INSTALLMENT THREE | SEPTEMBER 4, 2013

COLLABORATIVE INNOVATION: ENGINEERING GLASS PROPERTIES FOR DIFFERENTIATED LIGHTING PRODUCTS

As the leader in Technical Glass Manufacturing for over 85 years we have seen emerging technologies disrupt every industry we serve at one time or another. In today's world, companies face an increased rate of product obsolescence as a result of accelerating technological advancements. Companies are challenged to continually innovate to differentiate themselves in new and meaningful ways. In the last Expert Perspective installment, "Profits and Product Differentiation with Supply Chain Collaborators: Building a Win-Win Relationship", we broadly discussed the advantages of collaborating with your supply chain to uncover competitive advantages. In this installment, Kopp's Manager of Research and Engineering, Adam Willsey, explains how custom engineered glass properties provide an advantage in lighting product development and how, through collaborative innovation, Kopp Glass has successfully worked with customers to bring groundbreaking products to market.

MEET KOPP'S EXPERT

Adam Willsey, Manager of Research and Engineering, holds a Master's degree in Material Science and Engineering as well as a Bachelor's Degree in Biomedical Material Engineering from the Inamori School of Engineering at Alfred University in New York.

Over the last several years the adoption of energy efficient lighting technologies, specifically Light Emitting Diodes (LEDs) and plasma sources, has accelerated. While neither technology is new, their emergence is disrupting longstanding industry specifications and many of our customers' established product lines creating demand for rapid new product development. To complicate matters, these technologies bring a whole new set of challenges that lighting engineers and designers must overcome to realize their efficiency advantages. In response to these and other changing industry needs, we are expanding our technical expertise to design lenses and glass compositions for the latest technologies. Our capability to manipulate glass properties on an atomic level, specifically transmission, color temperature and chromaticity, has enabled our customers to bring fully optimized lighting products to market.

⇨ LIGHT TRANSMISSION

Transmission is the fraction of light that passes through a material at a specific wavelength.

For our purpose, let's compare light emitted from a source to music coming from a radio. In this analogy, light transmission is like a volume dial which can raise or lower the emitted light. Through advanced glass engineering, we provide lighting designers and engineers with a volume dial capable of multiple functions (think added tone controls like bass and treble). We manipulate transmission by developing glass compositions to absorb or transmit specific wavelengths of light. While this capability has many benefits in the visible light spectrum, I'd actually like to look at an innovative application in the Ultraviolet (UV) range.

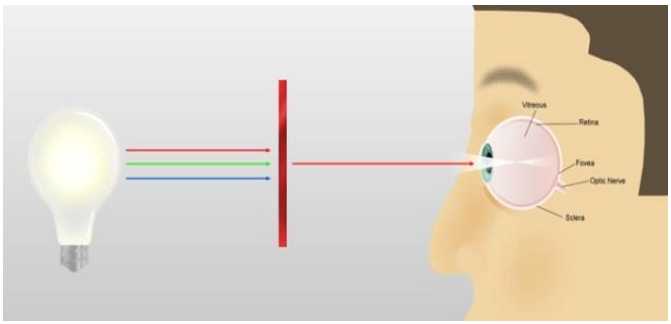

Figure 1: Diagram describing the relationship between light source, filter, and eye response

Ultraviolet (UV) light is just outside of the wavelength range perceived by the human eye. UV light is used to perform various industrial processes, including: the curing of adhesives, medical imaging, additive manufacturing, large format printing, non-destructive testing, sterilization, and more. In most of these applications, UV light is used to initiate a reaction in a secondary material and therefore the properties of the light hitting a target surface are critically important. LEDs are becoming a viable source for UV lighting products and equipment as replacement to mercury vapor lamps. In contrast to the old technology, LEDs are a monochromatic light source with limited spectral distribution, creating many challenges for applications looking to adopt the technology. Our solution involves the marriage of not just our glass engineering capabilities to optimize spectral properties but also our precision molding expertise to develop specialty optics. Our unique and highly transmissive glasses allow for greater efficiency through both the light output and engineered distribution of the light to a surface. Custom prismatic lenses designed for specific UV applications have a clear competitive advantage where faster reaction times and efficiency are essential.

☼ COLOR TEMPERATURE

A description of the color of light given off by a lighting system as compared to well characterized blackbody radiators.

Another key variant and design challenge I'll explore next is color temperature. Let's revisit the radio analogy: just as each song on the radio is different, the same thing can be said about light sources. All light sources have a spectral distribution that describes the intensity of light relative to the electromagnetic wavelength spectrum. Where incandescent sources come in one flavor akin to listening to the same song repeating on the radio, new light sources have unique and different spectrums like a radio station with lots of variation in music genres.

