Avantes Spectrometers: Versatility Worldwide

Finding fires with AvaSpec

Developed in Portugal, the Forest Fire Finder is an advanced fire detection and tracking system. The system consists of an individual or a series of towers which feature telescopic optics to measure spectra over forested areas. The system features an AvaSpec-ULS2048-USB2 spectrometer, a video camera, weather station, telescope, processing/controlling unit and communications unit. The telescope and the video camera scan the horizon non-stop, at an angle of 320 degrees. The telescope is connected to the spectrometer by means of a fiber and can collect spectra up to 15km away. These spectra are then processed and analyzed. The video camera takes pictures at pre-set intervals and can also be used to send real-time video. It is aligned with the telescope, to ensure what is measured.

Should the system detect a forest fire, automatically alerts are sent out through SMS, IP, GSM, etc. The alert contains needed information, such as fire location, detection time, weather conditions and an image of the detected fire. The weather conditions include wind speed and direct, temperature and humidity.

Application Note: CEMS Continuous Emission Monitoring Systems

Environmental preservation in China has been closely examined in recent times, and there is increasing concern about reducing environmental pollution.

Industrial gas emissions have contributed enormously to the air pollution and must be monitored continuously. In China there are several companies which develop and manufacture CEMS (Continuous Emission Monitoring System). CEMS is used to do the air pollution measurement. These systems monitor the concentration of industrial gases and suspended particles emitted from air pollution sources.
UV spectrometers are integrated to the CEMS used for calculating the absorption of SOx/NOx. Over 200 CEMS systems do have 'Avaspec inside' and we expect this to be multiple in the future.

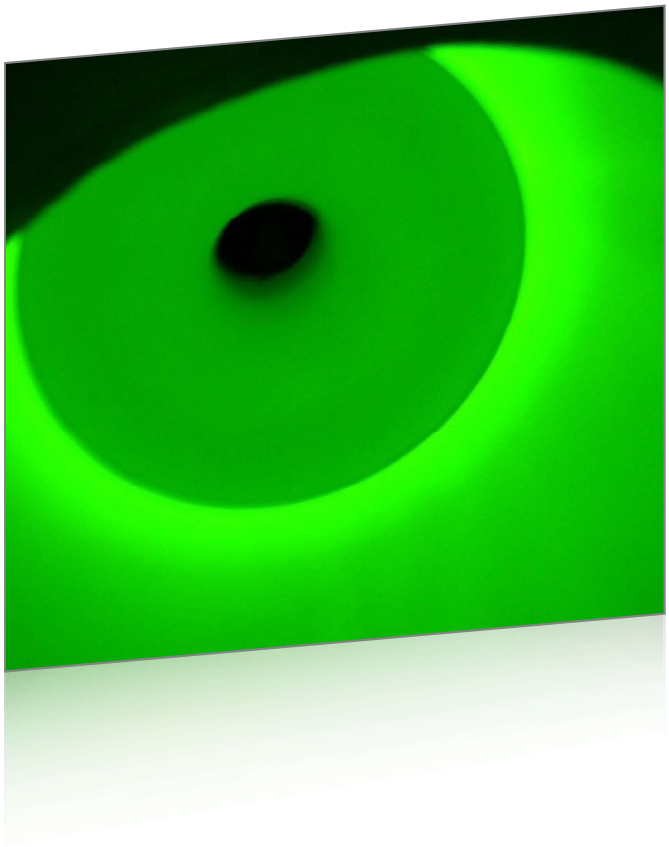
These AvaSpec spectrometers have high demands regarding stray-light, optical resolution, stability and sensitivity.
The AvaSpecULS2048x16 has proven to be a very good choice for this application. This is because this device has a very high quantum efficiency and SNR(500:1) in the UV range, besides it has a lower stray light.
DOAS (Differential optical absorption spectroscopy) is one of the techniques which is used in these systems.

Application Note:

Light Effects on the Biological Clock

Most organisms have a circadian clock which has evolved as a consequence of the rotation of the earth around its axis. The circadian clock resides in the suprachiasmatic nucleus and generates rhythms of about 24 hours. The suprachiasmatic nucleus adapts to daily changes in its environment. Light is the main synchronizer of the biological clock to the external light-dark cycle and is detected by ocular photoreceptors in the retina. Light information is then send to the suprachiasmatic nucleus via the optic tract. In the suprachiasmatic nucleus light information leads to an enhancement in electrical activity of the neurons.

To determine the effects of light on the circadian clock in mice, in vivo electrophysiological recordings of neurons of the circadian clock were performed. Mice were exposed to three different wavelengths of light using monochromatic LEDs. The wavelengths of light used were UV (λ max 365 nm), blue (λ max 467 nm) and green (λ max 505 nm). During light exposure the extracellular activity of a group of neurons of the suprachiasmatic nucleus were recorded.



Integration of Avantes Spectrometers in Multi-element LIBS Analysers

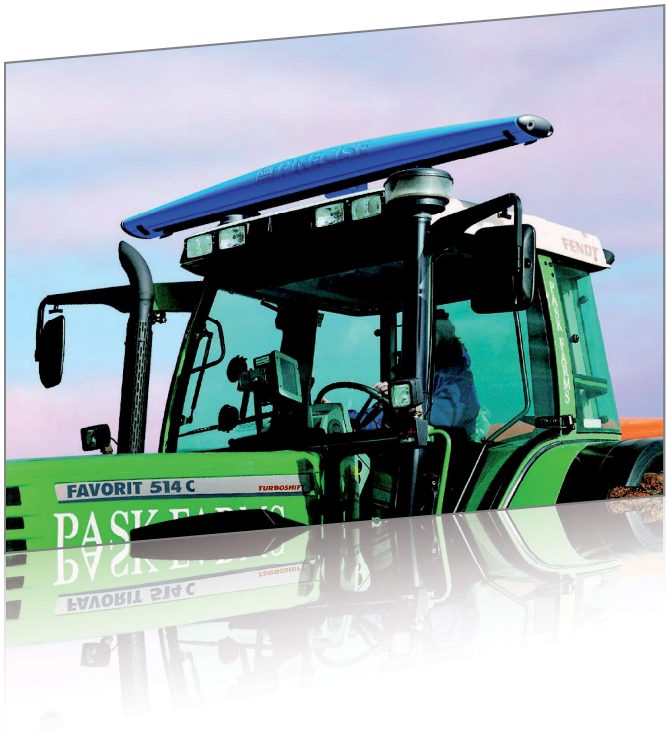
The Laser Induced Breakdown Spectroscopy (LIBS) gives information about the elemental composition within a small spot on a sample surface and, in addition, even low Z elements can be measured with good sensitivity. With the LIBS Software Suite (LSS) calibration (univariate or multivariate, PLS) and classification (PCA, NN) models for a wide range of analysis tasks can be created. The calibration models can be used for offline and online measurement. The SECOPTA GmbH in Berlin, Germany has integrated Avantes spectrometers in different FiberLIBS and MopaLIBS element analysers for industrial and laboratory applications.

Monitoring Fertilizer Concentration on the Go

To measure and apply the appropriate levels of fertilization on crops can be a time consuming activity. This is what the Yara system was designed to facilitate. Featuring a dual channel AvaSpec series spectrometer, fiber-optics and processing electronics mounted in a blue box on top of a tractor, the system makes real-time measurements of the optical appearance of crops and intelligently applies fertilizers accordingly.

Relevant for the fertilization is the level or nitrogen in a crop, which is measured by means of reflection spectroscopy. In the visible range (380-740 nm) the reflection is an indication of the leaf chlorophyll content, in the NIR range (700-1000 nm) reflectance is mainly affected by the crop's biomass.

Included with the Yara system is a terminal for real-time monitoring. A special viewing geometry and integrated irradiance correction guarantees accurate measurements. The system logs crop and GPS data on a on-board data card.



Testing Leakage of Cooling Water of (Nuclear) Power Plants

In Japan there are many (nuclear) power plants and they are all build on a rocky based bottom. These rocks also have underground water streams, in case of an earthquake (not unrealistic in JAPAN) radioactive cooling water might leak through the rocks into these clear water streams and spread the radio- active radiation on to a greater area, which will be extremely dangerous for environment and all living creatures.

