

Measure LEDs Better

Getting the correct reading when measuring LEDs is not always straightforward. First you have to overcome the jargon used to describe their output, then decide which parameter you need to measure. The right kind of test equipment is the next decision, and life is not made any easier when standard photometers can grossly misrepresent the light level from LED-based solid state lighting.

Here at Pro-Lite, we have been working with LEDs for nearly 20 years and we understand the science of optical radiation measurements. Choosing equipment from us means you can tap into our expertise and have confidence you are making your measurements the correct way.

Our approach has been to put together a complete range of instruments for almost any application in LED measurement, a strategy we call "TOTAL LED MEASUREMENT". We have partnered with some of the leading, global specialists in this field, including LABSPHERE, KONICA MINOLTA, RADIANT IMAGING and OCEAN OPTICS to bring you creative solutions to even the most challenging light measurement problem.

Let us help you to measure better.

See us at the following events:

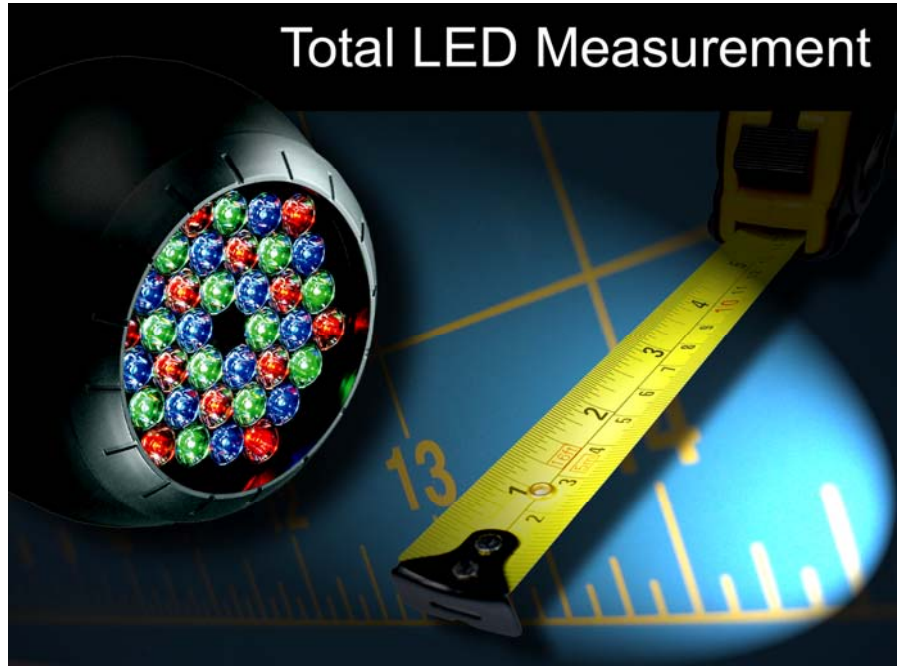
June 4-5: euroLED 08 conference & exhibition (Ricoh Arena, Coventry).

<http://www.euroled.org>



July 10: Practical Light Measurement Training Course (Photonics Cluster, Aston Science Park, Birmingham).

<http://www.photonicscluster-uk.org>



Total LED Measurement

Pro-Lite serves the LED and solid state lighting industries with integrating sphere photometers from Labsphere and CCD imaging photometers from Radiant Imaging. As a result of recent alliances, we also now supply spectrometers from Ocean Optics and a full range of light meters from Konica Minolta. Pro-Lite is now uniquely placed to provide equipment and services for measuring almost any LED and display parameter, including:

- ▶ Forward or total luminous flux (lumens)
- ▶ Intensity (candelas)
- ▶ Luminance (candelas/m²)
- ▶ Illuminance (lux)
- ▶ Spectral power distribution
- ▶ View angle
- ▶ Chromaticity
- ▶ Correlated colour temperature
- ▶ Dominant wavelength & purity
- ▶ Colour rendering

This newsletter provides an overview of all of the equipment and services we offer for those working with LEDs and solid state lighting. The newsletter lists suitable measurement equipment for each optical parameter separately.

For further details on any product mentioned, we invite you to visit:

<http://www.pro-lite.co.uk/File/led.php>

LED Jargon Buster

LUMINOUS FLUX: the total photometric power emitted in all directions, measured in lumens.

LUMINOUS INTENSITY: the luminous flux from a point source emitted per unit solid angle, measured in candelas.

