temperature range
- Process flow rate
- Options and accessories



www.vaisala.com

Please contact us at  
www.vaisala.com/requestinfo

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