The idea is to drill several deep holes in a specific area around the power plant (aprox. 50 m deep) and measure fluorescence in the underground water stream. To the cooling water used in the coolwater system of the power plant a tracer is added, this tracer will cause a strong fluorescence signal when measured with the AVANTES system in a 50 meters deep well. When in case of an earthquake cooling water would leak it can be traced within a reasonable time as the distance from detection well to power plant is short.

For a company in Japan we developed a special flow cell with an integrated LED 480 nm, an AvaSpec with a backthinned detector (VB grating and SLIT 200) will detect the fluorescence in the control room. A 50 m powercable and a 50 m fiber was part of the solution as well.

High Dynamic-Range Time Intensity Measurement of Intense Femtosecond Laser Pulses

Ultrafast lasers are now broadly used in many research fields such as high intensity laser-matter interaction, femtochemistry, THz generation or time-resolved spectroscopy.

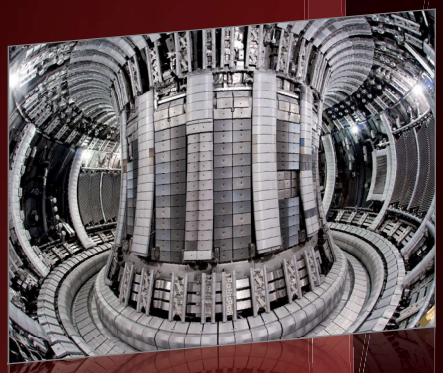
Characterization of femtosecond laser pulses has always been a difficult task, but with a new technique called Self-Referenced Spectral Interferometry, invented and patented by Fastlite (Paris, France), researchers can perform single-shot, calibration-free measurements with a simple and compact setup.

The Wizzler system, which includes an AvaSpec-2048L spectrometer, provides spectral intensity, spectral phase and coherent contrast measurements with an unprecedented dynamic range over 40dB, and is now becoming the reference tool in the field of femtosecond pulse measurements.

The included spectrometer covers a bandwidth ranging from 650 to 1080 nm and matches the full spectral bandwidth covered by the widely used Ti:Sapphire lasers. The hardware trigger allows single-shot acquisition up to 1kHz.

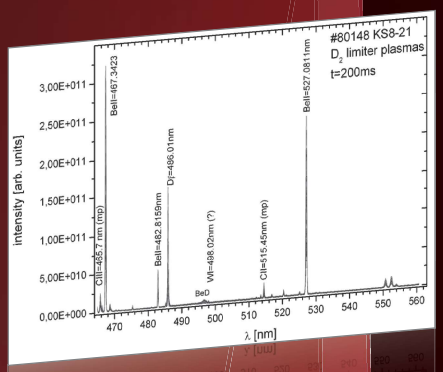
Plasma-Surface Interaction Measured by Avantes

Just a small town in the English countryside, but it hosts a research facility that might change the world as we know it. The Joint European Torus, based in Oxfordshire, researches how to use fusion energy in daily life. Fusion offers the promise of energy that is environmental friendly, safe and available in almost unlimited quantities. Avantes spectrometers are used at the facility to measure changes during these plasma experiments.



Deputy leader Dr. Sebastijan Brezinsek of the JET-EFDA task force E2 is responsible for all spectrometers used at both the English and German facilities. When upgrading the torus, new miniature spectrometers were also needed. Mr. Brezinsek explains their choice:

"we used a European Tender and the Avantes spectrometers offered the best quality for the best price. They are used to measure changes in the internal environment of the torus over time and they run 24 hours per day, for several years to come. This way we can measure the influence of the plasma on the internal environment of the torus. So far the quality of Avantes has proven itself."



To prevent any influence from radiation, fiber cables guide the light to a facility 100 meters away from the torus building. There the 53 Avantes spectrometers work non-stop. For this application Avantes had to develop special systems, or as Klaas Otten, Avantes' technical sales manager, puts it:

"we are used to design custom made spectrometers for different applications. The systems used at JET-EFDA have special casing and low-noise detectors, to prevent any distortion. This system asked for individually triggered spectrometers, with fast data acquisition. Plasma is a fast changing substance and therefore fast repetition rate was one of the key requirements."

Avantes supplies their spectrometers with high-performance measurement software, AvaSoft. For JET-EFDA, the DLL-package was used to control the instruments. According to Mr. Brezinsek:

"all our measurement systems connect to one central software solution, therefore we decided to use Avantes' DLL-files. This way we can combine all information into one view, thus enhancing the quality of our work." He concludes: "Thanks to Avantes, we can do our work better, faster and deliver better results. In France we are building a torus that should supply five times the energy we put into the system. This will really be the future of power supply in the world and Avantes helps to make it possible!".

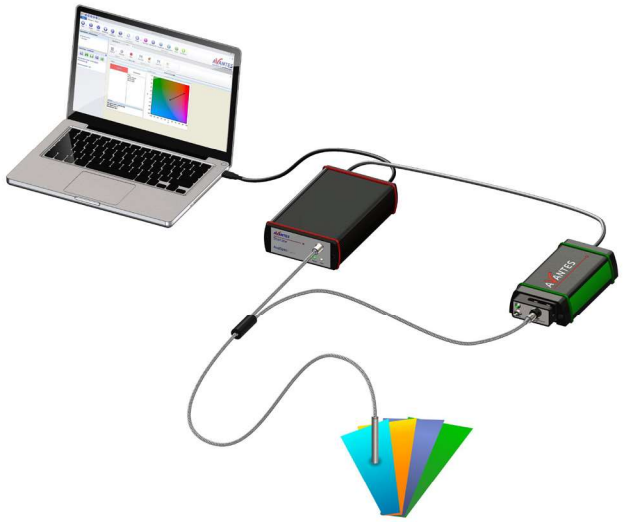
AVANTES
solutions in spectroscopy

Color Measurements

The human eye has a spectral sensitivity that peaks at around 555 nm, which means that the color green gives an impression of higher brightness than other colors. At 490 nm the sensitivity is only 20% compared to the sensitivity at 555 nm. Furthermore, the human eye can only distinguish about 10 million different colors which is actually quite limited relative to the needs of color measurement applications. Spectrometers are designed to measure exact wavelengths, and are therefore ideal for color measurements.

Visible light has a wavelength range of 390-750 nm, so generally color measurement systems are configured to cover the range from 380-780 nm with a spectral resolution of around 5 nm (FWHM).

To facilitate reflective color measurements a reflection probe or integrating sphere is typically required. In either case, a white continuous light source illuminates the surface to be measured and a white reflective standard tile is needed for calibration. Color measurements may be applied to a variety of industrial applications such as color of textile, paper, fruit, wine, and bird feathers. Avantes has developed a variety of custom probes to meet the specific demands of the color measurement application. Color measurements are manifested in the L*a*b* color model which includes parameters for brightness and hue.



Color Measurement Setup for Small Areas

This bundle features an AvaSpec-ULS2048CL-EVO spectrometer that is tuned for visible light, which makes it ideal for color measurements. An illuminant A halogen light source for illumination and a reflection probe (with reflection probe holder) are included as well.

Typical applications:

- In-line reproducibility
- Analysing small spots & lines

Spectrometer	AvaSpec-ULS2048CL-EVO	Grating BB (360-780nm) 200 µm slit AvaSoft-Full & AvaSoft-Color
Light source	AvaLight-HAL-S-Mini	PS-12V/2.08A
Fiber optics	FCR-7UVIR200-2 RPH reflection probe holder	
Included	WS-2 white reflection tile	

Color Measurement Setup for Surfaces

To measure color, wide angle diffused light from a sample is analyzed. This bundle includes a handheld 50 mm integrating sphere and a compact spectrometer. With this bundle, your measurements are free of the gloss-specular component. The measurement optics are placed under a 8° angle (D/8 SPIN).

