

JVC D-ILA[®] 4096 x 2400 pixel Projection Display Technology

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Abstract

The development of the fifth generation D-ILA LCOS technology for 4K x 2.4K projection is reviewed along with a new projector optical engine that greatly increases system contrast ratio. The new 4K D-ILA incorporates a device aperture diagonal reduction from 1.70 inches to 1.27 inches and total pixel increases from 3840 x 2048 / 4096 x 2048 to 4096 x 2400 (~10 Megapixels). The highest resolution, aperture fill factor, and pixel density of any current projection display technology are achieved. The resolution of 4096 x 2400 is compatible with Digital Cinema standards. It also permits 4x enlarged WUXGA images for design and CAD applications. D-ILA LCOS technology combines a nematic liquid crystal layer and a single crystal silicon CMOS backplane addressing circuit in a reflective mode display image modulator. D-ILA devices and projectors have been mass produced since 1998 starting with SXGA+ front projectors with the world's first demonstration of 4K x 2K projection in 2001, and an 8K x 4K dual projector system in 2005. To achieve a device contrast ratio of 20,000:1, the D-ILA homeotropic liquid crystal was optimized along with the surface flatness and specularity of the CMOS backplane. The new wire grid polarizer optical engine reduces scattered light to increase contrast ratio without a dynamic iris and the color management system increases the color gamut from a compact xenon arc lamp. The compact system and 3500 lumen output allows application in many venues. (Fig.1)



Figure 1 - DLA-SH4KG

Introduction

The D-ILA (Direct-Drive Image Light Amplifier) technology, has been at the forefront of reflective LC microdisplays (LCOS) starting with the first production SXGA+ projectors in 1998 shown in Fig. 2,^{1 2 3}. This was the result of a project at the JVC Central Research Laboratories started in 1993 to develop LCOS technology. This continued with the 2048 x 1536 pixel resolution projector- the QX-1- in 1999⁴. The first demonstration of a projector of any technology at 4K x 2K pixels was a D-ILA projector at SIGGRAPH in 2001 (Fig. 3). In 2005 at the Aichi Expo in Nagoya Japan and at NAB in 2006, NHK and JVC demonstrated an 8K x 4K D-ILA based projection system⁵.



Figure 2 DLA-G10



Figure 3 QHDTV Projector

This next generation 4K projector is based on a newly designed D-ILA device with 4096x2400 resolution and >20:000:1 device contrast ratio.

Device

The latest generation device comes from a family of D-ILA imagers that goes back 10 years. (Fig. 4, Table 1)

