WOLF
CINEMA

DLD-380FD
Laser-Illuminated
Home Theater Projection System

BLUEscent

Technology White Paper

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The Advantage of Solid State Illumination

Home cinema projectors have historically been illuminated by lamps, providing the required brightness to light up large home theater screens. However, such lamps must be replaced over time, and come with moderate-to-high replacement costs [including subsequent system re-calibration costs]. Projector lamps will diminish in output levels over time, and as they decay they cannot be further modulated to deliver constant peak white and contrast level performances.

New and exciting solid state illumination technologies are here today, and provide many benefits for home theater enthusiasts. Projectors with solid state light sources are designed around four different architectures:

1) ***All laser*** – uses red, green and blue lasers [generally used in Cineplex installations]
2) ***Laser Phosphor*** – uses blue lasers and a phosphor wheel to create white or yellow light
3) ***LED [Light Emitting Diodes]*** – uses red, green and blue LEDs
4) ***Hybrid*** – uses a combination of LED and lasers

Each of these approaches has its strengths and weaknesses – and each comes with certain design variations that further differentiate the products and how they may best fit a specific application. For example, Wolf Cinema has released three LED-based projection systems over the last 5 years, two of which remain available in the company's current assortment. These LED solutions are terrific imagers in their own right, with extended color gamut and excellent contrast performance. The only limitation with LED systems is in peak white performance, typically around 1000 ANSI [post calibration].

In this paper, we will focus on Wolf Cinema's implementation of the new BLU-Escent™ laser illumination technologies, as originally developed by our OEM partner JVC Kenwood. The DLD-380FD projection system boasts a sixth-generation, three-chip D-ILA™ light engine core, powered by the BLU-Escent laser phosphor illumination technology, mated with our outboard ProScaler MK III video processor, and features numerous other imaging enhancements to deliver bright, colorful and high contrast images over very long system life.

The BLU-Escent Laser Illumination Technology

The DLD-380FD projector – while physically and cosmetically similar to Wolf Cinema's lamp-based D-ILA projectors – uses a solid state illumination module consisting of a laser block and a phosphor wheel (Figure 1).

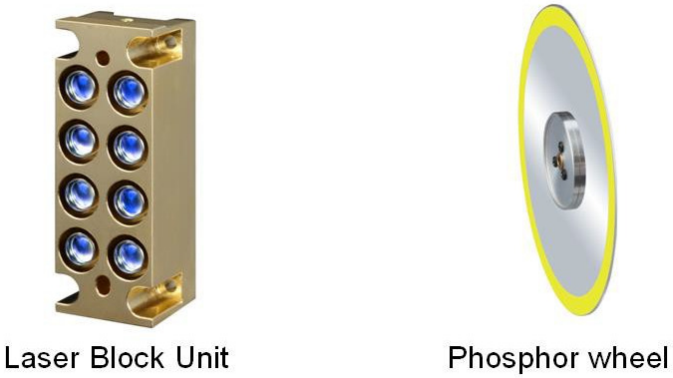

Figure 1: Elements of the BLU-Escent Light Source

The laser block consists of 16 high powered blue lasers. These are extremely reliable and stable for tens of thousands of hours. The blue laser light excites the phosphors along the edge of the wheel, which creates yellow light. The yellow light is further separated into red and green components – which, along with the blue laser light, provide for the R-G-B illumination needed for the imaging block in the projector.

The DLD-380FD projector's illumination system is further differentiated by its unique design architecture. The BLU-Escent engine uses a reflective phosphor wheel, rather than a transmissive one as may be used in other systems. As shown in Figure 2, this reflective approach reduces optical loss and boosts luminance efficiency. The result is significantly higher contrast, excellent peak white performance and increased system reliability.