Typical applications:

- Rough surfaces
- Textile and printed paper
- Fruits

Spectrometer	AvaSpec-ULS2048CL-EVO	Grating BB (360-780nm) 100 µm slit AvaSoft-Full & AvaSoft-Color
Light source	AvaSphere-50-LS-HAL-12V	
Fiber optics	FC-UVIR200-2-ME	
Included	WS-2 white reflection tile	

UV/VIS Absorbance Measurements

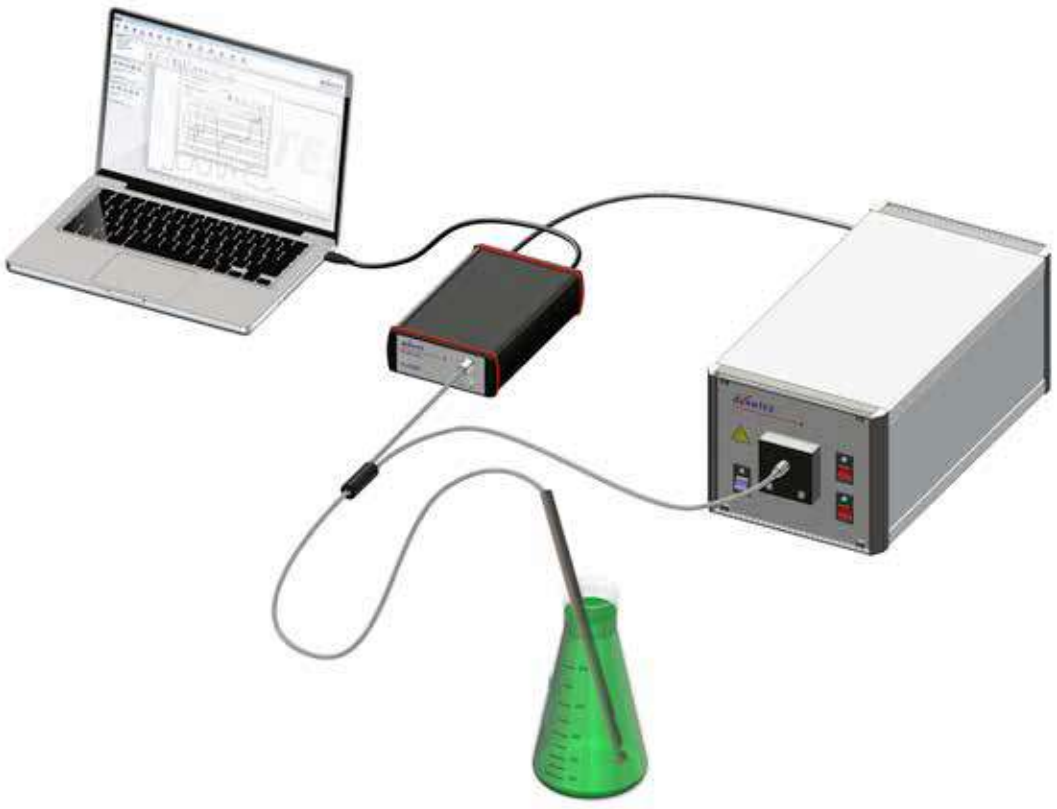
The absorbance (also called optical density) of a material is a logarithmic ratio of the radiation falling upon a material, to the radiation transmitted through a material. UV/VIS absorbance measurements encompass a wide variety of chemical and biochemical applications which involve many areas of research and industrial end uses. UV/VIS absorbance can be applied qualitatively and quantitatively in spectroscopic measurement applications ranging from blood parameters to chemical concentrations in process and reaction monitoring. Fiber-optic spectrometers offer a tremendous value proposition for UV/VIS measurements because of their relatively low cost, small size and ability to be introduced in harsh environments through the fiber interface. Combined with a fiber-optic transmission dip probe, inline flow cells or the more traditional cuvette cell, a fiber-optic spectrometer can accurately and repeatably measure over the range from 200-1100 nm.

Small Instruments Come of Age

Scientists who are largely familiar with more traditional bench top spectrophotometers may have the perception that fiber-optic instruments cannot provide the resolution or stray-light rejection required for more demanding applications. In fact, fiber-optic spectrometer technology has come a long way and Avantes' instruments are on the leading edge for this technology. Our instruments are capable of measuring at resolutions as high as 0.05 nm in the UV. In terms of stray-light rejection, Avantes has developed a special optical bench called the ultra-low stray-light (ULS) optical bench to provide optimal performance for our customers. AvaSpec ULS spectrometers have stray-light levels as low as 0.04%.
Typically UV/VIS absorbance systems consist of a spectrometer, stabilized light source and fiber-optics, which are connected to some form of sampling accessory (probe or cuvette cell). Single fiber-optic spectrometers can be configured for broadband measurements (200-1100 nm) or narrow band (any range from 200-1100 nm) depending upon the desired wavelength range and resolution. Avantes UV/VIS instruments are also fully compatible with our AvaSpec NIRLine spectrometers, which enable spectroscopic measurements out to 2500 nm.

Common System Configurations

Avantes modular platform enables users to configure systems in a variety of ways and also allows the flexibility of changing the system configuration later to provide additional functionality. The typical UV/VIS absorbance system consists of an AvaSpec spectrometer, AvaLight fiber-optic light source, fiber cables



and a cuvette cell holder. To the left this system configuration is shown with a cuvette cell holder above with a dip probe configuration below.

Our affordable AvaSpec-ULS2048CL-EVO provides excellent resolution (1.0 nm FWHM) over the entire range from 200-1100 nm, or higher resolution for a shorter-range configuration. For higher resolution (0.6 nm FWHM from 200-1100 nm) the AvaSpec-ULS4096CL-EVO is recommended. Customers that demand higher signal-to-noise performance and higher sensitivity in the UV or NIR should consider Avantes SensLine instruments. The AvaSpec-ULS2048XL-EVO has a high-performance back-thinned CCD detector and the AvaSpec-HERO is Avantes highest sensitivity spectrometer with a thermo-electrically cooled CCD detector and a high numerical aperture optical bench. Any of Avantes' instruments can be combined with our AvaLight-DHS-BAL deuterium halogen source and a CUV-UV/VIS cuvette cell holder.

The CUV-DA-DHS is a nice alternative, which enables directly coupling of the cuvette cell holder to the front plate of the light source to minimize the use of fiber-optics. This same system configuration can be integrated into a single housing (AVS-Desktop) to provide an integrated spectrophotometer module with a common power supply for the light source and spectro-meter.

Fiber-Optics

One of the key value propositions to fiber-optic instruments is the ease with which measurements can be made inline or in-process using a fiber-optic probe or accessory. Avantes offers a variety of sizes and configurations of fiber-optic transmission dip probes, which include special configurations for measurements in high temperatures (up to 500 °C), high pressure or vacuum. Also available are fiber-optic flow cells for standard and micro-fluidic applications.

Instrument Control Software

Avantes proprietary AvaSoft software is a Windows-based 32- and 64-bit compatible software package which enables full instrument control and includes a basic chemometry add-on module (AvaSoft-Chem). For customers requiring more sophisticated analytical software, which enables model development and multi-variate analysis, Avantes instruments are fully compatible with Panorama-Pro software from LabCognition.

UV/VIS/NIR Absorbance Setup

Designed for broadband measurements, this UV/VIS/NIR absorbance bundle features a high-power deuterium halogen light source with integrated shutter and a variable dip probe. A versatile bundle to measure absorbance in most situations.

Typical applications:

- Colorization of fluids
- In-line measurements
- Color of liquids in test tubes and flasks

Spectrometer	AvaSpec-ULS2048CL-EVO	Grating UA (200-1100nm) 25 µm slit, DCL-UV/VIS-200 OSC-UA Order Sorting Filter AvaSoft-Full
Light source	AvaLight-DH-S-BAL	
Fiber optics	FDP-7UVIR200-VAR	

Irradiance Measurements

Radiometry deals with the measurement of all optical radiation inclusive of the visible portion of this radiant energy. Irradiance is a parameter of radiometry. It describes the amount of radiant power impinging upon a surface per unit area. Irradiance measurements can be done in the UV, VIS and NIR wavelength ranges.

Avantes works with a variety of irradiance applications ranging from pulsed solar simulator characterization to free space measurements of radiant sources such as street lights. The AvaSpec line of instruments provides exceptional resolution and stray-light rejection to ensure the accuracy of these measurements. Typical system configurations involve one or more spectrometers configured for the appropriate range 200-400 nm for UV irradiance, 360-1100 nm for VIS irradiance and 1100-2500 nm for NIR irradiance. While broadband configurations covering 200-1100 nm are feasible with one spectrometer, optimal performance is achieved with dedicated UV (200-400 nm), VIS/NIR (400-1100 nm) channels.

The spectrometer or group of spectrometers is connected via fiber-optic cable to a diffuser with a known surface area and the entire system is calibrated against a NIST traceable source for irradiance. Avantes offers a variety of cosine diffusers and integrating spheres for irradiance applications. The calibrated system is shipped as an integrated system (connected together) and should remain in this configuration in order to ensure the integrity of the calibration. FC/PC connectors are recommended in lieu of the standard SMA, which enable repeatable disconnection and re-insertion of the fiber-optics, so the system may be disconnected for transportation.

