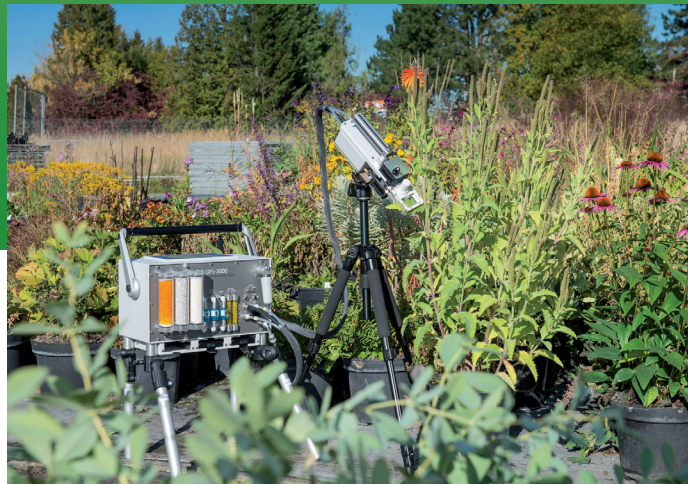


## GFS-3000

Portable Gas Exchange & Fluorescence System



- High precision measurements of CO<sub>2</sub> assimilation, stomatal conductance, and chlorophyll fluorescence.
- Easy to combine with IMAGING-PAM or P700 analysis.
- Various cuvette options and leaf area adapters.
- Control ranges: 0-2000 ppm CO<sub>2</sub>, 0-nearly 100% humidity, 10 K below ambient temperature to 60°C, 1- 3000 µmol m<sup>-2</sup> s<sup>-1</sup> homogenous light illumination.
- For field and laboratory usage.
- Intuitive software and automated experiments.

The GFS-3000 is the instrument for precise and reliable gas exchange measurements. It provides accurate assessment of photosynthesis, transpiration, and respiration under ambient conditions or with climate control.

The flexible measuring head design enables customizable configurations for different species and experimental setups. In addition, by combining this gas exchange system with other WALZ instruments, data from different fields of photosynthesis research can be integrated to provide a more complete understanding of physiological processes.

The integrated PC provides operation and graphical data processing on a large color touch-screen that is easy to read in the field, even in bright sunlight. User-friendly software guides you through the operation, e.g. facilitates running light-curves or A/ci curves (assimilation versus intercellular CO<sub>2</sub> curves). Manual operation, program routines or self-programmed experimental runs can be easily accomplished.



## DUAL-PAM-100

P700 & Chlorophyll Fluorescence System



- High performance system for simultaneous analysis of PS I and PS II.
- Combines PAM fluorescence and dual-wavelength infrared absorption measurements.
- Available as MODULAR and FIBER version. Both systems can be easily upgraded for suspensions.
- Performs saturation pulses analysis and fast kinetics recording with a time resolution of 30 µs.
- Operated by the highly versatile DualPAM software.

The MODULAR version offers exceptional flexibility. High sensitivity detectors are available to measure the fluorescence of very dilute suspensions. An optional cooling/heating Peltier element controls the suspension temperature.

Specific emitter-detector modules have been developed to determine various components of photosynthesis: The proton motive force is measured by the 515 nm electrochromic shift. Scattering changes caused by membrane energization are recorded at 535 nm. NADPH formation is monitored by UV-A-excited fluorescence. Photosynthetic pH formation is assessed by the pH-sensitive fluorescence of dyes.

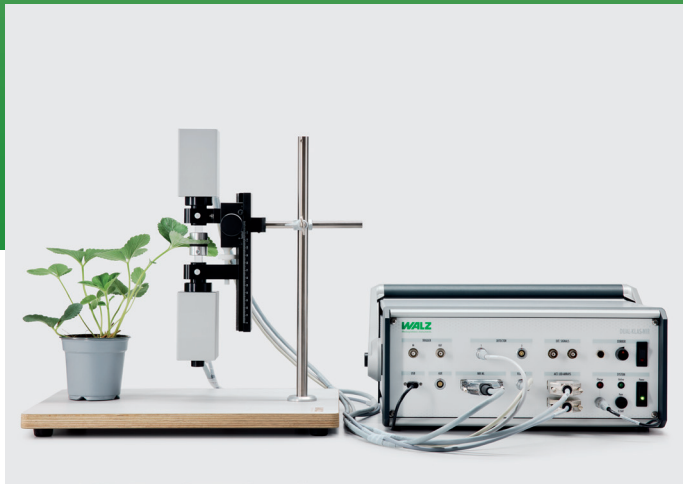
The MODULAR version can be coupled to the GFS-3000 Gas Exchange System allowing simultaneous analysis of PS I and PS II photochemistry plus CO<sub>2</sub> gas exchange.