ILLUMINANCE: the luminous flux received per unit area, measured in lux.

LUMINANCE: the luminous flux emitted per unit solid angle and per unit area. In the SI system, luminance is measured in candelas per square meter, but the nit is often used instead.

CHROMATICITY: defines the colour of a lamp. A simplified numeric system based upon the ratio of the three tristimulus values X, Y & Z in relation to the sum of the three.

CORRELATED COLOUR TEMPERATURE: CCT describes the colour of white LEDs. It is the blackbody colour temperature that the LED most closely resembles, reported in units of Kelvin.

DOMINANT WAVELENGTH: a useful measure of the colour of a coloured LED, being the monochromatic wavelength (in nm) that the LED most closely resembles.

<http://www.pro-lite.co.uk/File/glossary.php>

Measuring the Total Flux of LEDs

With the advent of high brightness LEDs intended for illumination applications, measuring the total flux of LEDs has become widespread. Flux is measured using an integrating sphere. The size of sphere is chosen based upon the "power" (flux level) and size of the sample. Luminous flux can be measured using an integrating sphere equipped with a photodiode fitted with a filter that imparts a photopic spectral response. For improved accuracy, a CCD spectrometer measure the spectral radiant flux and computes the luminous flux and colour parameters. Uniquely, spectroradiometers also provide colour rendering information.

Luminous Flux of Single LEDs

The Labsphere HLMS-200P is an affordable, handheld, filter-photometer complete with built-in 50mm integrating sphere that can measure the forward luminous flux in lumens from single LED emitters. With a 12mm entrance port, the HLMS-200P can measure light levels from 0.05 to 7,000 lumens.



Labsphere HLMS-200P
Portable Flux Meter

Forward Spectral Flux of Single LEDs

The Ocean Optics USB4000 fibre optic spectrometer forms the heart of a highly affordable spectroradiometer that can measure the forward flux of single LED emitters when equipped with the FOIS-1 38mm integrating sphere. From the measured spectral radiant flux, the SpectraSuite software computes the luminous flux, chromaticity, colour temperature, dominant wavelength and colour rendering of the LED. The USB-4000 can also be configured for measuring the illuminance and intensity from single LEDs as well as LED clusters and complete luminaires.



USB4000
Plug & Play
Spectrometer

Total Spectral Flux of High Power LEDs and LED Clusters

Labsphere's SLMS and CSLMS spectroradiometer systems employ versatile, interior-access integrating spheres ranging in size from 25cm to 2m to handle the measurement of any type of sample, from 0.1 lumens up to 260,000 lumens. Total flux is measured with the sample placed within the sphere; forward or partial flux is measured with the LED placed at a 50mm port on the sphere wall. From the measured spectral radiant flux (350-1050nm), the LED-specific LightMtrX software computes luminous flux, radiant flux, correlated colour temperature, chromaticity, dominant wavelength and colour rendering. Choose from two grades of spectrometer: SLMS systems employ room-temperature detectors; CSLMS models use a TE-cooled, and back-thinned CCD array to increase measurement sensitivity and improve signal to noise at long exposure times.



Ocean Optics USB4000 for
LED Measurements

The SLMS / CSLMS systems also promote enhanced measurement accuracy through the use of **auxiliary correction**. The fitment of an auxiliary lamp allows for the complete correction of the sample absorption and reflection errors that could otherwise run to many tens of percent. Auxiliary correction is vital if you are to avoid a gross under-reading as a result of lenses, reflectors, heat sinks and drive electronics that are placed in the sphere with the LED. Similarly, gross over-readings arising from reflections from samples placed externally can also be corrected using the auxiliary lamp. Modular accessories for the SLMS / CSLMS systems allow reconfiguration for spectral irradiance (illuminance), spectral intensity (luminous intensity) and angular intensity measurements.



Labsphere LMS-100
25cm Integrating Sphere for
Total Flux Measurements

For further information: <http://www.pro-lite.co.uk/File/led.php>

Tech Note: Total Flux

Flux is the term used to describe the total light emitted from an LED, often incorrectly called the power. Total flux is that which is measured from an LED in all directions; forward or partial flux is a measurement of only those rays propagating forwards. The units of flux are lumens, Watts or Watts/nm.