Customers that wish to conduct their calibrations may consider one of Avantes' intensity calibration sources. The AvaLight-HAL-CAL is available for VIS/NIR wavelengths (360-2500 nm) and the AvaLight-DH-CAL is available for UV/VIS wavelengths (200-1100 nm).
The Avantes AvaSoft-IRRAD software module enables irradiance parameter measurements such as radiometric quantities - µWatt/cm^2, µJoule/cm^2, µWatt or µJoule, photometric quantities Lux or Lumen, color coordinates X, Y, Z, x, y, z, u, v, color rendering index and color temperature, and number of photons µMol/s•m^2, µMol/m^2, µMol/s and µMol. AvaSoft-IRRAD software also facilitates the performance of irradiance intensity calibrations.

Irradiance/Spectroradiometry Setup

Irradiance means measuring how much light reaches a specific place. In this bundle, a cosine corrector is included to collect light from a 180 degree angle, so the measurements are precise. The comprehensive AvaSoft-Irrad software makes it possible to perform fully calibrated, traceable radiometric and photometric measurements.

Typical applications:

- Solar lighting
- Environmental & general lighting

Spectrometer	AvaSpec-ULS2048CL-EVO	Grating UA (200-1100nm) 25 µm FC/PC slit, DLC-UV/VIS-200 OSC-UA Order Sorting Filter AvaSoft-Full & AvaSoft-Irrad Irrad-CAL-UV/VIS
Fiber optics	FC-UVIR200-2-ME-FC/SMA	
Included	CC-VIS/NIR	

Download the latest software for your AvaSpec at www.avantes.com!

LED Measurements

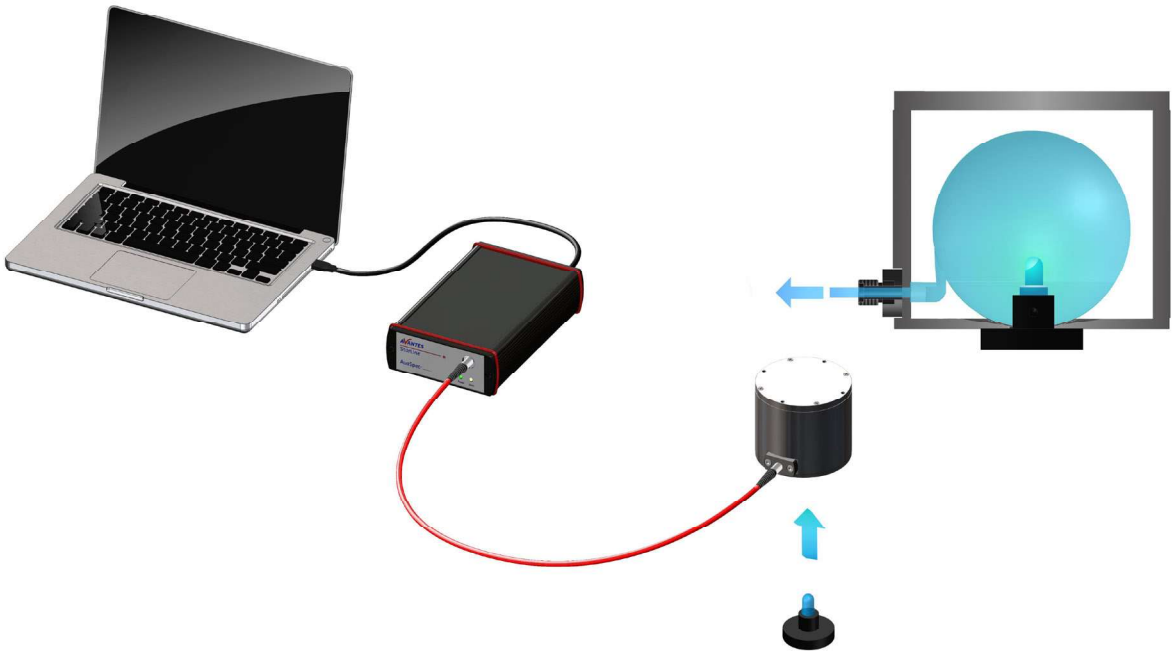
The measurement of LEDs presents unique application requirements for which Avantes has the appropriate instrumentation and applications experience to assist our customers in configuring a system. Avantes' many years of working with LED application has prompted us to develop a variety of system configurations that meets most LED metrology requirements. Light Emitting Diodes can be measured in a wide variety of colors and brightness. Accurate measurement of the LEDs therefore is essential. This can be done in two ways: photometry and radiometry.

Photometry relates to visible radiation alone, just as the response of the human eye. Radiometry goes beyond these limitations. In both photometry and radiometry, the LED can be characterized in emitted power or in intensity. Emitted power is all the power (flux) emitted from the LED in lumens or Watts, collected and measured without regards to the direction of the flux. The intensity is the ratio of the flux, leaving the source and propagating in the element of solid angle containing the given direction, and is expressed in candelas.

For basic measurements of photopic parameters and irradiance (excluding flux) a system is typically configured with the AvaSpec-ULS2048CL-EVO spectrometers, a 25 or 50 µm slit and 300 line/mm grating covering the range from 360-1100 nm and provides 1.4 -2.4 nm full width half maximum (FWHM) resolution. A 2 meter fiber-optic cable (FC-UV200-2-FC-SMA) is mated to the instrument and terminated in a cosine function diffuser (CC-UV/VIS/NIR) which has 3.9 mm diameter surface area. The entire system is irradiance calibrated with an NIST source over the specified wavelength range for spectral irradiance (µW/cm^2/nm). This calibrated system can be operated using Avantes proprietary AvaSoft-IRRAD software which provides the following parameters: X, Y, Z, x, y, z, u, v, CRI, Color Temperature, Dominant Wavelength, Complementary Dominant Wavelength, FWHM, Centroid, Peak Wavelength & Purity. Additionally raw data in scope mode is displayed, as well as the X-Y chroma-ticity diagram. Optionally, the system can be configured with longer fiber lengths and the AvaTripod to hold the diffuser in place during measurement. The system can be controlled via Avantes dynamic linking library (DLL) interface through LabView, C#, C++ and a number of other programming environments.

For flux measurements the entire LED must be inserted into the port of an integrating sphere. Avantes offers a complete line of integrating spheres ranging from 30-200 mm (internal diameter).

For system calibrations, Avantes offers the AvaLight-HAL-CAL calibration sources which are offered in configurations that are compatible with cosine diffusers and small integrating spheres (30, 50, 80 mm).



Avantes also offers two system configurations to enable the CIE Average LED Intensity (ALI) measurements which are specified in the CIE Publication No. 127. AvaSPEC-IRRAD-ILEDA and AvaSpec-IRRAD-ILEDB correspond to the condition A (316 mm measurement distance) and condition B (100 mm measurement distance) standards, respectively. The system is typically based upon the AvaSpec-ULS2048CL-EVO spectrometers which are configured with a 25 or 50 µm slit and 300 line/mm grating covering the range from 360-1100 nm and provide 1.4-2.4 nm (FWHM) resolution. A fiber-optic cable (FC-UV200-2) is mated to the instrument and terminated in our AvaSphere-IRRAD-30 integrating sphere which couples with the corresponding ILED-TUBE-A or ILED-TUBE-B. The system is irradiance calibrated with a NIST source over the specified wavelength range for spectral irradiance (µW/cm²/nm). The ILED TUBE-A or ILED-TUBE-B is coupled with the Ava-LED-Holder-5 mm (LED holder for 5 mm/T1 ¾ LEDs) which is coupled with a current stabilized power supply.

LED Light Measurement Setup

More and more countries are banning incandescent lamps from being sold, hugely boosting LED sales. Avantes offers the necessary tools for the photometric and radiometric measurement of LED lights. The spectrometer in this bundle is irradiance calibrated in order to obtain absolute values.