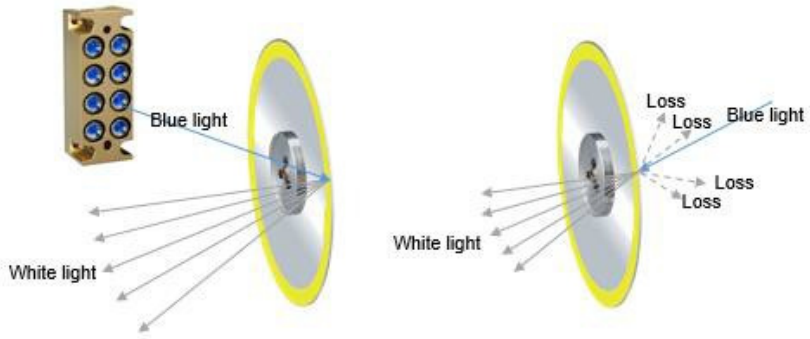

Figure 2: Reflective vs. Transmissive Laser Phosphor Wheel Designs

Figure 3 below shows the block diagram of this three-chip laser illumination system. The laser's blue light is captured, collimated and passed through a partially reflecting filter. This filter reflects some of the blue light to illuminate the primary blue D-ILA panel. The remaining blue laser light passes through the filter to excite the phosphors along the edge of the slowly spinning phosphor wheel. The re-emitted yellow light now contains the red and green primary components, and they are combined with the blue light and forwarded to the respective R-G-B imaging sections of the light engine. Some simple despeckling of the blue laser light is needed, but the yellow light from the phosphors is speckle free:

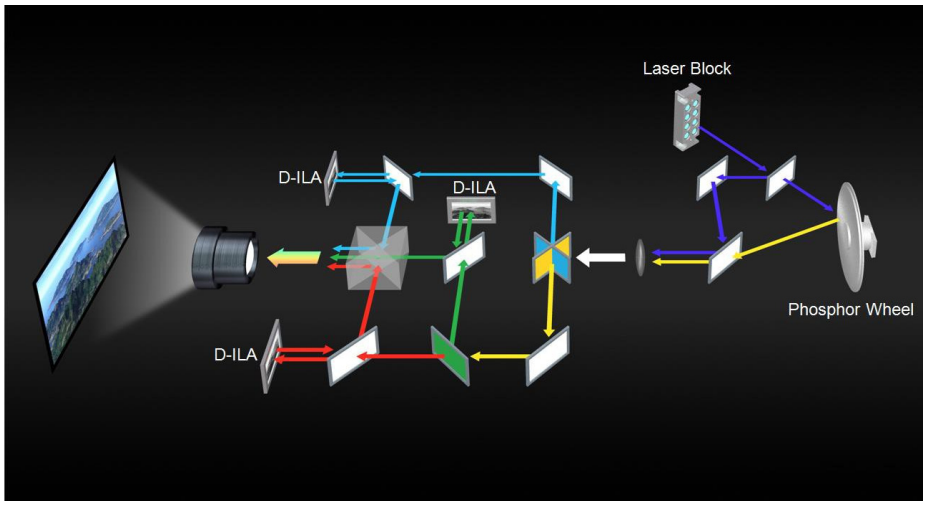

Figure 3: BLU-Escent Block Diagram

The imaging block consists of three D-ILA (LCoS) reflective panels, illuminated by the red, green and blue light sources. After modulation at each panel, the primary light sources are combined and projected through the lens. D-ILA panels are known for their high performance and ability to create very high contrast images.

Ideally Suited for Home Theater Installations

Today's home theater installations are quite demanding and must be designed to:

- Provide for high reliability over extended viewing times
- Remain stable over time in peak white performance
- Offer excellent brightness and high resolution for screens up to 12' wide [3.7 meters]
- Provide for high contrast levels and extended, accurate color gamut [colorimetry]
- Offer flexibility in mounting positions [i.e., long throw optics, ample lens offsets]
- Provides for exceptional value and low cost of operation over time

Wolf Cinema's new DLD-380FD projection ensemble builds upon our on-going commitment to provide high performance imaging solutions that meets these needs – and also raises the bar in a number of key areas.