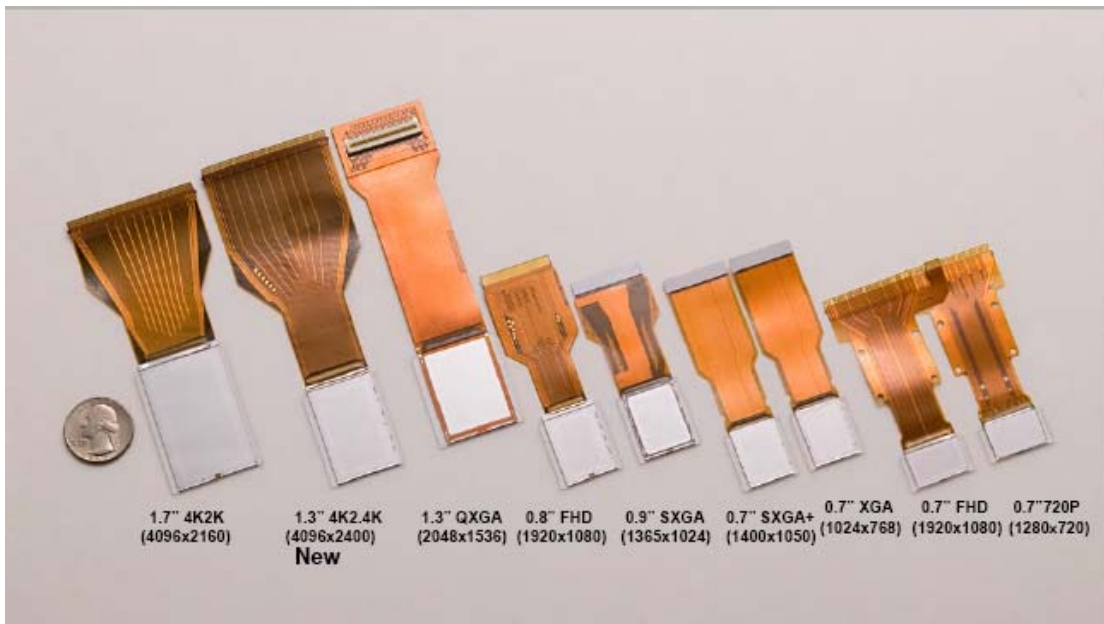


Figure 4 DILA Device Line up

	1.7-inch 4K2K	1.3-inch 4K2K (New)	1.3-inch QXGA	0.8-inch FHD	0.9-inch SXGA	0.7-inch SXGA+	0.7-inch XGA	0.7-inch FHD	0.7-inch 720P
Display Size (inch)	1.73	1.27	1.3	0.82	0.90	0.72	0.72	0.70	0.70
Pixel number (V x H)	3840 x 2048	4096 x 2400	2048 x 1536	1920 x 1080	1365 x 1024	1400 x 1050	1024 x 768	1920 x 1080	1280 x 720
Aspect Ratio	16 : 9	16 : 9	4 : 3	16 : 9	4 : 3	4 : 3	4 : 3	16 : 9	16 : 9
Pixel Pitch (micron meter)	10.0	6.8	12.9	9.5	13.5	10.4	14.2	8.0	12.0
Drive mode	Analog	Analog	Analog	Analog	Analog	Analog	Analog	Digital	Digital
Major Applications	*Ultra high definition systems *Air traffic controlling *Simulation *CG Monitor *Work sharing systems *High Realistic sensation telework	*Ultra high definition systems *Air traffic controlling *Simulation *CG Monitor *Work sharing systems *High Realistic sensation telework	*Digital Cinema *Environmental Video system *Simulation *CG Monitor *Stages, Concerts *Exhibitions	*High end home theater *Wide screen rear projection TV set *Digital Archive (Digital museums) *Digital Cinema	*Presentation *AV theater *Simulation *CG Monitor	*Presentation *AV Theater	*Presentation *AV Theater	*Rear Projection TV set *Home Theater *Amusement	*Rear Projection TV set *Home Theater *Amusement

Table 1 D-ILA device types and basic specifications

The current 4K device is 3rd generation photolithography using 0.25 μm silicon process technology. Next generation 0.18 μm processing will allow for smaller, lower cost devices and higher resolution devices of 8Kx4K resolution or higher. (Fig. 5)