Typical applications:

- Irradiance
- Illuminance
- Radiometric & photometric flux
- Luminous intensity
- Color coordinates

Spectrometer	AvaSpec-ULS2048CL-EVO	Grating VA (350-1000nm) 25 µm FC/PC slit, DLC-UV/VIS-200, OSC AvaSoft-Full & AvaSoft-Irrad Factory-calibrated system for irradiance IRRAD-CAL-VIS
Fiber optics	FC-UVIR600-2-ME-FC/SMA	
Included	AvaSphere-50-IRRAD AvaSphere LED adapter	

For the latest product information and other updates, go to www.avantes.com.

Thin Film Metrology

Optical thickness of a coating is determined by white light interference and the pattern is translated into optical thickness through mathematical calculations.

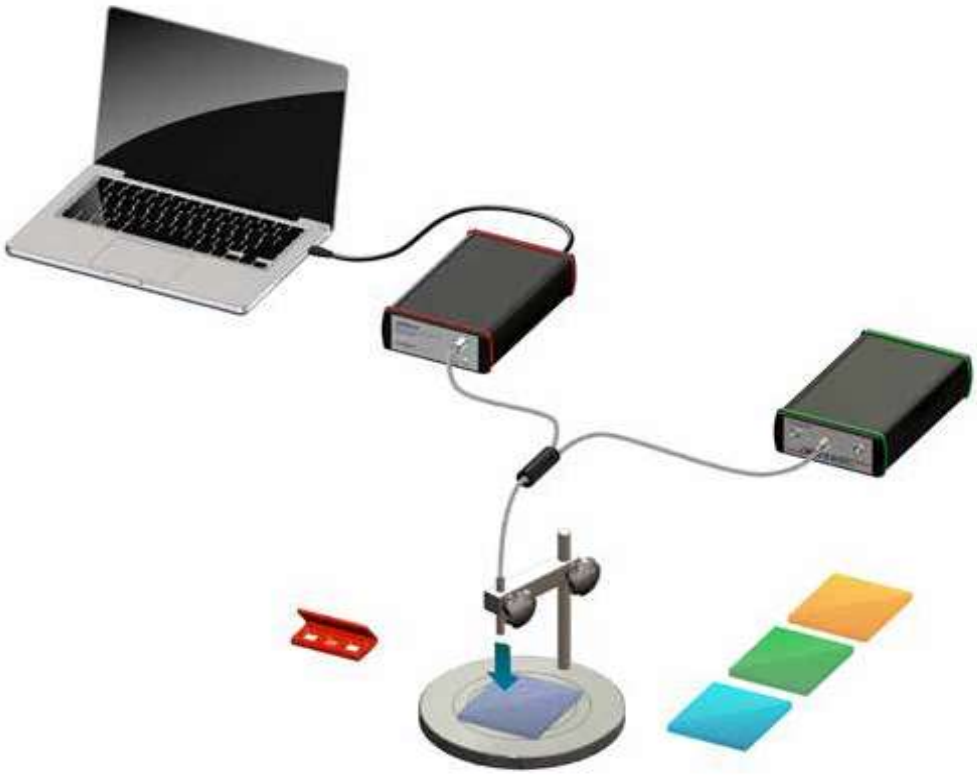
Thin film metrology involves the use of these mathematical calculations to the presence and thickness of coatings which have been deposited on a substrate material using a variety of processes. The techniques available for this measurement range from profilometry to ellipsometry, spectroscopic reflectometry and x-ray analysis. Avantes instruments and fiber-optic sampling tools enable spectroscopic reflectometry measurements to support applications in a variety of industries from semiconductor to solar and optical coating measurements. Avantes thin film solutions provide measurement systems for single and multi-layer thin films on a number of substrates.

Thin Film Quality Control

Thin film deposition processes require regular monitoring and quality control particularly as new recipes are implemented and optimized in a coating facility. Typical applications require regular quality control inspection during the initial phases requiring a high-speed offline measurement system to validate film thickness. Avantes thin film solutions enable high-speed spot measurements which can facilitate thin film presence and thickness validation.

Thin Film Reflectometry

Spectroscopic reflectometry involves illuminating samples with a white light (typically tungsten halogen or deuterium- halogen) at an incident angle which is normal to the sample and then measuring the reflectance and interference from the same geometry. Depending upon the nature of the coating ultra-violet, visible or near infrared wavelength measurements may be necessary to obtain an optimum fitting of the measured curve relative to the theoretical reflectance curve. The theoretical curve is developed from a database of optical constants (n and k). The "n" value is the refractive index and "k" is the extinction coefficient. The sampling process initially involves measuring a reference uncoated substrate followed by the sample measurement using the same conditions. Characteristics about the substrate (thickness and material) are inputs for the software along with characteristics of the thin film layers (material, thickness). Reflectance spectra are captured and analyzed by software algorithms which compare the measured data to theoretical calculated values derived from the database of optical constants. The software provides a calculated thickness value along with a measure of goodness of fit relative to the theoretical curve.



Single-Layer Thin Film Metrology

Avantes' single-layer thin film metrology system consists of our AvaSpec-ULS2048CL-EVO fiber-optic spectrometer, AvaLight-DHc/deuterium-halogen light source or AvaLight-HAL tungsten halogen light source, the FCR-7UV200-2-ME (optional FCR-7UV400-2-ME for higher throughput) fiber-optic reflection probe and our Thin Film Stage. The software that drives the single layer system is Avantes' AvaSoft-Thinfilm which is a 32 or 64-bit application which supports single layer measurements of thin films ranging from 10 nm-50 µm with 1 nm resolution. AvaSoft-ThinFilm supports UV/VIS and NIR wavelength measurements from 200-1100 nm. The system is available with an optional thin film standard which provides samples of uncoated and coated substrates for validation purposes. For most specular surface UV measurements, the AvaLight-DHc compact deuterium halogen source is adequate, but for more diffuse coated surfaces, the higher power AvaLight-DH-S is recommended.

Thin Film Measurement Setup

This bundle was especially designed for single layer thin film measurements, with a light source, a reflection probe and a stage and standard included. The setup can measure thin films ranging from 10 nm up to 50 µm with a resolution of 1 nm and supports UV, VIS and NIR measurements from 200 up to 1100 nm.

Typical applications:

- Semi-conductor industry
- Solar panels
- Coating

Spectrometer	AvaSpec-ULS2048CL-EVO	Grating UA (200-1100nm) 100 µm slit, DCL-UV/VIS-200 OSC-UA AvaSoft-ThinFilm
Light source	AvaLight-DHc	PS-12V/1.0A
Fiber optics	FCR-7UVIR200-2-ME	
Included	ThinFilm stage & standard	

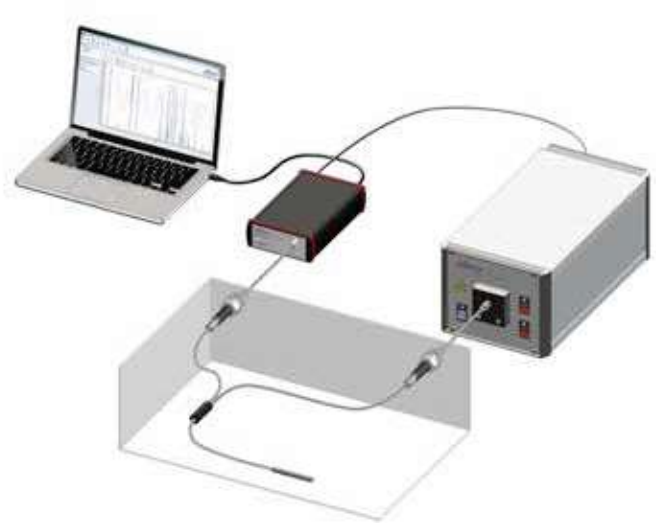
Monitoring Coating Processes in Vacuum Chambers

Layer thickness, composition, surface finish, light transmission, reflectance, polarization ability: these are some of the important parameters that need to be monitored during coating processes. They all are facilitated by spectroscopy and spectroscopic interferometry. Fiber-optics provide a versatile tool to measure in remote vacuum and clean room chambers.

The illumination and detection can be organized at different fiber positions relative to the coating: to allow specular reflection, diffuse reflection, transmission, polarization, interference, fluorescence and even Raman scattering to be measured. Fiber-optics can be arranged to either monitor several positions or to measure at different spatial positions or masking conditions simultaneously.

For on-line production environments, several fiber-optic sensors can be placed to monitor a production run. Ionic sources, such as plasma sources, can be monitored for spectral emission to confirm their conditional efficiency during the operating process.

