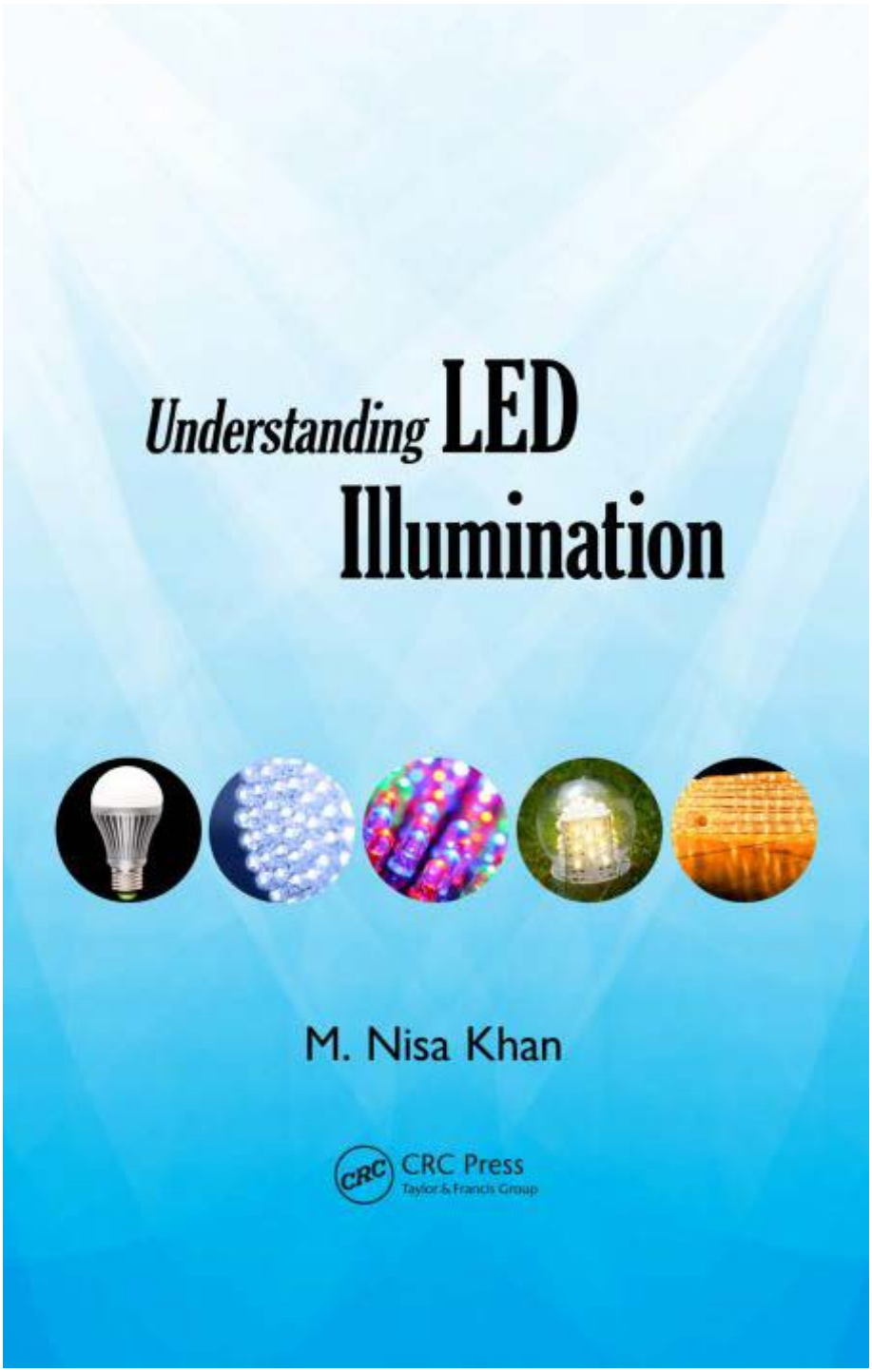

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LED UPDATE

By Dr. M. Nisa Khan

As president of IEM LED Lighting Technologies, Dr. M. Nisa Khan consults in the solid-state lighting industry and educates consumers about LED lighting. She has a bachelor's degree in physics and mathematics, and master's and Ph.D. degrees in electrical engineering. Email her at nisa.khan@iem-led.com

Understanding LED Illumination

My forthcoming book addresses science, art and the human psychology of LEDs and lighting.

Over the past 100 years, electric lights have enormously changed the world by offering visibility during darkened hours. Electric lamps have brought benefits to personal lives and every aspect of society – education, manufacturing, entertainment, government and all other professions. They have also illuminated signs and boosted sales for businesses.

Unfortunately, artificial lighting still has not reached many parts of the world because a standard, electric-power source and distribution grid system is too costly to build in many impoverished countries. However, LED lamps are attracting attention as alternatives because they're a practical, low-power, electric-light system that doesn't require a grid. LED lamp technologies that incorporate smart controls promise to revolutionize the lighting industry by lowering energy consumption. Such systems will also feature increased lifespan and improved reliability compared to incandescent and fluorescent lamps.