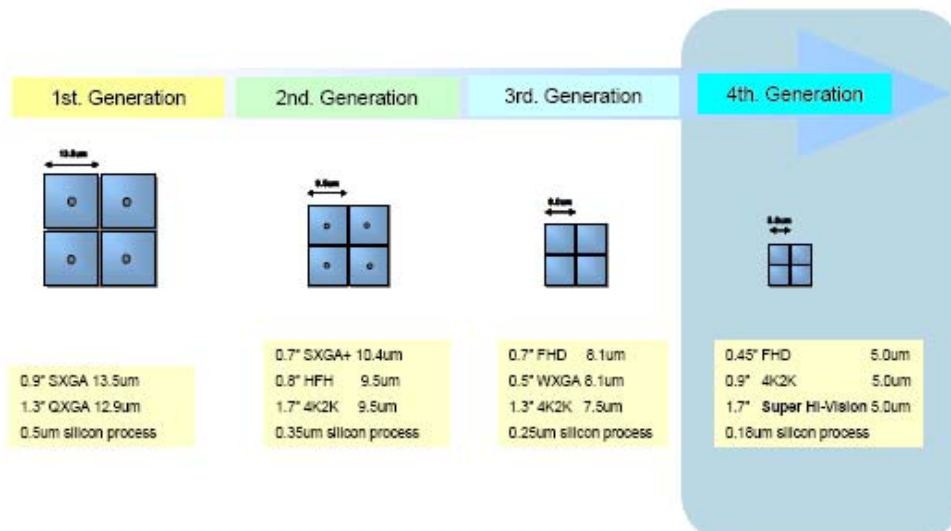


Figure 5 DILA Photolithograph Generation

Smaller lithography helps maintain high aperture ratios that give the DILA a superior image quality over other display types. This also improves total efficiency and contrast ratio (Fig. 6).

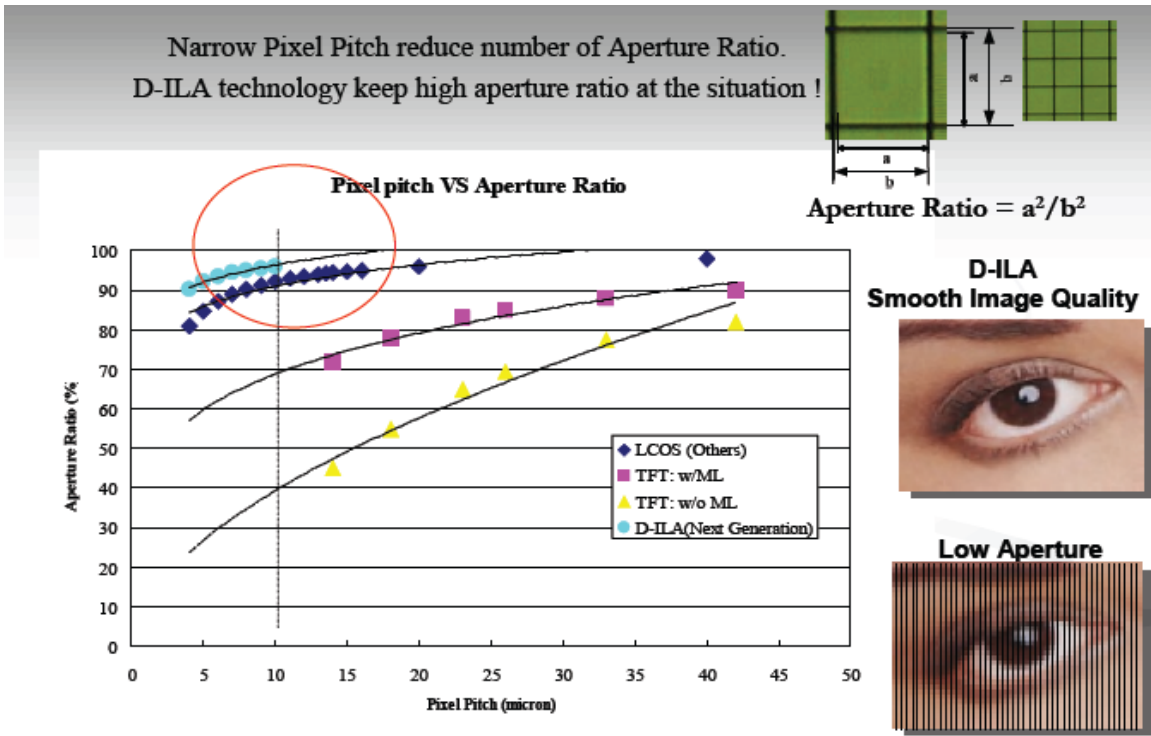


Figure 6 Pixel Pitch vs. Aperture Ratio

All D-ILA devices incorporate the highly reliable tilted perpendicular liquid crystal with inorganic, vertical alignment structure (VAN) for long life. JVC's latest developments gives extremely high contrast ratios (up to >40,000:1) for very dark blacks with very little dispersion in the turn on characteristics. The new thinner liquid crystal layer improves the response time to <4.5 msec total rise and fall time. (Fig. 7, 8)

