Goniometric Properties of LEDs

Richard Young and Alan Tirpak, Optronic Laboratories, Inc.

Abstract

The production and use of LEDs continues to increase rapidly. They are being used in applications previously occupied by traditional lighting components such as incandescent lamps, as well as indicators, signs, displays and new lighting developments. Measurements of LED devices are required so that performance can be assessed, both in relation to other LED devices and as replacements for existing applications. These measurements must be consistent across the industry to ensure comparisons are valid.

LEDs come in many packages, often with integral lenses, diffusers or phosphors that alter the angular distribution and spectral emission properties. Simple ray-tracing can give insights into lensed LEDs, showing that angular properties depend critically of packaging. Some of these packages result in the LED behaving like multiple sources, depending on angle of observation. This type of behavior is illustrated in Figure 1.

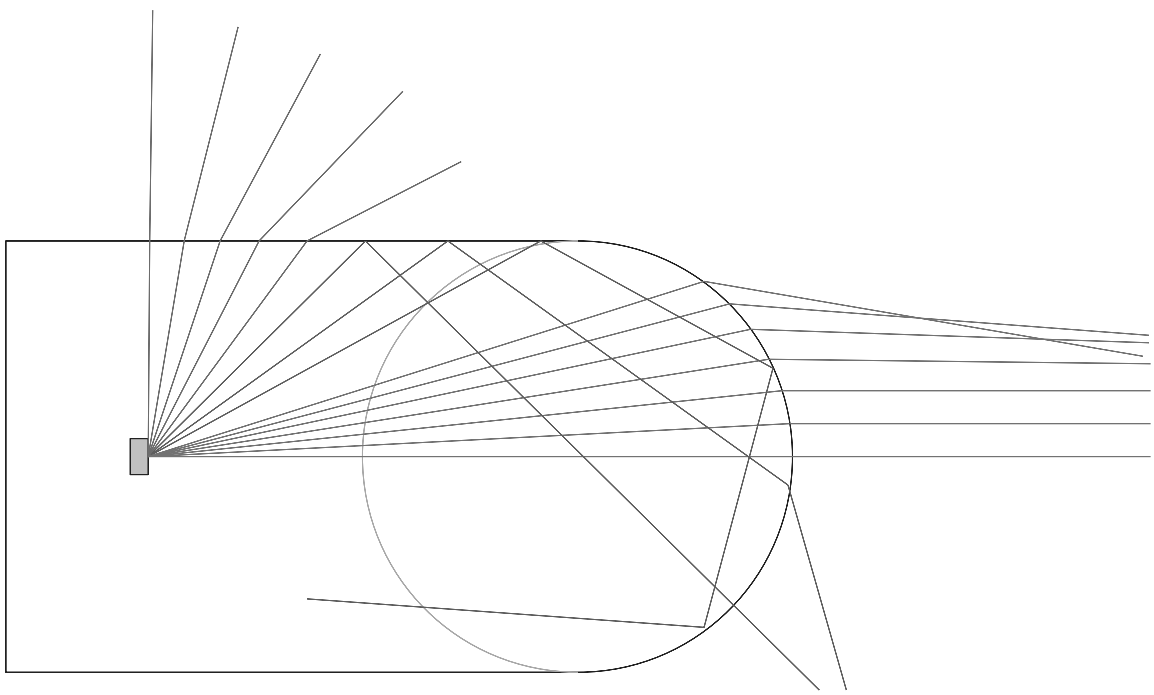

Figure 1. *A simple ray-trace of a modeled LED package shows that light emerging from a LED can be complex even when the design is simple. Rays through the front lens may be concentrated, or even focused. Rays through the side wall are refracted forward, and rays between these undergo total internal reflection before leaving the device.*

Often, information provided on LEDs would include angular characteristics of luminous intensity only, with a single relative spectral power distribution (SPD) assumed to represent all angles. The SPDs of many LEDs vary with angle however, and the LED cannot be represented by separate spectral and angular graphs. This has been recognized for some time with certain white LEDs, where the color separation is so extreme it is obvious even to a casual observer. What then is the interpretation of a single chromaticity value, color rendering index or dominant wavelength that may be provided by suppliers of these devices? Also, is this effect limited to white LEDs or does it occur to some lesser, but still significant, extent in other LEDs.