The P700 flux method is one of the unique features of the DualPAM software: it permits to determine the flux per time of electrons through a PS I reaction center.



## DUAL-KLAS-NIR

Measuring System for P700, Plastocyanin, Ferredoxin & Chlorophyll Fluorescence



- The deconvolution method using four wavelength pairs provides clean signals for plastocyanin (PC), P700, and ferredoxin (Fd).
- Simultaneous measurement of the PS I donor side (PC and P700) and acceptor side (Fd) provides a comprehensive understanding of electron flow.
- The redox state of Fd is a reliable indicator of feedback inhibition of electron flow.
- Changes and differences in the PC to P700 and Fd to P700 ratios are easy to survey.

The DUAL-KLAS-NIR is the ideal tool for investigating topics like cyclic electron transport, photosynthetic control, inhibition of PS I by chilling and fluctuating light, or PS I damage caused by mineral deficiency. It is available in configurations for both leaves and suspensions of microalgae, cyanobacteria or isolated chloroplasts. A linear positioning system enables the emitter and detector units to move smoothly relative to each other.

When measuring all channels simultaneously, the time resolution is approximately 1 ms. Single-channel measurements have a time resolution of 30 µs, which is sufficient for measuring the polyphasic rise. A special feature of the instrument is that green ML measures fluorescence through the leaf and blue ML measures it from the leaf's upper surface, respectively.

The software structure is similar to that of the DUAL-PAM-100. It is streamlined to operate the six-channel DUAL-KLAS-NIR as smoothly as the two-channel DUAL-PAM-100 device.



## MINI-PAM-II/POROMETER

Leaf-Clip for measurements of stomatal conductance



- Compatible accessory for all MINI-PAM-II instruments.
- Rapid assessment of stomatal conductance and monitoring of stomatal movement
- Suitable for various samples: leaves, needles, blades of grass, etc.
- Ambient CO<sub>2</sub> sensor, GPS, leaf's angle of incidence to the sun
- Dark shield for easy determination of FV/FM and measurements with controlled actinic light intensities
- Pressure of closing mechanism is adjustable

The MINI-PAM-II/POROMETER is a new leaf-clip applicable to all MINI-PAM-II instruments. With multiple integrated sensors, information can be obtained quickly and precisely, combining measurements of stomatal conductance, chlorophyll a fluorescence, ambient CO<sub>2</sub> level, and the sample's position and orientation to the sun at a given time and place. This provides a much more nuanced and comprehensive characterization of the plant's physiological state.

The MINI-PAM-II/POROMETER allows you to quickly determine the current stomatal conductance of your sample. But porometer data can also be measured during MINI-PAM-II protocols, such as induction curves or light curves. Unlike other commercially available porometers, the MINI-PAM-II/POROMETER can therefore be used not only to access stomatal conductance but also to retrieve and monitor stomatal movement.

Whether in research or applied science, this leaf clip gives data to answer a broad range of questions.



## DIVING-PAM-II

Underwater Fluorometer



- The DIVING-PAM-II is the proven PAM fluorometer for investigating photosynthesis underwater.
- The system includes a spectrometer for measuring PAR, reflectance, and fluorescence spectra.
- Available with blue or red light, both with far-red LED.
- With sunlight-readable LCD display, WiFi communication, and infrared reflection switches for instrument control.
- Equipped with a pressure and temperature sensor.
- Laboratory operation via WinControl-3 PC software.

The DIVING-PAM-II is designed to study photosynthesis in coral endosymbionts, algal mats, macroalgae and seaweed, at depths of up to 50 m.

Its spectrometer allows following the depth-dependent spectral variations of light. The DIVING-PAM-II analyzes photochemical yield of PS II, photochemical and non-photochemical energy quenching. Routines for induction and light response experiments are built in. A sensor module using advanced optode technology to measure water oxygen and pH is available.

The release button of an optional sample holder allows one-handed measurements. The sample holder positions the spectrometer parallel to the sample level so that electron transport rates can be calculated. Clips for dark acclimation and for positioning of fiberoptics on bulky samples are available. The accessories for the MINI-PAM-II are compatible with the DIVING-PAM-II.



## WATER-PAM-II

Chlorophyll Fluorometer for Phytoplankton



- Most sensitive instrument for the analysis of phytoplankton in aqueous samples.
- Detailed analysis of the sample's photosynthetic performance including quenching parameters.
- Analysis of algae population.
- Easy operation, numerical and graphical display of measurements.
- Ideal for on-deck and field applications.
- Batteries provide power for more than 30 h.
- Optional Flow-Through Cuvette.

The WATER-PAM-II provides answers to the important questions about phytoplankton samples: how much, what, and how active.