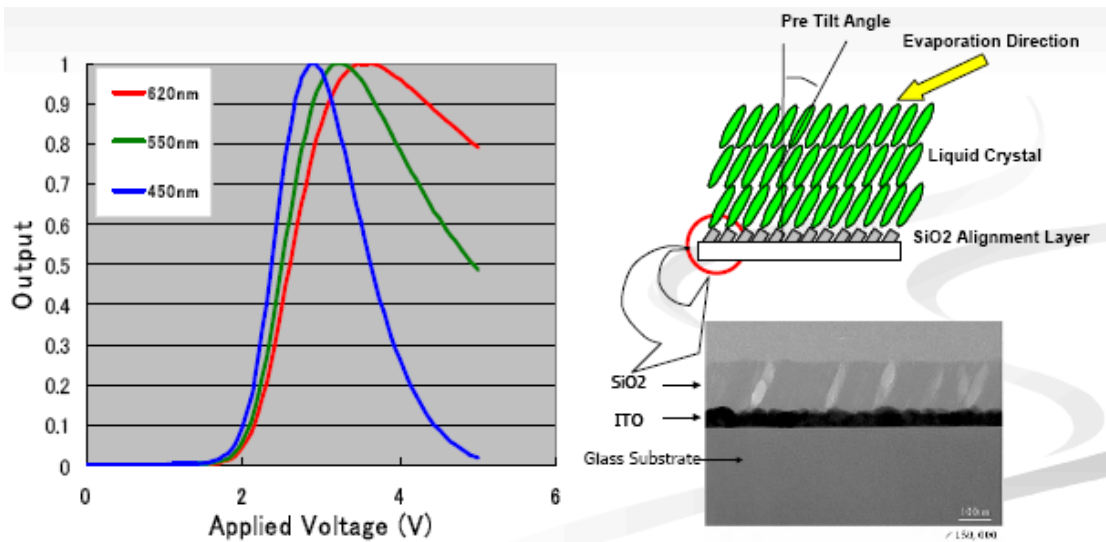


Figure 7 VAN mode LC

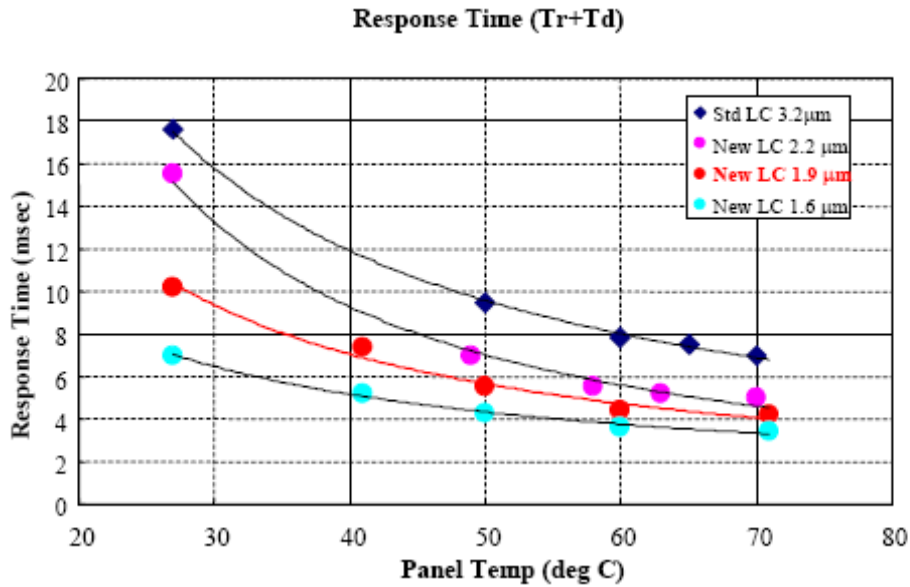


Figure 8 Device response time

To further improve overall contrast ratio, improvements in both surface planarization and total reflectivity have been implemented. The reflectivity and light blocking structure of the silicon substrate are important factors. The pixel electrodes of the D-ILA device have a 93% aperture ratio, and have high intrinsic reflectivity⁶. An additional dielectric mirror improves total reflectivity to over 80%, including aperture ratio. This reduces light scattering at the interface and between pixels as shown in figure 9.