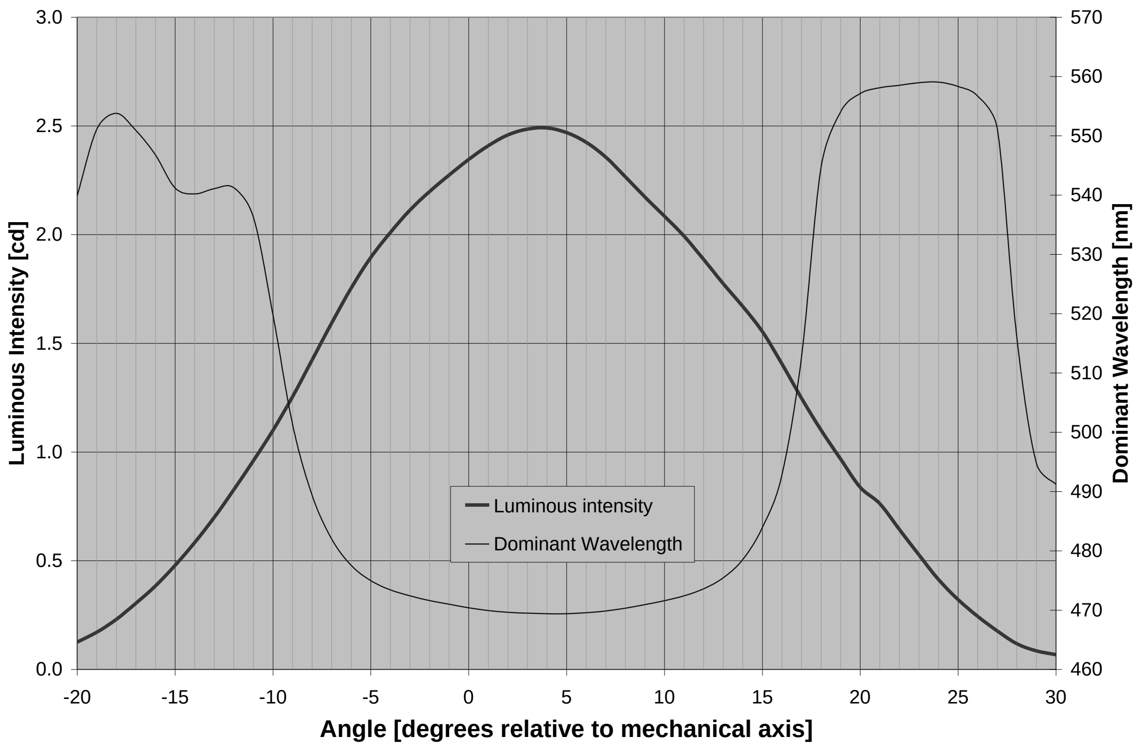

Figure 2. *Studies of several angular parameters of LEDs can reveal a more complete picture than intensity variations alone. The white LED measured here shows large changes in dominant wavelength with angle, making it potentially unsuitable for some applications.*

By studying a range of intensity and color related parameters with angle, a much more complete picture of the LED properties and potential uses is provided. A range of LED types and colors indicates the magnitude of variations can be extreme or virtually negligible. Only by measuring these parameters does their significance become apparent, as shown in Figure 2.

Biography for Richard Young

Dr. Young's interest and contributions to optical radiation measurement span more than 30 years. He was educated in England, where he received a B.A. honors degree and Ph.D. in Chemistry. His Ph.D. and post-doctoral research subjects included fluorescence and phosphorescence of plastics, novel imaging systems, forensic science and holography. In 1983 he moved to the commercial sector, where he designed instrumentation and developed new spectroscopic techniques. He is also a Chartered Chemist, a member of the Royal Society of Chemistry and a fully qualified teacher.

In 1994 he relocated to the USA and joined Optronic Laboratories, Inc. where he was promoted to vice president at the end of 1994. He continues to develop new systems and methods and works closely with all sectors of industry.

He joined the Council for Optical Radiation Measurement (CORM) in 1994 and immediately took an active role in most CORM radiometry sub-committees. He served as co-chairman of the 1996 Annual CORM Conference. He was elected as a CORM director in 1998, CORM radiometry committee chairman in 2000 and CORM vice president in 2001. He co-chaired the CORM 7th.report and CORM 8th report committees. He is an active member of several CORM and CIE technical committees, and is a member of SPIE and ORM.

Biography for Alan Tirpak

Alan Tirpak is an Applications Engineer with Optronic Laboratories in Orlando, FL. Alan holds Bachelor and Master of Science degrees in Physics from the University of Central Florida (UCF). His research activities include published work at the College of Optics and Photonics (COP), formerly CREOL and the UCF Department of Physics which involved the mechanism of photo-thermal refraction in silicate glass in the area of non-linear optics as well as on HIBS, a Sandia National Labs patented ion beam analysis tool, to increase the sensitivity of the instrument. Mr Tirpak has worked on industrial projects for both Raytheon and The Department of Defense prior to his joining Optronic Laboratories.