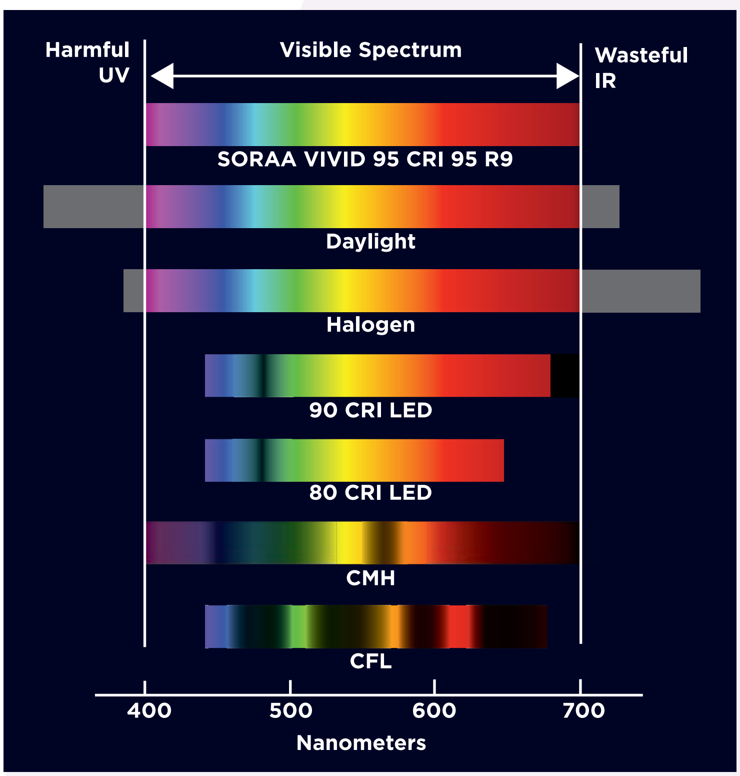
QUALITY OF LIGHT: PERFECT SPECTRUM, PERFECT BEAM

SORAA®

Simply Perfect Light™

With the emergence of Solid State Lighting technology, Quality of Light is taking on a new significance. Light Emitting Diodes (LEDs) based on native substrates (GaN on GaN™) make it possible for the first time to design light sources that provide unprecedented color performance and beam control- smaller, brighter, more beautiful and efficient than any previous lighting technology. Colors are rendered much more vibrantly because the basic spectrum is complete, and color consistency is superior. Smaller, brighter LEDs mean a crisp, dramatically more efficient beam, better distribution and glare control.



What do we mean by "perfect spectrum" in man-made light sources? Most of us think of daylight when we think of the perfect light source. Daylight does provide beautiful light, but must be constantly mitigated, as it contains harmful ultraviolet radiation, and can be overpoweringly bright and glaring when not controlled properly with good daylighting design in buildings. Daylight also exhibits a wide range of color temperatures and spectral qualities, depending on geographic location, time of day, and season.

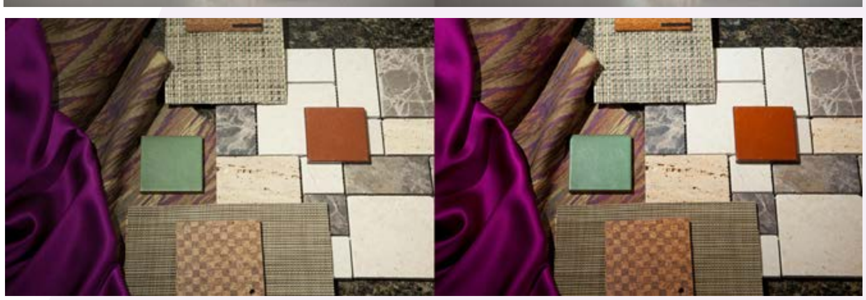
In man-made light sources, a perfect spectrum is one that exhibits qualities closest to daylight- smoothness, proportion, and balance, but is ideally attuned to human sensitivity. It contains all the emissions required to render the widest range of colors in the objects we see-If the color is not contained in the light source, it is not revealed in reflectance of objects. This is a major drawback of many lighting technologies that are truncated, clipped, or deficient in key wavelengths that are important to our perception of the world around us (Figure 2).

A perfect spectrum contains only the wavelengths visible to us- no ultraviolet (UV) or infrared (IR) radiation. This makes it both beautiful and efficient, as energy is not wasted producing unnecessary heat (IR), UV radiation, or unbalanced amounts of light in different parts of the spectrum.