High Reliability

Home theater projectors are often used between 3-4 hours a day – and in many instances even longer, when enjoying the wide variety of film, television and gaming content available today. Ultimately, a home theater enthusiast's satisfaction is highest when all system components, including the projector, work reliability and with minimal downtime. The DLD-380FD easily meets and even exceeds these requirements.

In a typical projection system, the lamp is the primary component that requires constant maintenance and regular replacement. In our BLU-Escent laser-phosphor design, there is no lamp to replace and thus can be considered nearly "maintenance free" for extended periods. The laser illumination components are designed with lifetimes of up to 20,000 hours or more, depending on your usage. This means you can enjoy a 2-hour movie every night for over 27 years [!], without ever having to replace a lamp. In addition, this saves on the projector recalibration costs, since the laser module does not require special adjustments over time.

As with all video projectors and other sensitive electronic components, heat buildup is the main concern. Proper thermal management is critical for all video projection systems, and the DLD-380FD is no different in that regard – but unlike a lamp that can fail due to excessive heat, here we need to protect the blue laser assembly and phosphor wheel.

The BLU-Escent system uses an aluminum substrate for the phosphor wheel, which has its own dedicated fan to keep cool air moving across the wheel. This design helps maintain a constant wheel surface temperature and reduces phosphor aging [but at some cost to overall SPL levels; this projector runs slightly louder than others, between 42-48 dB]. This successful design keeps the entire laser illumination assembly running at very stable operating temperatures, while maintaining excellent light output levels over extending viewing times.

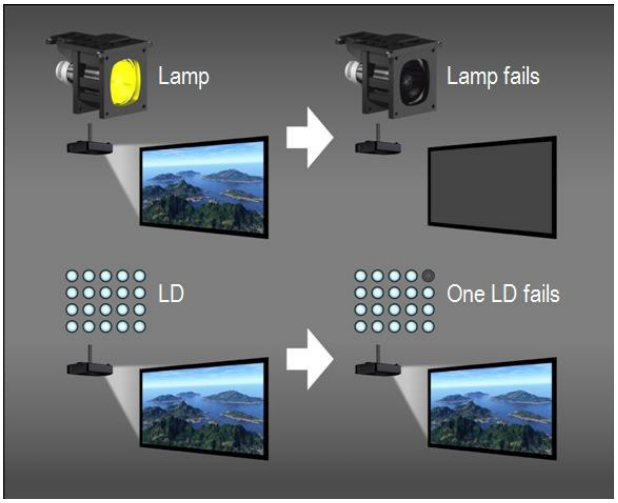

Figure 4: A UHP Lamp Failure Causes a Dark Screen but a Laser Diode Failure only Reduces Brightness Slightly

The blue lasers are semi-conductor devices that will in fact degrade slowly over time. But, if one laser should fail catastrophically, there are several blue lasers still operating so the projector

can still continue to output a significant amount of light (Figure 4).

During its long service life, in the unlikely event that the laser itself suffers an outage, our professional service team can simply swap out the entire LD (Laser Diode) engine for a new one, without major adjustment or recalibration. Overall, Wolf Cinema guarantees that the illumination system – the BLU-Escent laser modules and phosphor wheel – will last over 20,000 hours [to 50% brightness] in the most demanding home theater environments.

V4K™ 3840 x 2160 Resolution

Resolution is also an important factor in today's projector choices. The DLD-380FD boasts the remarkable V4K™ on screen imaging technology [also known as "e-shift"]. Originally co-developed by Japan's NHK Engineering and the Victor Company of Japan [JVC], this technology implementation by Wolf Cinema delivers an image with 4 times the pixel density of standard 1920 x 1080 sources.