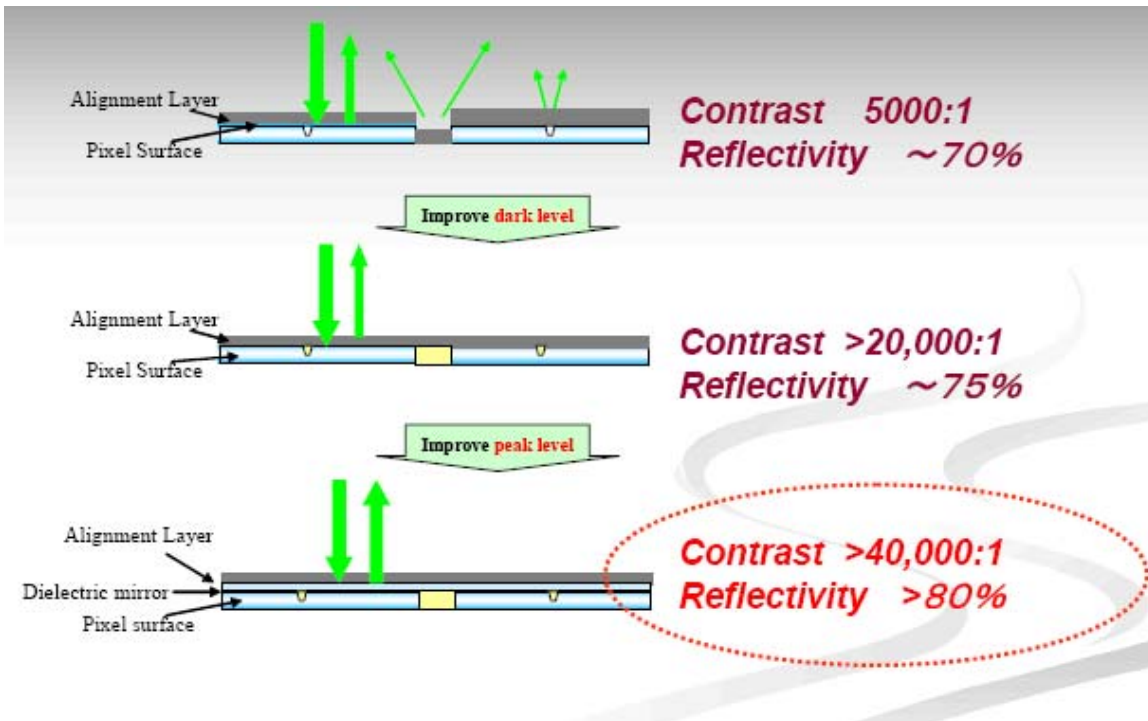


Figure 9 DILA Contrast and Reflectivity

Figure 10 shows the major specification for the 4096x2400 device used in the latest JVC projector.

Major Specifications

Device size	1.27-inch diagonal
No. of pixels (H x V)	4096 x 2400 pixels
Pixel pitch	6.8 μm
Gap between pixels	0.25 μm
Aperture ratio	93%
Device contrast	20,000:1
Response time (tr+tf)	4.5 ms
LC mode	Vertical Aligned LC
LC alignment film	Light stabilized inorganic alignment film

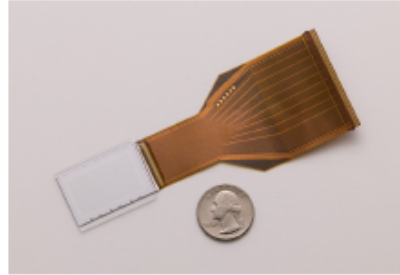


Figure 10 4Kx2.4K Device Specification

Optical Engine

A newly developed; three wire grid polarizer optical engine is utilized in this projector (Fig 11). The wiregrid technology in combination with the new device gives >10,000:1 contrast ratio.