Figure 1 (top): Fruit and plate illuminated by first generation 80 CRI LED lamps (left) and SORAA VIVID 95 CRI/95 R9 lamps (right).

Figure 2 (left): Comparative Spectra of Light Sources-Many common light sources are significantly lacking in important parts of the visual spectrum, or have highly unbalanced spectral distributions. the SORAA VIVID spectrum is well balanced, with all the necessary wavelengths and none of the unnecessary ones.

PERFECT SPECTRUM: RICHER COLORS, BRIGHTER WHITES



Figures 3-4 (top): Most foods and beverages contain colors in the deep red spectrum that are missing in other LED lamps (left). SORAA VIVID 95 CRI/95 R9 LED lamps (right) render food and beverages as they are meant to be seen, making them more appetizing. Figure 5: Retail directional lighting demands optimal color rendering as provided by SORAA VIVID 95 CRI/95 R9 LED lamps (right). By contrast, jewelry, clothing, and accessories appear slightly drab and uninviting when illuminated by other LED lamps (left). Figure 6: Fabrics and finish materials illuminated by first generation LED lamps (left) and SORAA VIVID 95 CRI/95 R9 (right).

Color Rendering

When light sources with low color rendering capabilities are compared side by side with perfect spectrum light sources, the difference is dramatic. Soraa Vivid lamps, with a color rendering index (CRI) of 95 and R9 (deep red rendering) of 95, provide light emission in parts of the spectrum missing from first generation Low CRI LEDs, such as deep reds, cyans, and violet. Many of the things that are most important to us in our environment- faces, food, fabrics, furniture, and finishes- contain complex colors that don't look quite right unless they are lit with perfect spectrum light containing these essential colors.

White Rendering

An often overlooked characteristic of light sources is their ability to render white, which is arguably as important as color rendering. Most white-colored manufactured products include optical brighteners, also known as fluorescent whitening agents (FWAs), which are designed to pick up short-wavelength light (UV and violet) and re-emit it as longer-wavelength visible light (Figure 10). The effect is an increase in bluish tint as well as an increase in reflected brightness, both of which serve to make such whites "whiter". Optical brighteners have been developed over decades and are included in a wide range of materials, including clothing, cosmetics, plastics, detergents, and paper. These brighteners are excited by conventional light sources such as daylight or incandescent lamps, and they contribute to our everyday experience of white perception. Despite the ubiquity of white objects in our lives, Whiteness Rendering is not captured by standard measures of light quality, such as the Color Rendering Index (CRI).

Conventional (blue-based) LEDs cannot render such white materials properly because they lack emission of short-wavelength light that is necessary to excite the FWAs. The result is that these white materials look yellow and dingy under conventional LED lighting (Figures 7 and 8). This is a fundamental flaw in conventional LEDs, and even those with a very high CRI fail at rendering whiteness properly.

Soraa's GaN-on-GaN technology is engineered to render white materials with optical brighteners in exactly the same way as natural incandescence. Excitation of brighteners is provided by violet light, rather than harmful ultraviolet light. The result is a bright, white appearance optimal for modern-day clothing, cosmetics, paper products, and appliances.