Analysis of the photosynthetic activity of phytoplankton samples can be determined by single measurements or with easy-to use protocols such as induction curves and light curves.

Sample composition information is provided by the algae analysis function. This is a procedure for determining the composition of the algal population distinguishing three algal groups, based on differences in their antenna characteristics. The very compact and lightweight instrument is powered by replaceable standard or rechargeable AA batteries and can store data from more than 27,000 saturation pulse analyses.

The WATER-PAM-II can be used as a stand-alone instrument or integrated into automation systems. Versatile accessories include a Flow-Through Cuvette for high-throughput measurements.



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2026



## HEXAGON-IMAGING-PAM

Chlorophyll Fluorometer for Large Sampling Areas



- Visualization and analysis of the photosynthetic activity of samples on 20 x 24 cm in high resolution.
- Imaging-based dissection of photosynthetic performance, inhibition analyses, photochemical and nonphotochemical quenching parameters.
- Blue high-power LED array with exceptionally homogeneous illumination.
- Two additional types of far-red sources for F0' measurements and state shift experiments.
- Suitable for diverse samples such as leaves, algae, multiwell plates and potted plants.

The HEXAGON-IMAGING-PAM provides high-resolution, localized analysis of photosynthetic activity. Analysis of photosynthetic activity over an area of 480 cm². This allows large leaves, potted plants, algae in sterile culture flasks or multiple small objects to be measured. Photosynthetic parameters of areas of interest can then be directly compared.

For convenient use, we have combined various measurement setups in one device. The position of the base plate can be adjusted in height or equipped with special potholders. Samples can be inserted through the front sliding doors or the tray slot at the side.

The software simultaneously displays the sample image and numerical or graphical analysis of selected areas of interest. Preconfigured settings for single measurements and standard protocols make it easy to use.

As control computer we recommend the IMAG-HEX/PC, an Intel NUC Mini PC with Windows OS. For automation, the HEXAGON-IMAGING-PAM can be fully remote controlled.



## LSA-2050

Leaf State Analyzer



- Portable field instrument for non-destructive assessment of leaf health status.
- Determines the leaf chlorophyll concentration.
- Measures the protection against high-light stress by anthocyanins and carotenoids.
- Determines the screening of harmful ultraviolet radiation by flavonoids and hydroxycinnamic acids.
- Derives the maximum quantum yield of PS II ( $F_v/F_m$ ) from saturation pulse analysis.
- Records leaf position and orientation.

The LEAF-STATE-ANALYZER LSA-2050 analyzes the screening against natural radiation of four wavelength ranges: green, blue, UVA and UVB. Absorbance values indicating relative flavonoid and anthocyanin concentration are provided.

Chlorophyll concentration is measured by the Cerovic method, which avoids signal saturation at high chlorophyll concentrations. To assess the plant nitrogen status, the ratio of chlorophyll concentration to flavonoid absorption is automatically calculated. Fluorescence transients for  $F_v/F_m$  determinations are recorded at a time resolution of 100 Hz. Special darkening bags and darkening clips are available for dark-acclimation of leaves prior to  $F_v/F_m$  determinations.

The instrument can be configured to measure radiation screening and  $F_v/F_m$  on bulky samples such as fruits. By integrating the output of a suite of on-board sensors, ecophysiologicaly relevant geodata are automatically gathered and saved.



## MICRO-PAM

Multi-site Outdoor Monitoring System



- For long-term monitoring of photosynthesis in the field.
- Fluorometers with blue or amber light source are available.
- Measured parameters include PAM fluorescence, PAR, temperature, and humidity.
- PC-operated ONLINE configuration with 4 fluorometers.
- STAND-ALONE configuration with solar powered data acquisition system and up to 16 fluorometers.
- Optional add-ons for long-distance data transfer are a WiFi modem and a satellite modem.

MICRO-PAM fluorometers are the lighter and more compact alternative to the MONITORING-PAM fluorometers developed earlier. PS II photochemical quantum yield and relative electron transport rates are automatically determined.

The script programming language turns a MICRO-PAM system into an autonomously operating unit. Simple saturation pulse analyses, induction curves, and light curves are automatically performed at specific times of the day. The script programming language also allows to determine dawn and dusk.

The sampling frequency can be varied depending on light conditions.

The design of the MICRO-PAM fluorometer is weatherproof, but it should not be submerged in water.

For measuring the photosynthesis of aquatic organisms, the MONITORING-PAM AQUATIC version system is available.



## MINI-PAM-II

Photosynthesis Yield Analyzer



- The MINI-PAM-II is the classic fiberoptics PAM fluorometer for field studies.
- Available with blue or red light source, both with far-red light.
- Built-in computer and easy operation of via touchscreen.
- Laboratory operation via WinControl-3 PC software.
- Analysis of the photochemical yield of PS II, photochemical and non-photochemical energy quenching.
- Calculation of electron transport rate with an optional leaf clip that measures PAR, and also leaf temperature and humidity.