Case Study: Testing the Efficiency of LED Lenses

Carco Technical Plastics (CTP), a leader in the field of LED optics, developed a range of high-efficiency lenses for use with Luxeon high power LEDs from Lumileds. CTP needed a means of determining the throughput efficiency of the lenses, a measurement made more difficult by the fact that the LED optics were available with half angle divergences between 1.5 and 45 degrees and diameters from 20 to 60mm. A Labsphere integrating sphere photometer provided CTP with a simple means of accurately measuring the photometric throughput efficiency of the lenses. The integrating sphere was used to record the total luminous flux from the LED with and without the lens in place. Reflection errors from the lenses were simply solved using auxiliary correction.

To learn more about this and other applications of our instruments, visit www.pro-lite.co.uk/File/case_studies.php



Measuring the Intensity of LEDs

The decision on whether to measure the intensity or flux from an LED depends upon the intended application. High power LEDs are typically used for illumination, making a flux measurement appropriate. On the other hand, low power LEDs are mainly used as indicator lamps, making an intensity measurement the correct test. A photometer measures luminous intensity in units of candelas, which is a lumen per steradian. A spectroradiometer measures spectral radiant intensity in units of Watts per steradian per nm and computes the luminous intensity and colorimetric parameters.

Average Intensity of Single LEDs

The Labsphere I-1000 and I-2000 are LED intensity heads that conform to the requirements of CIE 127 for average, near-field intensity measurements. The I-1000 tube measures LEDs held at 100mm (condition B), whereas the I-2000 is made up of two parts that support measurements at either 100mm or 316mm (condition A). The device under test is either held in place at the input using a Labsphere LS-series LED holder, or using a customer-supplied jig. The I-1000 / 2000 are used in conjunction with a Labsphere CDS-series CCD spectroradiometer which measures the spectral radiant intensity from 350-1050nm.

LightMtrX application software computes the luminous intensity, chromaticity, dominant wavelength, colour temperature and rendering. Calibration of the Labsphere intensity heads is either performed at the factory, or an optional intensity calibration lamp is available (model IES-1000) to allow the user to perform the calibration in-situ.

Far-Field Intensity Measurements

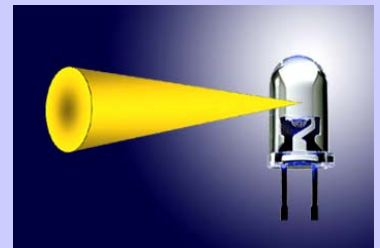
The Ocean Optics USB4000 fibre optic spectrometer that provides a highly-affordable platform for testing LED flux can also be configured for far-field intensity measurements. This type of measurement should not be used for single LEDs; instead, far-field measurements are performed on LED clusters and arrays, or on complete LED luminaires. The preferred configuration places a cosine diffuser at the input to the optical fibre, which is calibrated using a spectral irradiance standard.

The system directly measures spectral irradiance, and by entering the steradian field of view into the SpectraSuite software, the luminous intensity of the lamp is reported. Being a spectroradiometer, the colour and colour rendering properties of the lamp are also calculated.

For further information:
<http://www.pro-lite.co.uk/File/led.php>

Tech Note: Intensity

Intensity is the flux emitted from a lamp per unit solid angle. Intensity is what you measure when the lamp is a point emitter, in other words you are in the photometric "far-field". Conversely, when you move up close to the source ("near-field"), you transition to measuring luminance. Intensity should be measured in a defined direction; unless the lamp is isotropic, the intensity will vary with direction of view. The units of intensity are candelas, Watts/steradian or Watts/steradian.nm. A candela is a lumen per steradian (the unit of solid angle). Intensity does not vary with distance from the lamp.



Intensity measurements are often realised using a photodetector (or spectrometer) placed at the end of a baffle tube, viewing the LED within a defined field of view and at a known distance. In reality, intensity photometers often record the illuminance of the lamp and one converts from lux to candelas by multiplying the illuminance by the square of the distance between the lamp and the detector.

The problem with LEDs is that they don't conform to the ideal of a point source which meant in the past that measurements of far-field intensity were highly instrument-specific. CIE 127 addresses this by defining standard measurement geometries. The CIE geometry defines – in effect – a near-field or average intensity. A photodetector with an area of 100mm² views the LED at a distance of either 100mm (condition B) or 316mm (condition A), equivalent to view angles of 0.01 or 0.001 steradians respectively.