A typical application for a vacuum chamber system is monitoring an on-line coating process on a web. For this type of system a vacuum feed-through is used to transfer light into the vacuum area and then passes to the reflectance probe. The reflected light is passed through another vacuum feed-through to a spectrometer, AvaSpec-ULS2048CL-EVO or SensLine instrument. The reflectance probe can be easily disconnected using the SMA interconnects. To compensate for fluctuations in the light source, a second channel can be added for light source reference measurements.



Vacuum Setup

Two vacuum feed-throughs are included in this bundle: one with a 200 µm fiber cable and one with a 600 µm diameter. The needed reflection probe and a deuterium halogen light source are included as well.

Typical applications:

- Coating
- Plasma

... and many more

Spectrometer	AvaSpec-ULS2048CL-EVO
	Grating UA (200-1100 nm), 50 µm slit, DCL-UV/VIS-200, OSC-UA
Software	AvaSoft-Full and ALL
Lightsource	AvaLight-DH-S-BAL
Fiber-optics	FCR-7UVIR200-2-ME FC-UVIR600-2-ME and FC-UVIR200-2-ME
Vacuum Feedthrough	FC-VFT-UVIR200 and FC-VFT-UVIR600

Plasma Measurements

Plasmas are known for many emission peaks, located closely together. To separate these peaks, Avantes has developed multi-channel spectrometers, featuring much higher resolution than a stand-alone device. For plasma monitoring, Avantes has developed two bundles, with everything you need to measure plasma.

Typical applications:

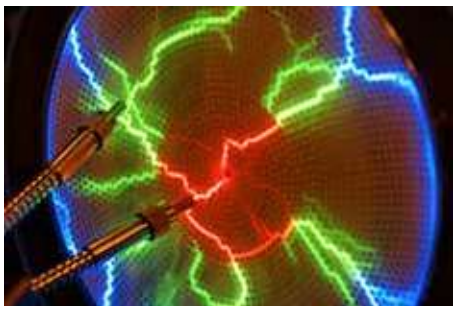
- Semi-conductor
- Solar cells
- Razor blades
- Fusion reactors
- Glass & coatings

High-Resolution Plasma Measurement Setup

This 200 to 960 nm quad-channel spectrometer boasts an optical resolution of 0.22-0.28 nm, four times better than a standard AvaSpec-ULS2048CL-EVO covering the same range. In AvaSoft Spectroscopy Software, the four channels are combined as if you were working with only one spectrometer.

Spectrometers	4-channel desktop housing 4 x AvaSpec-ULS2048CL-EVO	Gratings: • UC (200-450nm), 0.28 nm • UC (450-680nm), 0.26 nm • NC (660-830nm), 0.24 nm • NC (820-960nm), 0.22 nm All channels with 10 µm slit, DCL-UV/VIS-200 OSF-600 order sorting filter (where needed)
Fiber Optics	FC4-UVIR400-2-ME	
Software	AvaSoft-Full SPECline-A	

Extreme High-Resolution Plasma Measurement Setup



For even higher resolution than the above-mentioned quad-channel spectrometer, this version features eight channels, with an optical resolution of up to 0.09 nm. The wavelenght range is 200-930 nm, which means it detects from ultraviolet, through visibile, up to near infrared light.

The system is delivered in a 19" rackmountable enclosure.

Spectrometers	8-channel 19" rackmountable enclosure 8 x AvaSpec-ULS2048CL-EVO	Gratings: • UE (200-300 nm), 0.13 nm • UE (300-390 nm), 0.12 nm • UE (380-460 nm), 0.11 nm • UE (460-530 nm), 0.10 nm • VE (530-588 nm), 0.09 nm • VE (570-620 nm), 0.09 nm • NC (620-780 nm), 0.24 nm • NC (780-930 nm), 0.22 nm All channels with 10 µm slit, DCL-UV/VIS-200 OSF-600 order sorting filter (where needed)
Fiber Optics	FC8-UVIR400-2-ME	
Software	AvaSoft-Full SPECline-A	

Gemology Measurements

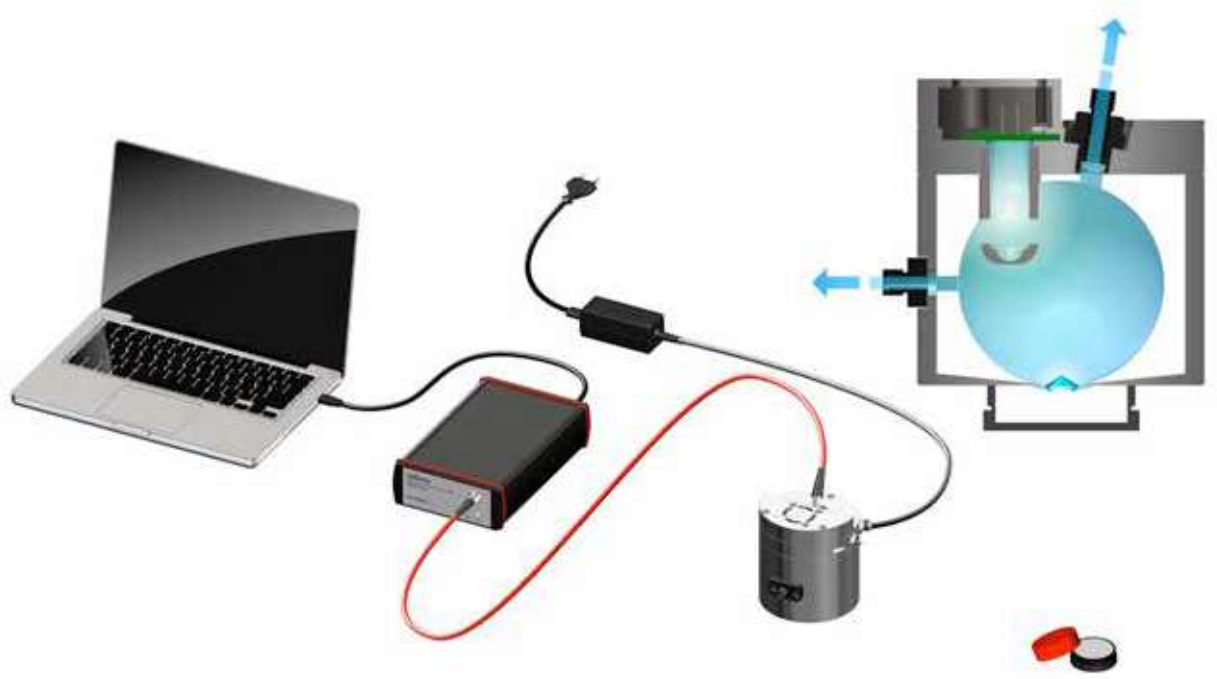
The measurement needs of the Gemology industry are demanding for a series of reasons. Chief among these can be low signal measurement and the need for rapid measurement systems to handle the volume of gemstones measured. Avantes offers basic measurement tools as well as advanced systems to meet various gemological requirements. Measurements can be accomplished with fairly simple systems using either integrating spheres or reflection probes up to photoluminescence systems requiring lasers and TE-cooled spectrometers.

Basic Gemology Measurement

Gemologists often have two basic questions, "What are the characteristics of the stone I'm asked to measure?", and "Are these characteristics natural?" This is because the industry has developed multiple methods to "enhance" stones to improve color and hide imperfections. Methods employed include heat treating, irradiating, resin filling, laser drilling and even simple surface medications such as petroleum product treatments.

A typical basis system consists of an AvaSpec-ULS2048CL-EVO spectrometer, a WS-2-GEM, white reference tile for gemology, and either an FCR-7UV200-2-BX fiber-optic reflection probe and AvaLight-HAL halogen light source or an AvaSphere-50-LS-HAL, reflection integrating sphere with Halogen illumination included. Although there are a number of possible applications, the measurement of the main chromium peaks (692.8 nm & 694.2 nm) in rubies or the determination of diamond types Ia or Ib status are frequently performed with this setup.

Type Ia or colorless diamonds show strong nitrogen absorption peaks at 415 nm and 478 nm, whereas type Ib, yellow diamonds have wider distribution of nitrogen atoms



eliminating these peaks. Other useful peaks are at 592 nm and 741 nm, peaks which indicate artificial coloring has occurred.