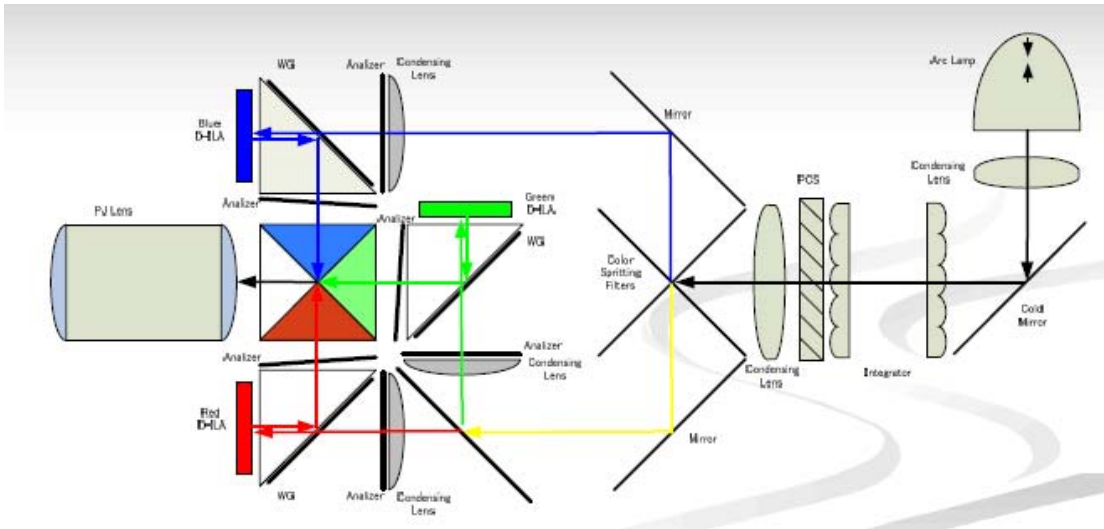


Figure 11 Three Wiregrid Optical Engine

Color management utilizes color splitting filters and an 825W xenon arc lamp to give a wide color gamut (Fig 12). A four Dual Link DVI interface with selectable 12 bit mode is utilized to take advantage of the high contrast ratio and wide color gamut to assure no visible color contouring.