The Photosynthesis Yield Analyzer MINI-PAM-II is the basic system for leaf studies. For carrying out rapid light curves in the field, the standard leaf clip can be modified to exclude external light. For small leaves, the Arabidopsis leaf clip is available. Bulky samples can be studied using a specially designed fiberoptics holder.

The MINI-SPEC/MP accessory allows to spectrally analyze PAR and to record leaf reflectance and fluorescence emission spectra.

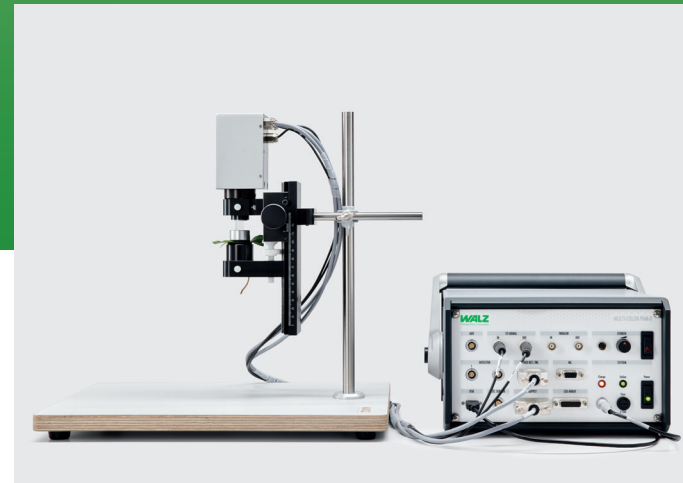
The optional state-of-the-art oxygen optode and a special cuvette permit simultaneous oxygen and PAM fluorescence measurements on suspensions of isolated chloroplasts and microalgae.

The MINI-PAM-II/POROMETER leave clip combines PAM fluorescence analysis with the measurement of stomatal conductance as derived from accurate determination of leaf water evaporation.



## MULTI-COLOR-PAM-II

ST-Kinetics and Multi-Wavelength Chlorophyll Fluorometer



- Modulated continuous light and non-modulated flash-based measurements in a single system.
- Modulated measurements stand out due to their sensitivity (gradient-free measurements), high time resolution (10 µs), and flexibility in fluorescence detection wavelengths, as well as the ability to select five actinic and measuring wavelengths plus white light.
- Non-modulated measurements (time resolution 300 ns) are flash-based (variable flash length and intensity up to 1 mol photons m⁻² s⁻¹), with the instrument recording the full flash kinetics.

Modulated measurements can be used to probe many processes related to electron transport and regulation. Flash-based measurements allow the monitoring of P680 redox kinetics, period-4 oscillations and Car-triplet induction and decay kinetics. By combining both techniques in a single measurement, users can precisely probe the relative  $Q_A$  redox state during continuous light measurements. With two detectors and free choice of detection wavelengths, it is also possible to probe variable PS I fluorescence.

When working with cyanobacteria or diatoms, for example, the availability of five excitation wavelengths enables excitation of the outer antennae rather than only the chlorophylls of the core antennae.

Plants were not forgotten either: both the flash lamp, which can be used stand-alone, and the two detectors with multi-color emitter can be used for measurements on leaves, seagrasses or macroalgae.



## PHYTO-PAM-II

Multiple Excitation Wavelength Phytoplankton and Photosynthesis Analyser



- Detailed analysis of the photosynthetic activity of samples, differentiated by four algal groups.
- High sensitivity for even extremely dilute phytoplankton suspensions, such as natural water samples.
- Two instrument versions.
- Five measuring light wavelengths, six actinic light colors, and FR illumination.
- The full range of saturation pulse analysis, assessment of chlorophyll a content.
- Sample-specific determination of the functional antenna size of PS II.

PHYTO-PAM-II instruments are the ideal tool for analyzing differences in photosynthetic performance of up to four algal groups within a given sample. Useful not only for population determination, but also for the defined analysis of the photosynthetic activity with respect to green algae, diatoms/dinoflagellates, cyanobacteria and phycoerythrin containing organisms, like cryptophytes. This differentiation is based on the well-established technique of using algal group-specific differences in fluorescence emission by excitation with multiple measuring light wavelengths. Even samples with very low concentrations of algae, as typically found in natural surface waters or coastal seawater can be analyzed.

The MODULAR version provides two extra optical ports, the option of changing detector filters, software-triggered stirring and temperature control.

The COMPACT version requires very little set-up time as the measuring head is integrated into the housing. Optionally, it can be equipped with the Flow-Through Cuvette and a 0–10 V pump control to automate sampling processes.



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