Advanced Gemology Measurements

Various entities report the use of photoluminescence systems to detect gemstone characteristics. This technique most often makes use of a laser excitation source, sample chamber, and detection system. The laser wavelength depends on the feature(s) being sought. Most often, the chamber will include provisions for cryogenic cooling. The detection system can range from simple cameras to photomultiplier tubes. Avantes has provided systems with various lasers as well as the AvaSpec-ULS2048LTEC (thermoelectrically cooled) spectrometer. An AvaRaman-Probe, fiber-optic Raman probe, is required as well to filter the excitation source out of the measured data.

One example of the usefulness of this technique is the detection of high-pressure, high-temperature treatment (HPHT). HPHT is sometimes used to improve diamond color, for instance turning brown diamonds into green or yellow diamonds.

Since many regulatory agencies require that all such treatments be disclosed, the chief concern is that stones could be misrepresented as natural or untreated stones. HPHT can be detected with an Avantes high-performance photoluminescence system as it leaves a trace peak at 694 nm.

Gemology Setup

In gemology, there are two basic questions: "what are the characteristics of the stone I'm measuring?" and "are these characteristics natural?"
The easy way to answer these questions is with the gemology bundle. This bundle includes a sphere and a special gemology white reference tile to quickly categorize and validate gems.

Typical applications:

- Color
- Natural or artificial
- Artificial coloring

Spectrometer	AvaSpec-ULS2048CL-EVO	Grating VA (360-1000nm) 25 µm slit, DCL-UV/VIS-200, OSC AvaSoft-Full
Fiber optics	FC-UVIR600-2	
accessories	AvaSphere-50-LS-HAL-12V AvaSphere-50-HOLD WS-2-GEM	PS-12V/1.25A

We offer three years limited warranty on all Avantes spectrometers, light sources (excl. bulbs) and accessories.

Fluorescence Measurements

Fluorescence spectroscopy, also known as fluorometry or spectrofluorometry, is a type of electromagnetic spectroscopy, which analyzes fluorescence from a sample. It involves using a beam of light that excites the electrons in molecules of certain compounds and causes them to emit light; typically, but not necessarily, visible light. It is a useful technique in many biological (chlorophyll and carotenoid), biochemical (fluorescence diagnosis of malignancies) and environmental applications. For most fluorescence applications the amount of fluorescence energy emitted is only 3% of the amount of excitation light energy. Fluorescence light has a lower energy (higher wavelength) than the excitation energy and is usually scattered light. This means it emits energy in all directions.

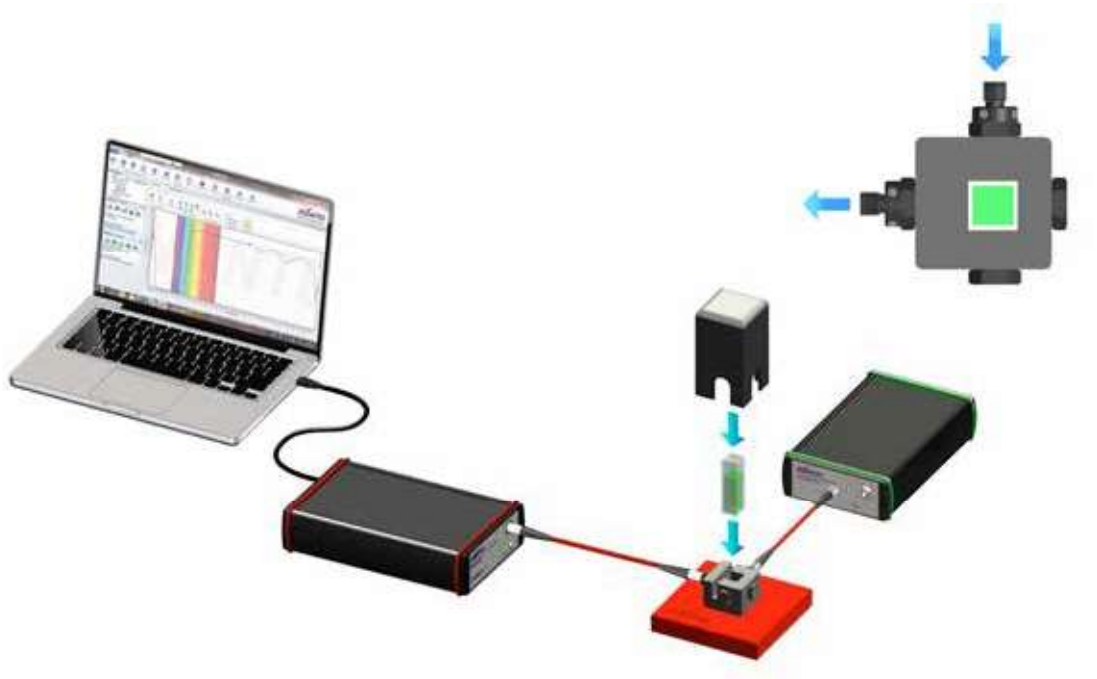
For optimal performance assuming the time acquisition window is not limited, Avantes recommends our AvaSpec-ULS2048LTEC spectrometer for this application, since it can support long integration times often exceeding 5 seconds.

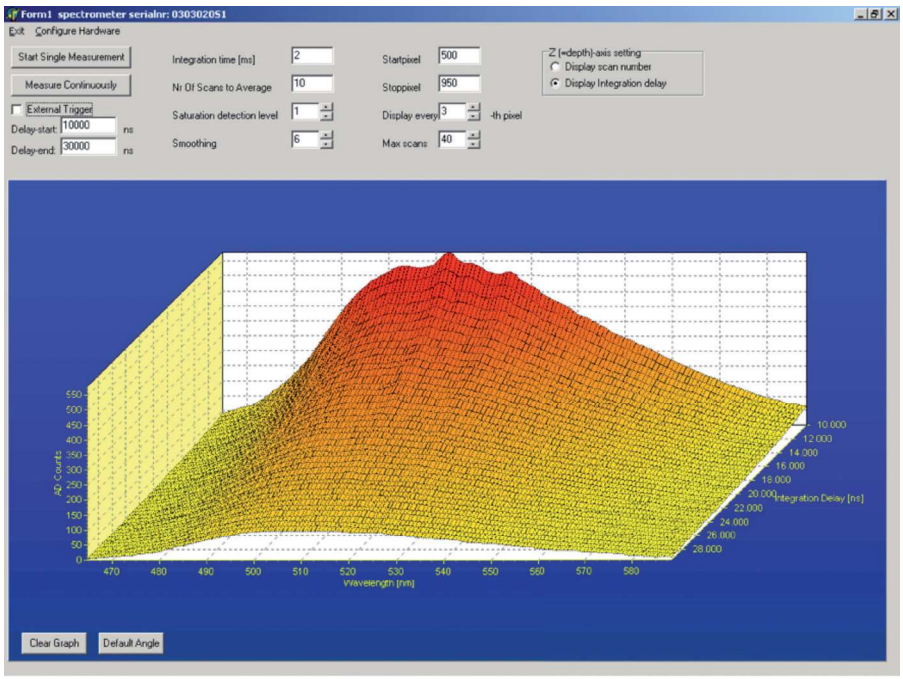
When higher-speed acquisition is required, Avantes recommends the AvaSpec-HS2048XL-EVO back-thinned CCD spectrometer. For maximal sensitivity the top model of the SensLine, AvaSpec-HERO spectrometer is recommended.

When configuring the measurement setup, preventing excitation light from entering the spectrometer is an important issue.

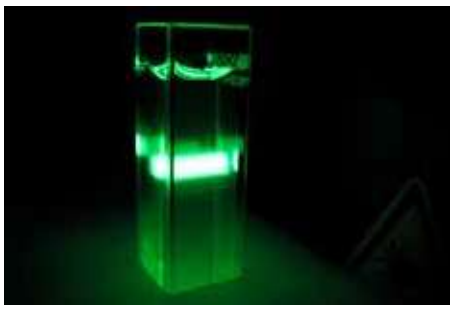
Possible methods to accomplish this, where one does not exclude the other, include:

- Make use of an AvaLight-LED light source which typically has a narrow bandwidth enabling the limitation of excitation to shorter wavelengths that are not part of the emission spectrum
- Use a broadband light source such as the AvaLight-HAL for high output in combination with an (interference) band-pass or low-pass filter.
- Make sure the optical path for excitation light and fluorescence are perpendicular. This means the excitation light will not enter the receiving fiber (use the CUV-UV/VIS-FL or the CUV-DA)
- Use the fluorescence decay time to separate excitation energy from the integration time start pulse. Use a pulsed light source to accomplish this (pulsed laser or AvaLight-XE Xenon flash)





Fluorescence Setup



In spectroscopy fluorescence is one of the more challenging setups, due to the low fluorescent emission (about 3% of the excitation energy). The AvaSpec-HS2048XL-EVO gives the highest sensitivity and the AvaLight-HPLED series provides excitation at the requested wavelength.