The original SD or HD signal is first processed with an advanced imaging algorithm to improve edge transitions, eliminates aliasing and stair-stepping, and increase contrast level performance within each video frame. Each frame is then temporally separated into two sub-frames [at 1920 x 1080 pixels each] and projected through the D-ILA engine and the separate V4K™processing panel. This panel utilizes a property of liquid crystals called birefringence and can rapidly switch between straight light and refracted light by 0.5 pixel, shifted both vertically and horizontally. New "sub pixels" are thus generated based on this process and a true 3840 x 2160 video frame is created. Amazingly this process has no moving parts and results in a smooth, film-like image with minimal visible pixel structure. [Figure 5]

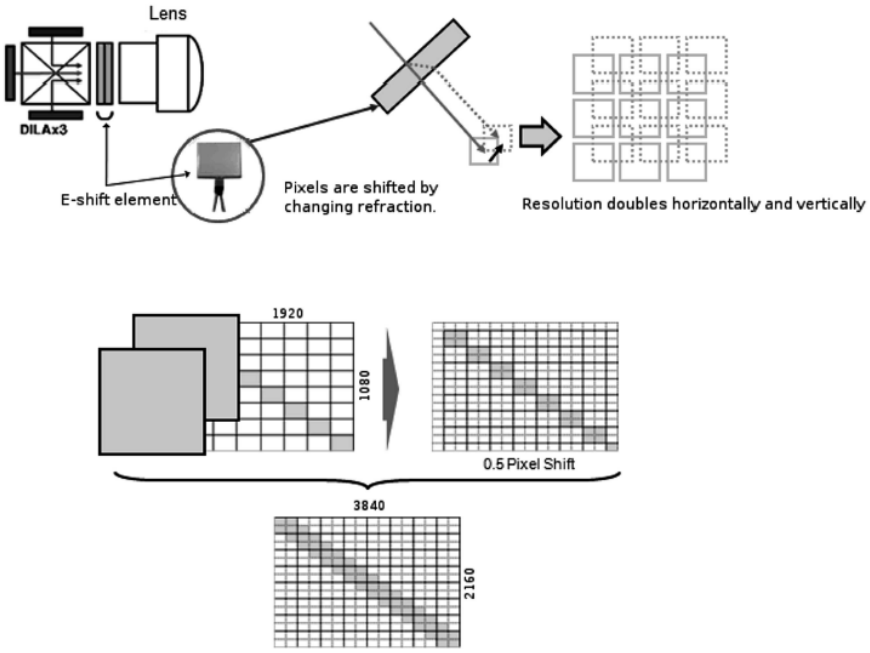

Figure 5: 3840 x 2160 imaging technology

High Contrast and Dynamic Range

The DLD-380FD provides for exceptionally high native contrast and outstanding overall dynamic range. Much of the high contrast performance is based on the inherent advantages and structure of the D-ILA panels themselves, but additional benefits are derived from the use of lasers as a light source. Lasers output light in a very narrow cone compared with LEDs or lamps, and they do so over a much smaller emitting area. It is therefore easier to capture all of the light as emitted from a laser than from an LED or lamp. This results in greater efficiency when delivering light to the D-ILA panels, and higher overall contrast due to less stray light. [Figure 6]

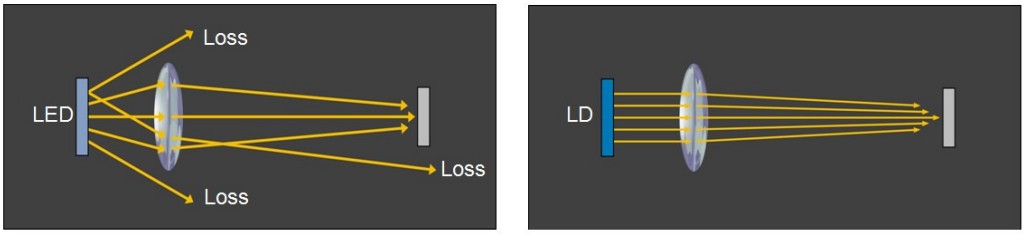

Figure 6: Collection of Light from an LED vs. a Laser Diode

Stable, Long-Term Imaging Brightness

The DLD-380FD projection system provides for ANSI brightness of approximately 1,600 lumens, which is the right level for many dedicated home theater applications. In addition to the long 20,000-hour laser lifetime, these projectors feature an Auto Intensity Mode option that employs 3 dedicated sensors to adjust the light source power and color to maintain stable brightness.