Labsphere's modular system for measuring the spectral intensity and view angle of single LEDs

- 1 LSA-3000 goniometer
- 2 CDS-1100 CCD spectrometer
- 3 I-2000 intensity receiver
- 4 I-1000 intensity receiver
- 5 IES-1000 calibration source
- 6 LS LED sockets

Measuring Illuminance

Illuminance is what you measure when you want to know the light level in lux reaching a surface from an LED, or more likely, an LED cluster or luminaire. Illuminance varies with distance, so measurements must be performed in-situ. Far field spatial illuminance measurements are frequently performed to assess the output of luminaires; knowing the distance between the lamp and detector allows for the calculation of intensity versus angle and the generation of IES plots. For the ultimate in simplicity and productivity, an imaging photometer based upon a CCD detector can be used to measure the spatial illuminance (or luminous intensity) from a lamp at literally millions of positions (or angles) in an instant.

Portable Illuminance Meters

Portable illuminance photometers such as the T-10 from Konica Minolta are the workhorses of photometry. Often called simply "lux" meters, they record the illuminance in lux at a specified distance from a lamp or luminaire. A cosine diffuser correctly scales the effective illuminance of off-axis rays. Compact, portable and inexpensive, the T-10 is quick and easy to use.

Portable Illuminance Colorimeters

The CL-200 from Konica Minolta combines the functionality of an illuminance photometer with a tristimulus colorimeter to give readings of lux, chromaticity and colour temperature.

Spectral Irradiance Measurements

The Labsphere E-1000 is an accessory integrating sphere receiver for the SLMS or CSLMS modular LED measurement systems that provides for spectral irradiance and hence high accuracy illuminance and chromaticity measurements.

Spatial Illuminance Measurements

Many applications in photometry require knowledge of the spatial or angular light output from a lamp. There are two approaches you could take: you could use a simple illuminance photometer and measure the light level point by point; or you could use an imaging photometer that measures the light level at literally millions of points instantaneously.

ProMetric™ imaging photometers from Radiant Imaging are powerful light and colour measuring instruments based upon CCD sensors. An illuminance measurement made using a ProMetric photometer is like taking a high resolution digital photograph. The lamp illuminates a white screen and the ProMetric camera takes a picture of the beam pattern on the screen. The difference is that the picture is encoded with the illuminance and chromaticity of every point in the image. Powerful application software reports the spatial illuminance distribution as well as the variation of luminous intensity with angle. Measurements made using an imaging photometer save time compared to spot measurements and potentially yield illuminance and colour differences that simple spot meters might well miss. As the case study opposite reveals, the power of an imaging photometer can easily be harnessed to perform an automated sequence of measurements to verify the performance of a light source.

For further information: <http://www.pro-lite.co.uk/File/led.php>



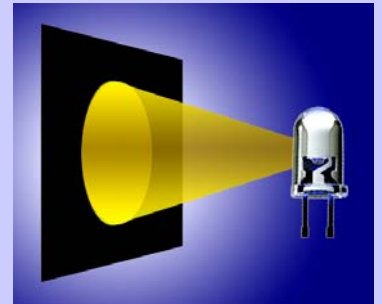
Konica Minolta T-10 Illuminance Meter



Radiant Imaging ProMetric™ CCD Imaging Photometer / Colorimeter

Tech Note: Illuminance

Illuminance is the luminous flux per unit area received at a surface, measured in units of lumens per square meter (lux). For a point source in the far-field, Illuminance decreases with the square of the distance away from the lamp (the so-called "inverse squared law"). The illuminance at a surface tilted at angle θ to the direction of illumination is reduced by the cosine of θ . It is for this reason that illuminance photometers are normally equipped with a cosine diffuser which scales the off-axis illuminance to take account of the reduced illuminance at higher angles.



Case Study: Automotive Headlamp Beam Pattern Testing

Ring Automotive needed a means of assessing the performance of their high performance auto headlamp bulbs. Concerned with the speed, complexity and cost of a traditional goniophotometer, Ring chose a ProMetric™ CCD imaging photometer for its speed, ease of use and relative affordability. To further enhance its utility, Radiant Imaging were commissioned to write custom software for the ProMetric camera to automate the testing of Ring's lamps in accordance with ECE R20.