Typical applications:

- Dyes identification
- Fluorescent lamps
- Diagnosis of malignancies
- Fluorescent labeling

Spectrometer	AvaSpec-HS2048XL-EVO	Grating HS500-0.33 (350-1100 nm) 200 µm slit, OSC-HS500 AvaSoft-Full
Light source	AvaLight-HPLEDxxx	PS-12V/1.0A
Fiber optics	FCR-UVIR200/600-2-IND FCR-FLTIP-IND	

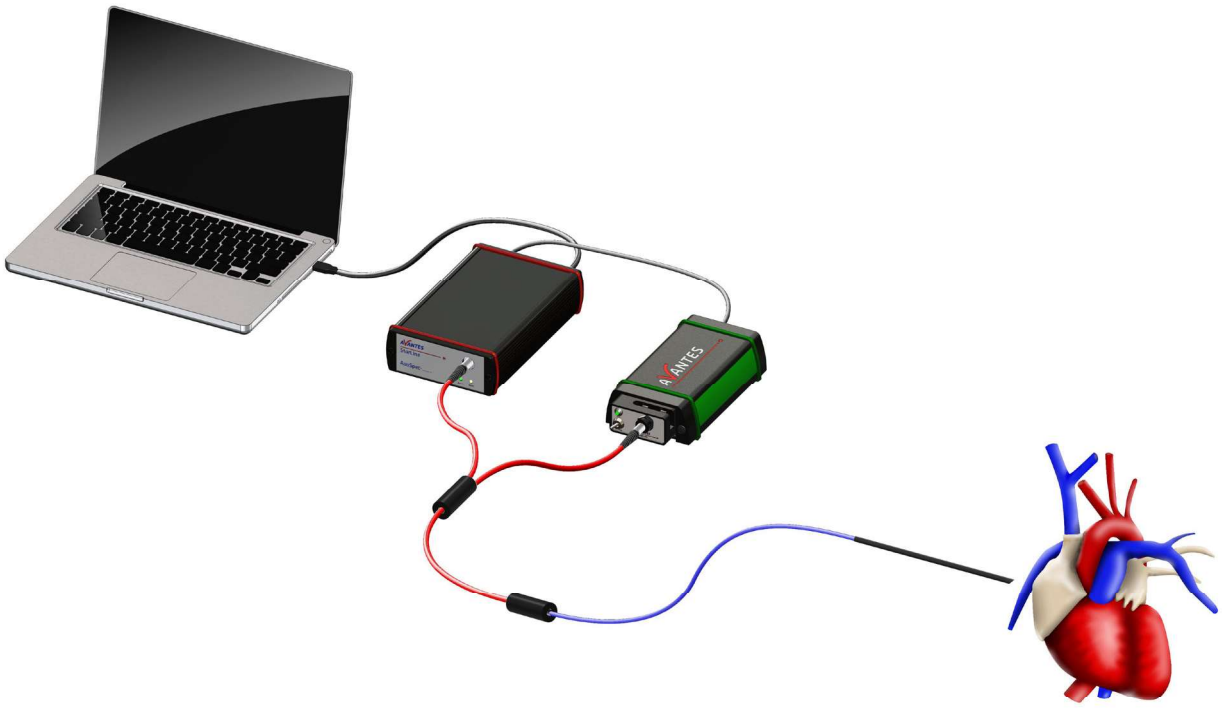
Biomedical Applications

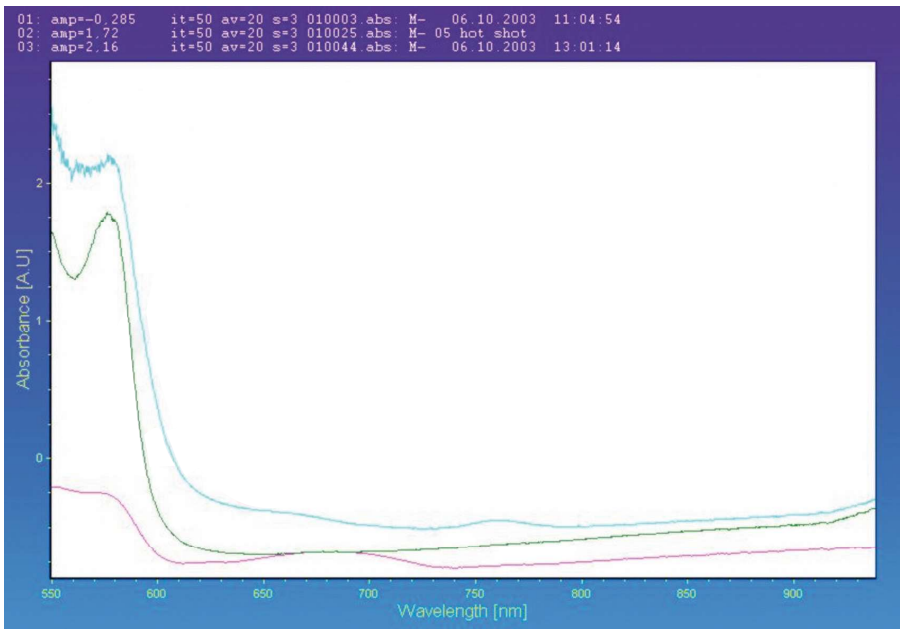
Avantes has extensive experience in the biomedical industry. Over the years, we have supported the development of both non-invasive and invasive spectrometry solutions for tissue and blood parameter measurements.

Some of the important medical indicators which Avantes has worked with include oxygen, hemoglobin, cytochrome and water concentration measurements in tissues and in the venous system. The AvaSpec-ULS2048CL-EVO and our SensLine instruments are frequently recommended for these applications. The AvaLight-HAL-S-Mini tungsten halogen light source provides an excellent, high-stability VIS/NIR source for biomedical applications involving reflection measurements. Avantes worked successfully with many customers to enable continuous measurements of oxygen saturation, concentration of total, oxygenated and deoxygenated hemoglobin.

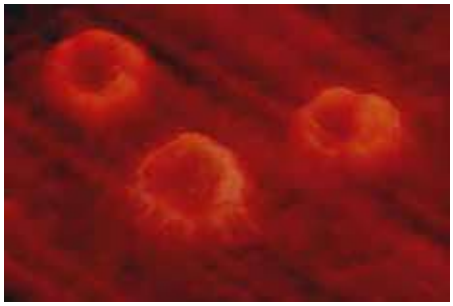
Some examples of implementations of Avantes solutions:

- Angiology / Pharmacology - Monitoring of the oxygen saturation after the application of vaso-active substances. Oxygen changes caused by Reynaud syndrome and microcirculation diseases in tissue.
- Dermatology - Detection of local -regional perfusion diseases, recurrence of melanomas.
- Diabetology - Micro-angiopathy, early detection of Endotheld dysfunction and ulceration.
- Cardio surgery - Oxygen consumption of the heart muscle during and after bypass operations.
- Neurosurgery / Oncology - Quantifying of oxygen consumption of (brain) tumors before/after radiation or operations.
- Pediatry / Gynecology - monitoring of oxygen concentration of critically ill newborns during birth.
- Plastic surgery / Transplantation medicine - Monitoring of transplanted and re-implanted tissues, bones or organs
- Accident surgery - Characterization of burned or frozen skin tissues.





Biomedical Setup



Spectroscopy helps achieve the goal of realizing non-invasive measurement devices. This bundle non-invasively measures concentrations of unknown samples or changes in concentration over time. This bundle is meant for R&D usage.

Typical applications:

- Oxygen in blood
- Hemoglobin
- Microvascular circulation

Spectrometer	AvaSpec-ULS2048CL-EVO	Grating NB (500-1000nm) 50 µm slit, OSF-475 AvaSoft-Full and AvaSoft-Chem
Light source	AvaLight-HAL-S-Mini	PS-12V/2.08A
Fiber optics	FCR-7UVIR200-2-MS-PK-S	
Included	WS-2	