The world could save a great deal of energy by switching to LED lighting, because the systems are more efficient and can run both on and off an electric grid. To reach this goal, the LED and the traditional lighting industries must close their long-standing gap.

So, what actually is this gap and how can relevant industry participants close it?

The more I learned about lighting, the more the gap became readily apparent.

I came into the lighting industry from the optoelectronics industry, which actually spawned LEDs decades ago. Previously, I had worked as a physicist and electrical engineer, having concentrated on optical science and semiconductors. Like many professionals in the optoelectronics community, I innovated new optical technologies and products.

Although the optics field requires intricate work, few, if any, of us, really understood or appreciated lighting. This note has been echoed by many lighting authorities, including Dr. David DiLaura who, at Lightfair 2009, said, "…LED people don't know lighting from licorice, but that they will learn."

He was right on both counts.

Lighting is an optical science. It deals with electromagnetic radiation within the visible spectrum. It's also art, and relevant to human psychology. Note, also, that lighting, meaning the illumination of an area, deals with light perceived by the human eye, which is different from light captured by photodetector devices.

The distinction is complicated, but important to recognize. Physical lighting quantities are only perceptions of the human eye, and these perceptions aren't truly analogous to other physical quantities.

For example, optical power detected by a fabricated sensor is radiant optical power measured in watts, but we don't "see" watts. What we see is luminous flux, which we quantify with a parameter called "lumen".

It all leads to the distinction between efficiency (the degree to which something is done well) and efficacy (the ability to produce the desired result). Lighting scientists express the merit quantity "lumen/watt" as efficacy (use "efficiency" when both quantities before and after conversion can be expressed by the same unit).

Luminous flux is generated from radiant power emitted by a lightsource, and it usually scales with the source power – but not always and not always the same way. Radiant power converts to what we perceive by weighting it with the human-eye sensitivity function at each wavelength in the visible spectrum and then summarizing them. However, applying such a conversion method doesn't always lead to what we see in different environmental conditions, because our perception is also affected by light levels, contrast, color and other physical parameters, as well as subjective parameters and each person's vision adaptability. Nevertheless, such conversion methods remain the best approaches we have to quantify lighting.

Most fascinating is the aspect of lighting that's beyond traditional optics and other hard sciences and engineering. As one explores this facet, two things become clear:

a) Lighting is a field in its own right, and many lighting, vision and color scientists have served the field as notable contributors.
b) LED lighting, because of the intricacies of optoelectronic science and manufacturing technologies, is more complicated than most LED and lighting scientists and engineers realize. LEDs are a different kind of light source, and understanding them requires knowledge of the fundamentals of lighting sciences and mathematics.

My forthcoming book, "*Understanding LED Illumination*," will be released in August. Its seven chapters offer the following features and benefits:

1) The basic notion of emphasizing the lighting aspects of LED lamps. The solid-state lighting (SSL) community should recognize that LED lamps must provide more than a glow and higher luminous efficacy. The quality of the glow must also be improved and be effective.
2) The basics of junction diode, and the intricacies of compound-semiconductor optoelectronic properties, including thermal, electrical, optical and mechanical aspects. The book provides lighting-industry professionals with a compact source from which to

learn semiconductor lighting; it's also a comprehensive resource for other relevant information.

3) The supply chain for LED modules and luminaires. By providing detailed, thermal-simulation methods and results, the book describes the importance of integrated designs for LED-lamp modules that comprise various components, including heat sinks, electrical drive and secondary-optical elements.
4) Comprehensive quantification and qualification methods for lamps. The book offers LED evaluation methods and terms in complete sync with lighting-industry norms.
5) Lamp properties to suit major lighting applications. It explains the unique challenges LEDs face to meet the demands of many general lighting applications.
6) The illumination challenges of LED lighting explained in scientific and mathematical terms with detailed optical simulations and a new theory. Readers can point to reasons why LED are directional and look harsh, and can also visualize why LEDs are naturally suited to illuminate planar surfaces such as signs.
7) A new method to make LED illumination as beautiful as incandescent radiation, while also maintaining the energy-saving benefits of SSL (U.S. Patent 8,348,467 issued to me on January 8, 2013). Imagine the attractive possibility of having energy-efficient LED lamps that won't blind us when we look at them.

The book provides readers with a solid text on LED and other lighting technologies, so they can make good choices toward illuminating our environment. It's a practical resource for readers involved in any aspect of lighting technology and provides the necessary background by connecting science, art and human psychology.

Although certain features are comparable to Edison's lightbulb, LED lighting is a new technology. It uses technologies similar to modern electronics, a relatively new technology that has changed the world dramatically by underlying communication technologies and gadgets that combine video, sound and interaction for all users – from anywhere in the world.

Electronic technologies' core elements also enable LED lighting. And, like any technology, LEDs involve hard science and engineering, and continuous advancements that ensure meaningful benefits and cost savings. "*Understanding LED Illumination*" offers the hope that we can light up the world better than ever before. It addresses lighting by combining science, art and human psychology – the same way light has touched us since the dawning of humankind. ■