All light sources lose output over time, but by setting the output power to the 50% point in the beginning, end users can maintain this level for the full lifetime of the light source. This is done by slight increases in the laser current over time to overcome efficiency losses, as illustrated in Figure 7. An added side benefit is the lower electrical power use, which reduces operating costs as well.

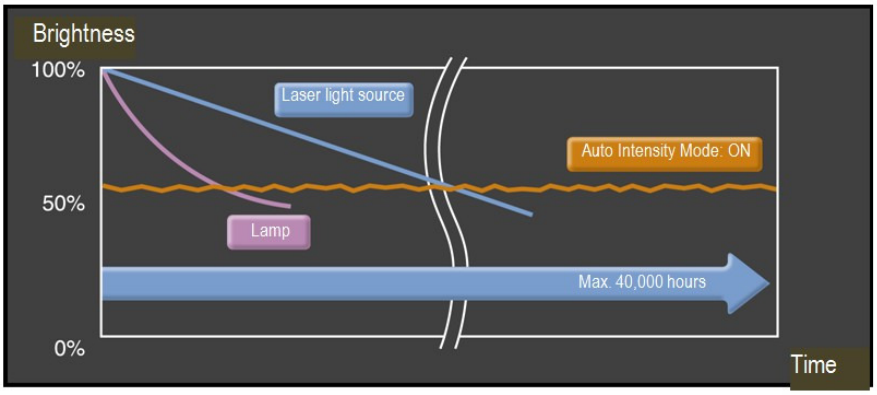

Figure 7: Light Source Brightness vs. Time

Stable Color Gamut

Lamp-based projectors are notorious for changes over time in color accuracy. As the arc gap in the lamp expands, the white point and color primaries can change, requiring periodic color adjustments. With the BLU-Escent illumination technology, the blue laser light and yellow phosphor light is consistent and stable over time. The modules are also stable within minor fluctuations in ambient temperatures – thus, they do not experience the visible image degradations that lamp-based projectors do.

In addition, the DLD-380FD is able to exceed the Rec. 709 and sRGB color gamut. This wide color response allows for even greater saturation of colors, as may be required.

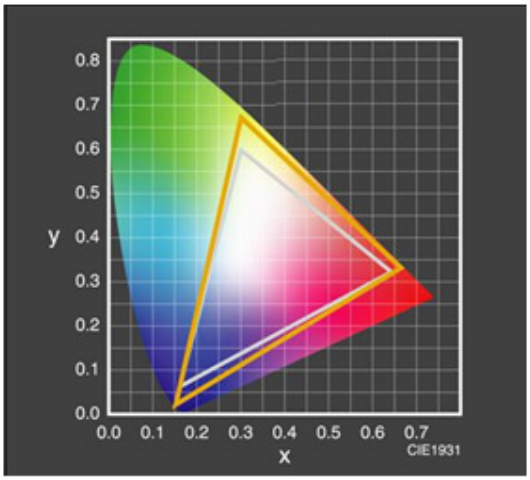

Figure 8: Expanded Color Gamut

Safety and Lamp Disposal Concerns

Moving from a lamp-based projector to a solid state light source means that there is no longer the mercury issue in the lamp to worry about, eliminating disposal concerns.

Since the projector contains a laser source, our team has taken special care to be sure no laser light can escape the projector housing. This is facilitated by the strong die-cast block that holds the blues lasers. Not only is this an excellent contributor for thermal management, it enables the projector to have a Class II laser classification. This means you follow the same safety considerations as you would with a lamp-based projector.

Outboard ProScaler MK III

Included in the system is our latest generation ProScaler MK III home theater Video Processor. This advanced slim-line component serves as the advanced connectivity and signal processing point for the video system. The ProScaler MK III provides for dual HDMI 1.4a inputs and

a single HDMI 1.4a output for connecting to the DLD-380FD projector head. The ProScaler's advanced calibration suite enables professionals and enthusiasts everywhere to achieve near-perfect color accuracy and ultra-wide contrast levels in all viewing modes. Standard definition sources (such as from DVDs and television broadcasts) are up-converted and displayed with improved visual depth, dimension, and reality. Per-pixel video de-interlacing, 10 bit video processing, MPEG mosquito/temporal and block artifact noise reduction provide vast improvements on marginal sources.