Simply put, color temperature describes the color of light given off by a lighting system. Incandescent sources have a color temperature near 2850 K, while many efficient white LEDs having a bluish-white color can range between 4000 K and 7000 K. Consumers have taken note of the disparity in color from new, efficient light sources and as a result lighting manufacturers are feeling pressure to offer solutions.

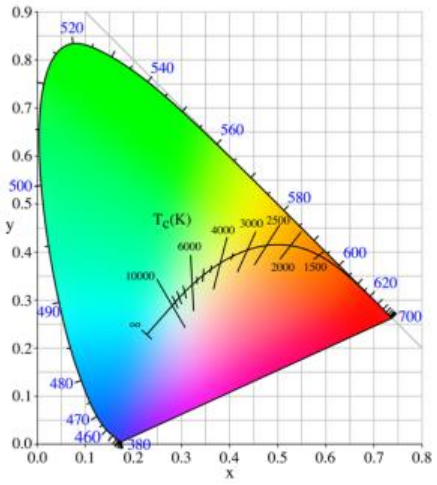

Figure 2: Planckian locus shown, lines crossing the locus indicate color temperature

At Kopp, we have the unique ability to engineer lenses that are capable of shifting color temperature by controlling light transmission. In general lighting applications it is imperative that color correction properties not result in significant losses in transmission. This is a tightrope which takes great expertise in glass engineering and lighting design to successfully walk. Once a specialty glass formulation has been developed, we can produce custom molded lenses using new or existing tooling or molds. This allows lighting manufacturers to provide lens options and retrofit solutions. For end users, the glass solution offers lower total cost of ownership, because glass will not degrade through exposure to the elements, thereby providing spectral properties that never fluctuate.

CHROMATICITY

Chromaticity (or color) is the imbalance of visible radiant energy that reaches the eye from a light source through an object.

Again, in keeping with the radio analogy, chromaticity is like the tuner that tells us what station we are listening to. The radio tuner displays a station number or location so that we easily return to it. In industry, we use the International Commission on Illumination's (CIE) color system to describe chromaticity coordinates. These coordinates are dependent on and calculated from three factors: light source, filter, and eye response.

Every day we are surrounded by lighting systems designed to be percieved as a very specific color, whether we are waiting at a train crossing, passing under a green traffic light, or landing on a commercial plane at an airport. The consistent use of color establishes an important visual language for communicating cues and ensuring safety in many areas of transportation. Because chromaticity is a function of light source, the emergence of LED technology has introduced complex challenges in many industries; one in particular is night vision products.

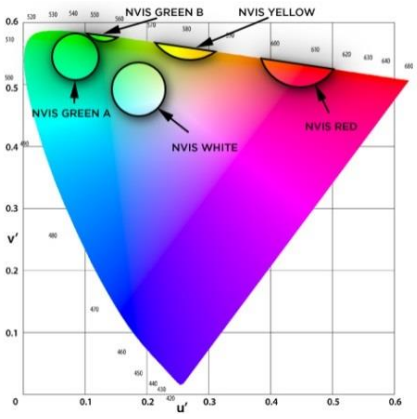

Figure 3: CIE Diagram showing MIL-STD-3009 Color Circles of Acceptable Targets for NVIS Lighting

Night Vision Goggle (NVG) technology has been used by the military for several decades to enable advanced nighttime operations. More recently, the same technology is seeing widespread adoption for use in civilian applications such as rescue helicopters or police surveillance. Compatible lighting and color uniformity are both critical factors for Night Vision Imaging System (NVIS) lighting environments, which if not properly controlled can cause undesired distractions, lead to eye fatigue, or result in permanent damage to the goggle systems. Kopp provides NVIS filter glass solutions designed to ensure compatible lighting across a broad range of applications, including: crew station lighting, exterior aircraft lighting, handheld systems, vehicular lighting, and ground lighting such as airfield and heliport.

In the aerospace lighting industry, adoption of LED technology is occurring in retrofit applications. Often these are complex situations where varied light sources need filtered while ensuring consistent chromaticity throughout the environment. Through close collaboration, we are able to tailor transmission properties to meet the chromaticity

specifications based on the unique characteristics of each varied light source. We have engineered our filter product line to meet narrowed ranges within the acceptable color specifications resulting in more controlled, consistent and uniform spectral properties.

When designing new NVIS compatible lighting for LED sources, it is imperative to optimize the light source selection and colored glass early in development to keep manufacturing costs low and avoid costly false starts. We have been involved in many projects that have gone to market ahead of schedule and under cost projections due to these collaborative efforts.

❖ ACHIEVING A SUSTAINED COMPETITIVE ADVANTAGE

We are given a set of conditions that exist, a result that is to be achieved, and challenged to provide a solution.

For over 85 years our approach to technical glass manufacturing has been collaborative. Companies who leverage Kopp's engineering capabilities can develop a meaningful competitive advantage in their respective industries, including higher margins through lower manufacturing costs, accelerated time to market and truly innovative new products while reducing product development risks by avoiding false starts.