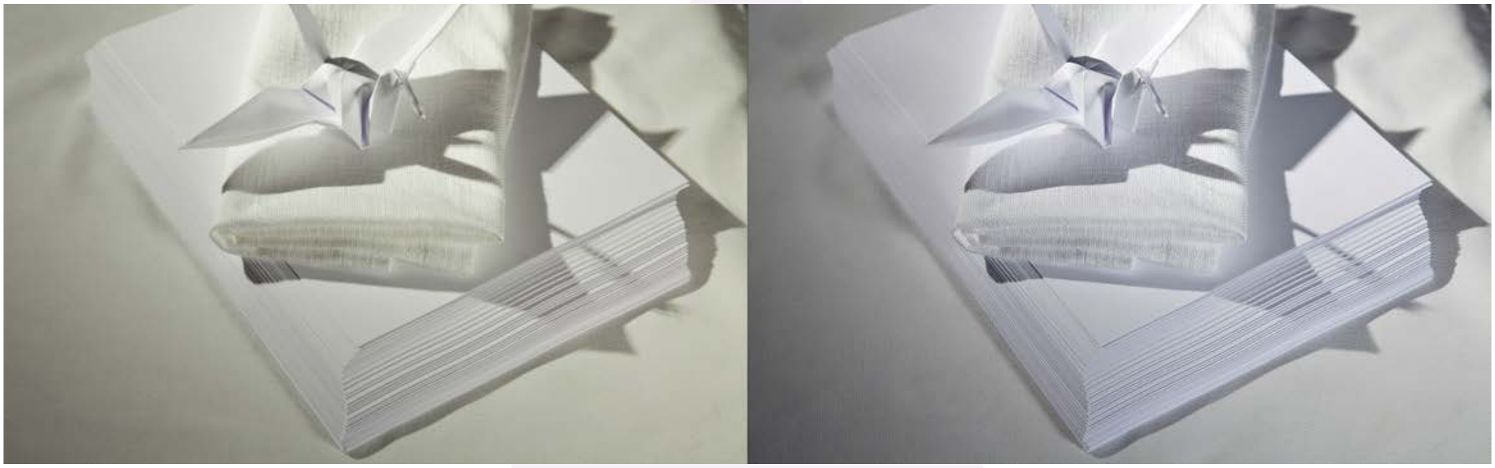
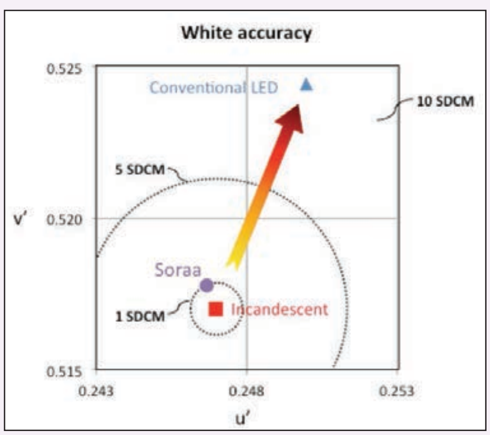
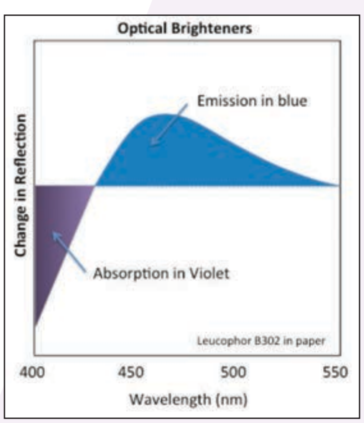
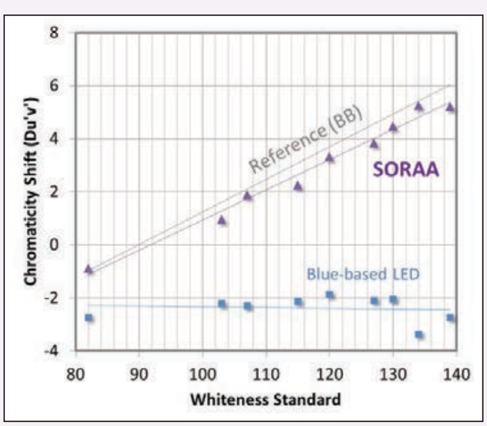


Figure 7 (top): White materials appear yellow and dingy when illuminated by other LED lamps (left). SORAA VIVID 95 CRI/95 R9 lamps (right) bring out the bright white properly. Figure 8 (above): Colors are more saturated and glowing against whiter whites, as shown in the example at right, illuminated by SORAA VIVID 95 CRI/95 R9 lamps. Other LED lamps (left) give colors and whites a less appealing appearance. Figure 9 (right): White accuracy metrics. Figure 10 (below left): how optical brighteners work. Figure 11 (below right): whiteness standards relative to the black body curve.







This was done by calculating the chromaticity shift of Whiteness Standards illuminated by a reference illuminant (e.g., 3000K blackbody emission). The slope of the chromaticity shift as a function of the whiteness of the Standards (as specified by CIE) was then assigned a value of 100 for the reference illuminant. The Soraa lamp emission spectrum was designed to match that slope (Figure 11). For blue-based LEDs, there is no chromaticity shift (no whiteness) effect, and the slope is zero.

White Accuracy can be quantified by measuring the reflected chromaticity of white materials under natural incandescent illumination and comparing it to the case of LED illumination. As Figure 9 shows, the error in whiteness accuracy can be many SDCMs using conventional LEDs, whereas in Soraa's case, the accuracy has been engineered to be within one SDCM.

Together with the outstanding color rendering of Soraa's perfect spectrum technology, this unique ability at white rendering results in a simply perfect light source - the only LED source truly able to render all objects in a pleasant and natural fashion.