The ProScaler MK III also incorporates our latest technology development known as E-VariScope™: multiple viewing modes that permit one to enjoy popular TV and film content on constant height, 2.35:1 wide aspect ratio screens. You'll have near-instant access to preferred aspect ratios – for example, 1.33:1 (4/3), 1.78:1 (16/9), 1.85:1, 2.35:1 and more – and all without the need for an external anamorphic lens (yet full anamorphic lens support is also provided). E-VariScope brings you that immersive 2:35:1 CinemaScope™ widescreen experience while eliminating those unwanted top & bottom "black bars," as commonly experienced on smaller-width 16/9 screens.

Conclusion

The DLD-380FD system is our most comprehensive laser-based illumination solution to date, and will provide years of trouble-free performance for home cinema enthusiasts around the world.

DLD-350FD Projector Specifications

Imaging Devices		0.7-inch D-ILA (1920X1080) x 3; >90% Aperture Ratio
Brightness		1600 ANSI Lumens (typical) / 1000 ANSI Lumens (minimum)
Resolution		3840 x 2160 V4K™ [e-shift] 4K Resolution
Contrast Ratio		150,000:1
Uniformity		Greater than 80%
Aperture		16 Steps (Lens Aperture)
Gamma Control		Std 2.2 Gamma and 3 Custom Gamma presets
Color Management		7-Axis adjustable CMS
HDMI Input-Supported Formats		1920x1080 60p/50p (Dual Input Capability)
Low Latency Mode		1080p60/50
Latency		25ms w/1080p60 Input
Color Bit Depth		10-bit Input via HDMI 1.4b, 10-bit display
I/O Terminals		2 x HDMI v1.4b (locking HDMI connectors); LAN: RJ45 x 1; RS-232C: D-Sub 9 pin (male) x 1; Wired Remote (Mini) x 1
Remote Control		RS-232C/LAN Fully featured control protocol Wired/IR Remote Control
Lens		1.45-2.78:1 Zoom Lens (Remote Zoom and Focus), ± 80% Vertical Offset, ± 34% Horizontal Offset
Light Source		Laser/Phosphor: 125 Steps Power Setting (25%-100%) Class II laser
Light source Life		20,000h (typical @ Max Power) / 40,000h (typical @ Low Power with Auto Intensity)
Power Requirement		AC 100V-240V, 50/60Hz
Power Consumption		290 Watts Maximum, 5W Standby
Noise Level (0-26℃, 32-79℉)		~42dB (A) at 39.4"/1m (3.3ft)
Operating Environment		Temperature range: 5℃-35℃
		Humidity: 20%-80% (non-condensing)
Operating Altitude		Recommended <2000 meters for safe operation
Installation Orientation		Angle free
Dimensions (W x H x D)		19.5 x 8.8 x 22.5 in., 496 x 224 x 572 mm
Weight		38.1lbs, (17.3kg)
Supplied Accessories		Power Cord x1 (US, EU); IR Remote Control
Approvals	Safety	North America CSA C22.2 No.60950-1-07（Amd1：2011）, UL60950-1-2011 2nd edition Europe IEC60950-1:2005(2nd)+Amd1:2009+Amd2:2013 EN60950-1:2006+A11:2009+A1:2010+A12:2011+A2:2013
	EMI	North America FCC part 15 Class A(US), ICES-003 Issue 5 Class A(CAN), Europe EN61000-3-2:2006+A1:2009+A2:2009, EN61000-3-3:2013, EN55022:2010(Class A), EN55024:2010 Australia EN55022:2010/AC2011 Class A
	Environmental	Common RoHS North America Proposition 65 (US) Europe WEEE New Battery directive
External Video Processor		Wolf Cinema ProScaler MK III (Refer to separate ProScaler Specifications)

All features, designs and specifications are subject to change without notice.

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