To learn more about this and other applications of our instruments, visit www.pro-lite.co.uk/File/case_studies.php



Measuring Luminance

Luminance is often – incorrectly – called the “brightness” of a light source. It is the luminous flux emitted per unit area per unit solid angle. Luminance is what we see when we look at a computer screen or display. Luminance measurements are performed close up to the light source (the “near field”); conversely, intensity measurements are what you perform when the emitter behaves as a point source in the far field. You would rarely measure the luminance of a single LED; rather, luminance is the appropriate measure of the output of a cluster of LEDs used as a flat panel display backlight or as a display in their own right. Spot luminance meters measure the brightness of one point on a display at a time; imaging photometers based upon a CCD detector can be used to measure the spatial luminance at literally millions of positions in an instant. For the highest colorimetric accuracy, a spectroradiometer records the spectral radiance across the visible spectrum one wavelength at a time, from which the luminance and chromaticity are calculated.

Portable Luminance Meters

The **Konica Minolta LS-100** is a portable single lens reflex (SLR) luminance meter with a 1° acceptance angle. Simply focus the meter onto the display, press the trigger and record the luminance from the measurement spot. The LS-110 features a more limited 1/3° field of view. Optional close-up lenses allow for measurements as small as 0.4mm diameter.

Portable Luminance Colorimeters

The **CS-100A** from **Konica Minolta** is a portable SLR luminance colorimeter (“chroma meter”) with 1° acceptance angle for measuring luminance as well as chromaticity and colour temperature. The **CS-200** uses a novel “spectral filtering method” to combine a colorimetric accuracy comparable to many spectroradiometers with the simplicity and affordability of a tristimulus colorimeter. The CS-200 has selectable 1, 0.2 and 0.1° view angles.



Konica Minolta CS-200 Chroma Meter

Spatial Luminance Measurements

Radiant Imaging's ProMetric™ CCD imaging photometers are powerful light and colour measuring instruments that can instantaneously measure the spatial luminance and colour from flat panel displays, backlights, LED arrays, automotive instrument panels and traffic signals. Because the ProMetric camera views the whole display in a single measurement, localised luminance and colour differences can easily be detected – artefacts that spot measurements may well miss.

Each ProMetric camera comes with powerful Windows-based application software that provides for instrument control, data acquisition and sophisticated image analysis. Supplementary applications include **PM-LED** for automated LED array measurement, **PM-OLED** for testing OLED displays and **PM-LED Correction** for setting the colour and luminance balance of LED display panels.



Radiant Imaging PM-1400F CCD Imaging Photometer / Colorimeter

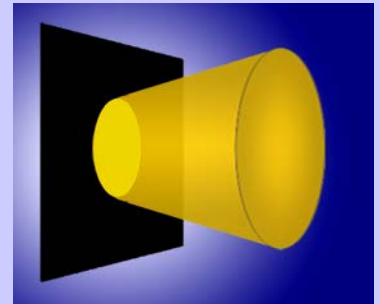
Spectral Radiance Measurements

The **Konica Minolta CS-2000** is a state-of-the-art polychromator-type spectroradiometer that has been specifically designed to accurately measure the wide dynamic range luminance from today's display devices. Of note, the CS-2000 is able to measure to very low luminance levels (0.003cd/m²) and also handle contrast ratio measurements of up to 100,000:1.

For further information: <http://www.pro-lite.co.uk/File/led.php>

Tech Note: Luminance

Luminance is the luminous flux per unit area per unit solid angle emitted from a light source, reported in units of lumens per square meter per steradian or candelas per square meter (cd/m²) or nits. Luminance measurements measure the “brightness” of the emission from a defined area on a light source or display, hence they are often called “spot photometers”. Luminance is what you measure when you are in the near-field (intensity is the far-field parameter). Luminance meters employ a lens to image a defined area on the light source. Unless the light source is Lambertian, luminance can vary with viewing angle, hence it is necessary to specify the direction of view when making luminance measurements.



Case Study: Instrument Panel Testing

Bentley Motors chose a Radiant Imaging ProMetric™ CCD imaging photometer to simplify the testing of automotive instrument panels and to ensure that the LEDs selected provide consistent illumination, create the required level of luminance and emit exactly the desired colour. The PM-1400 selected provides colour and brightness measurements which Bentley can rely upon for accurate communication of LED and display performance within its supply chain.

