Optimal Lighting Design Boosts Efficiency of Medical Diagnostic Instruments

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Laboratories and hospitals around the world rely on *in vitro* diagnostic instruments to test samples such as blood and tissue to diagnose a host of diseases and health problems. Most of these instruments use fluorescence-based approaches that require light at specific intensities and wavelengths to excite fluorescent probes used to detect proteins, antibodies, or cell states that can be used for medical diagnosis.

Although samples are traditionally sent to an off-site laboratory or central hospital site for testing, there are now *in vitro* instruments that can be used in a doctor's office or hospital unit. This allows the patient to receive a quick result rather than waiting a day or more. As more *in vitro* diagnostic instruments move toward point-of-care applications, there is a push for machines that are less expensive and easier to service and use.

For *in vitro* diagnostic instruments large and small, working with a trusted lighting expert can ensure an efficient light system designed to meet the specific requirements for the fluorescence tests performed by the instruments. With more instruments using LEDs, a lighting expert can also help with some of the challenges and intricacies that come with this popular light source.

A CUSTOMIZED APPROACH

Although it may seem simple enough to deliver light at a certain intensity and wavelength, off-the-shelf components typically don't offer the most efficient light delivery. In fact, large machines used by diagnostic laboratories or hospitals often lose about 90 percent of the light produced. As diagnostic machines get smaller and, in some cases, even portable, this inefficiency becomes more concerning because it means more energy is needed to run the machine and bulky fans must cool the instruments because the escaping light generates a large amount of heat.

A lighting expert can use design software and optical expertise to design the most efficient lighting system possible based on the light parameters necessary to run the fluorescence analysis while meeting all the regulatory requirements for medical devices. Choosing the right light source is one of the first decisions, and sometimes it can be a difficult one. Although LEDs are often used, some fluorescence tests require wavelengths that aren't available from off-the-shelf LEDs or aren't available at high enough intensity. Although this may cause a

problem for some suppliers, a lighting expert can use their optical expertise to create a combination of LEDs or a customized filter to achieve the desired wavelength. They can also decide if other light sources such as lasers should be considered.

This process not only involves choosing the best light source but designing the entire optical system. This includes selecting the optical fibers for light delivery, whether they are made in-house or obtained from another supplier. For some applications, high-quality glass fibers are the best choice. For instruments where cost is the primary concern, less-expensive plastic optical fibers can be used. However, these come with a trade-off of a short lifetime due to degradation.

When choosing a light expert, it is important to work with a company experienced in the medical application field. Also check for quality management systems such as ISO 13485 that show it can meet medical regulations and provide the required traceability for all components. In this market it can take years to get from the first prototype to a product that is profitable. This means you want to work with a lighting partner that has the financial standing to work on long projects that don't generate immediate payback. A large, financially secure company also has the insurances in place to handle liability issues, which are always possible when dealing with medical instruments.

BULBS VS. LEDS

For years, diagnostic instruments were designed for halogen or mercury lamps or xenon bulbs. These types of light sources are very stable, meaning they maintain the same intensity and wavelength throughout their lifetime. However, they must be replaced after 50 to 200 hours. LEDs, which offer lifetimes of years rather than hours, are now replacing traditional bulbs. Using a light source with such a long lifetime means large diagnostic instruments require very little downtime to change the light source. Because these machines often cost hundreds of thousands of dollars, or even as much as $1 million, not having to replace the bulb every 200 hours can keep labs profitable.

For smaller instruments, such as the ones used in doctor's offices or in a single hospital unit, changing a bulb every month could be burdensome to the medical staff. LEDs offer an inexpensive and long-lasting light source that helps reduce the size of the instrument as well as cost of operation because they don't require as much power to run.

Although LEDs bring some important advantages, there are a few challenges to using them in diagnostic instruments. LEDs loose intensity over time because of an inherent physical phenomenon. Over their long lifetimes this phenomenon can cause reductions in light intensity by as much as 70 percent, and the wavelength can also drift. These performance

changes aren't noticeable when LEDs are used for lighting applications or to backlight a television but surely affect the test results produced by diagnostic instruments.

SENSOR TECHNOLOGY FOR MANAGING AGING LEDS

Although drifts in intensity or wavelength due to aging cannot be eliminated, a lighting expert can help manage them in several ways. First, the entire lighting system, including the associated electronics, can be designed to manage the aging of LEDs. This might include running the LEDs in a temperature-controlled environment to help prevent aging or ensuring stable junction temperature by locally cooling or even heating the LED. The smartest way to manage the aging phenomena is through sensor technologies that monitor the intensity and wavelength output of the LEDs. These systems can be passive in that they monitor the output and raise an alarm if it goes beyond certain thresholds. There are also active sensor control systems that permanently measure the output of each LED and reconfigure the driving parameters by giving the LED more power, for example, to keep the light at a constant, defined intensity. Active systems help ensure the LEDs can be used for their full 20,000- to 30,000-hour lifetimes by adjusting the output as needed and then triggering an alarm when the LED can no longer be kept within operating conditions.

Although long lifetime is one of the biggest advantages of LED light sources, when they do fail after years of use, the exact LEDs originally used may no longer be available. Even if extra LEDs were stored in a controlled environment, they will not operate like new LEDs because they still age. Even when LEDs age together they lose intensity at different rates, making it challenging to combine them in an instrument. A lighting expert can help by foreseeing this problem during the design phase and implementing what is known as obsolescence management. This requires specifying the output intensity and wavelength of the LED light source instead of the exact LED, so it can be replaced with any light source that meets those specifications. This capability needs to be designed into the original diagnostic instrument so that the light source and any monitoring technology are housed in a modular unit that can be quickly switched out for another modular unit when needed.

In conclusion, partnering with a reliable lighting expert with experience in medical diagnostics can ensure your lighting system is optimized to a specific instrument and application and generates homogeneous light that facilitates comparable and meaningful *in vitro* diagnostic analysis.

About SCHOTT AG Lighting and Imaging

SCHOTT AG Lighting and Imaging develops, manufactures, and distributes fiber optic components for light and image transmission. Our portfolio comprises flexible and rigid components as well as hybrid products based on LED and fiber optic technology. We have been providing customized solutions to medical instrument manufacturers and working in medical applications for more than 50 years and have 130 years of experience in specialty glasses and materials. Our PURAVIS® high-performance glass optical fibers are ideal for many fluorescence-based diagnostic instruments because of their extremely long lifetimes, high color uniformity and light output, and improved transmission in the near-UV range.

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