To learn more about this and other applications of our instruments, visit www.pro-lite.co.uk



Measuring View Angle

LEDs are not isotropic light sources, meaning that their intensity varies with direction of view. The two properties from an LED or LED array that one would wish to measure as a function of angle are the luminous intensity (in candelas) or the luminance (in candelas per square meter). Measurements of intensity versus view angle are performed on a single LED whereas luminance versus angle is performed on an LED backlight or cluster. View angle is the simplified reporting of the angular extent of emission; for a single LED, the view angle is the angular range over which the LED's emission falls to 50% of that at its peak. The instrument used for measuring the angular variation from an LED is called a goniophotometer. Traditional goniophotometers rotate the sample one angle of azimuth and elevation at a time about a fixed direction of view. A novel alternative that measures the angular emission instantaneously over the complete 2π steradian hemisphere is the Imaging Sphere from Radiant Imaging.

Luminous Intensity Versus Angle

The **Labsphere LSA-3000** is a compact, self-contained, motorised goniophotometer with an on-board photodetector for relative intensity versus angle measurements with individual LEDs. It can also be used in conjunction with the I-1000 / I-2000 intensity heads and a CDS-series CCD spectrometer for measuring the absolute luminous intensity and colour as a function of angle.

The **Imaging Sphere IS-LI** is by far the fastest LED goniometer on the market today. Combining a ProMetric imaging photometer with a low gain dome, it measures the far-field luminous intensity (and colour) versus angle from LEDs and other small light sources over the complete hemisphere in seconds. The speed of the Imaging Sphere is orders of magnitude faster than a motorised goniometer, making production line testing of LED view angle an economic reality. As a further bonus, the ProMetric camera can be decoupled from the Imaging Sphere for spatial illuminance and luminance measurements.



Radiant Imaging's Imaging Sphere Goniophotometer

Luminance Versus Angle

The variation of luminance (and colour) over the complete hemisphere for one area on a display at a time is measured using the **IS-VA Imaging Sphere**. An optional motorised translation stage can be used to simplify view angle measurements over the complete display if required.

The measurement of luminance (and colour) for the whole display for one angle at a time is performed by the **ProMetric Flat Panel Measurement System (PM-FPMS)** made by Radiant Imaging. A ProMetric imaging photometer views the LED array which is mounted on a motorised goniometer platform.



Radiant Imaging's FPMS Flat Panel Goniophotometer

Source Imaging Goniometer

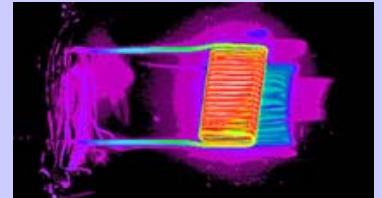
The **SIG-300** from Radiant Imaging is a source imaging goniophotometer that measures the near-field variation of luminance and colour with view angle from LEDs and other light sources. The SIG-300 is the instrument we use to perform Radiant Source Model testing (see box opposite) and possesses the extremely high stability and precision necessary to generate accurate source luminance mappings.

For further information: <http://www.pro-lite.co.uk/File/led.dho>

Software Tools: Design Better with Radiant Source™ Models

Ray-trace more accurately, reduce development costs and bring LED-based products to market more quickly with Radiant Source Models and ProSource® software. Radiant Source Models are the most accurate method for design engineers to model the near-field output of LEDs in optical and illumination design software. Radiant Source Models are data files mapping the luminous intensity or colour from an LED in all directions. Radiant Source Models require a ProSource licence and are compatible with leading optical and illumination design software programmes, such as ASAP, LightTools, TracePro and ZEMAX.

www.pro-lite.co.uk/File/software_overview.php



At Your Measurement Service

Pro-Lite offers cost-effective contract measurement services in two areas. 2D luminance and colour measurements of displays, LED clusters, illumination systems and signage are provided using our Radiant Imaging Pro-Metric CCD imaging photometer. Meanwhile, spectral flux and colour measurements on LEDs and other small light sources are made using our Labsphere integrating sphere spectroradiometer.

www.pro-lite.co.uk/service_overview

Measurement Training Course

For those working with LEDs, learn how to speak "LED", measure accurately and ease the pain of communicating specifications to your supply chain. Our one-day Practical Light & Colour Measurement Course has been universally praised for making the science of light measurements accessible and has been presented to more than 120 people since 2005. This course is delivered through the Photonics Cluster in Birmingham, although bespoke, on-site courses can be provided.

www.pro-lite.co.uk/training_overview

iLiTES is published by:

Pro-Lite Technology LLP, Innovation Centre, University Way, Cranfield, MK43 0BT, United Kingdom
Tel: +44 (0) 1234 436110 Fax: +44 (0) 1234 436111 info@pro-lite.co.uk www.pro-lite.co.uk