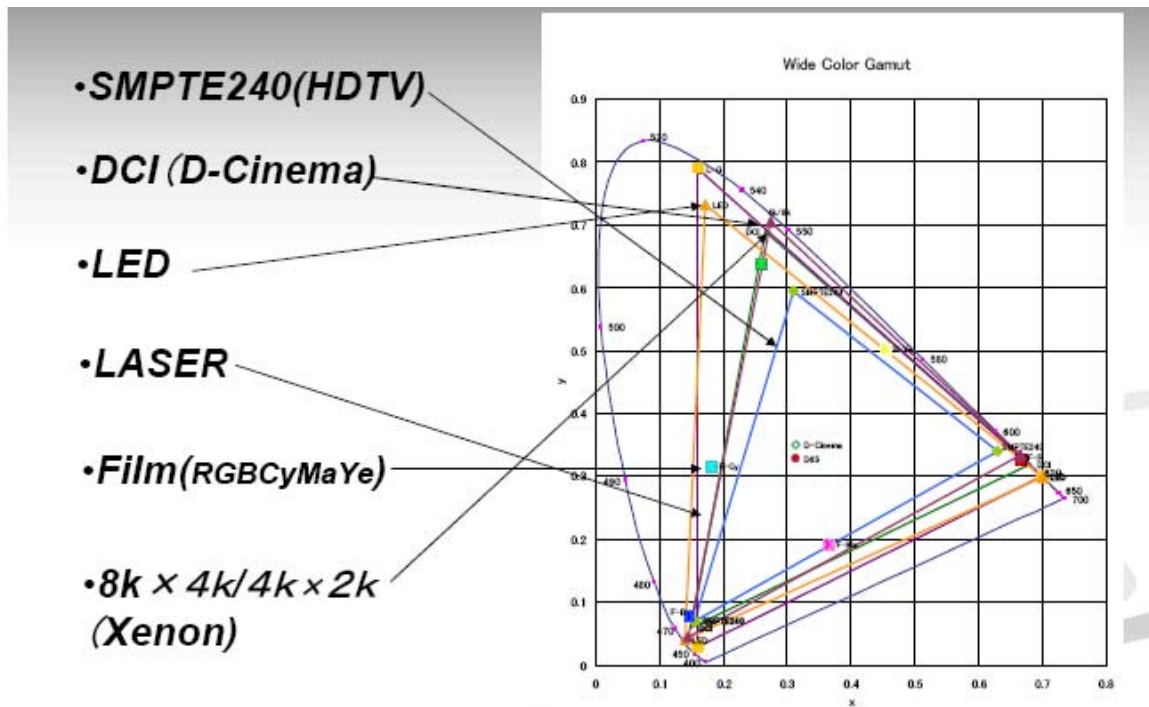


Figure 12 Color Gamut

Projector

Finally, the projector displays 4096x2400 resolution at 10,000:1 contrast ratio at 3500 Lumens. This wide dynamic range matches the 4ND (10,000:1) D_{max}/D_{min} contrast ratio of Vision Film stock used widely in Hollywood. This projector will find many applications from post work, to visualization laboratories, to simulation applications, to planetariums, to CAD viewing and more (Fig. 13).

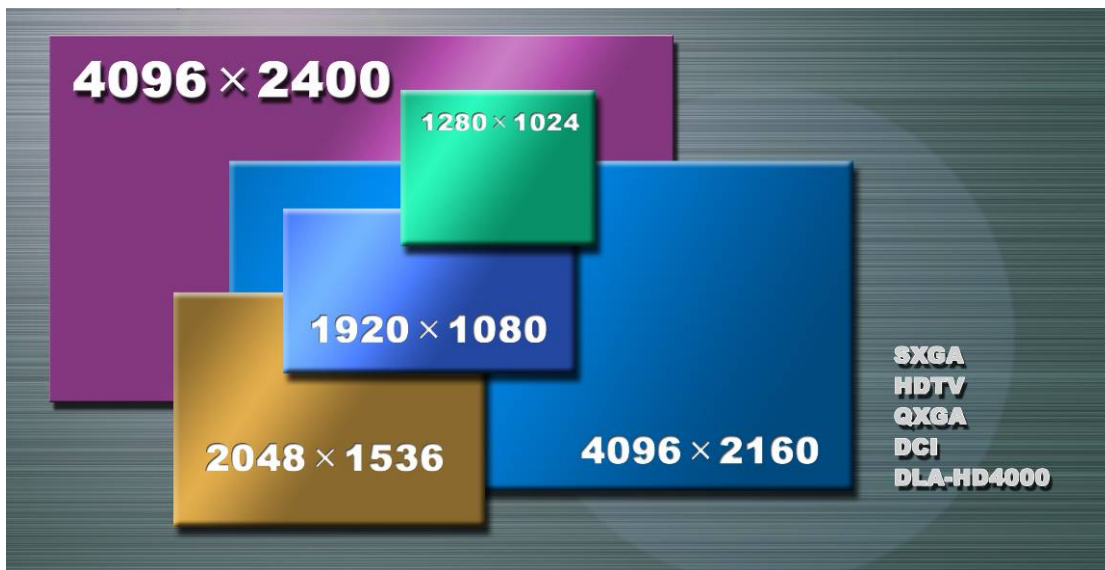


Figure 13 Comparison of 4096x2400 and other Resolutions

Internal to the projector is a thermal management design and efficient layout for a small footprint. The lamp is designed for easy change out and 110/220V inputs (Fig. 14).

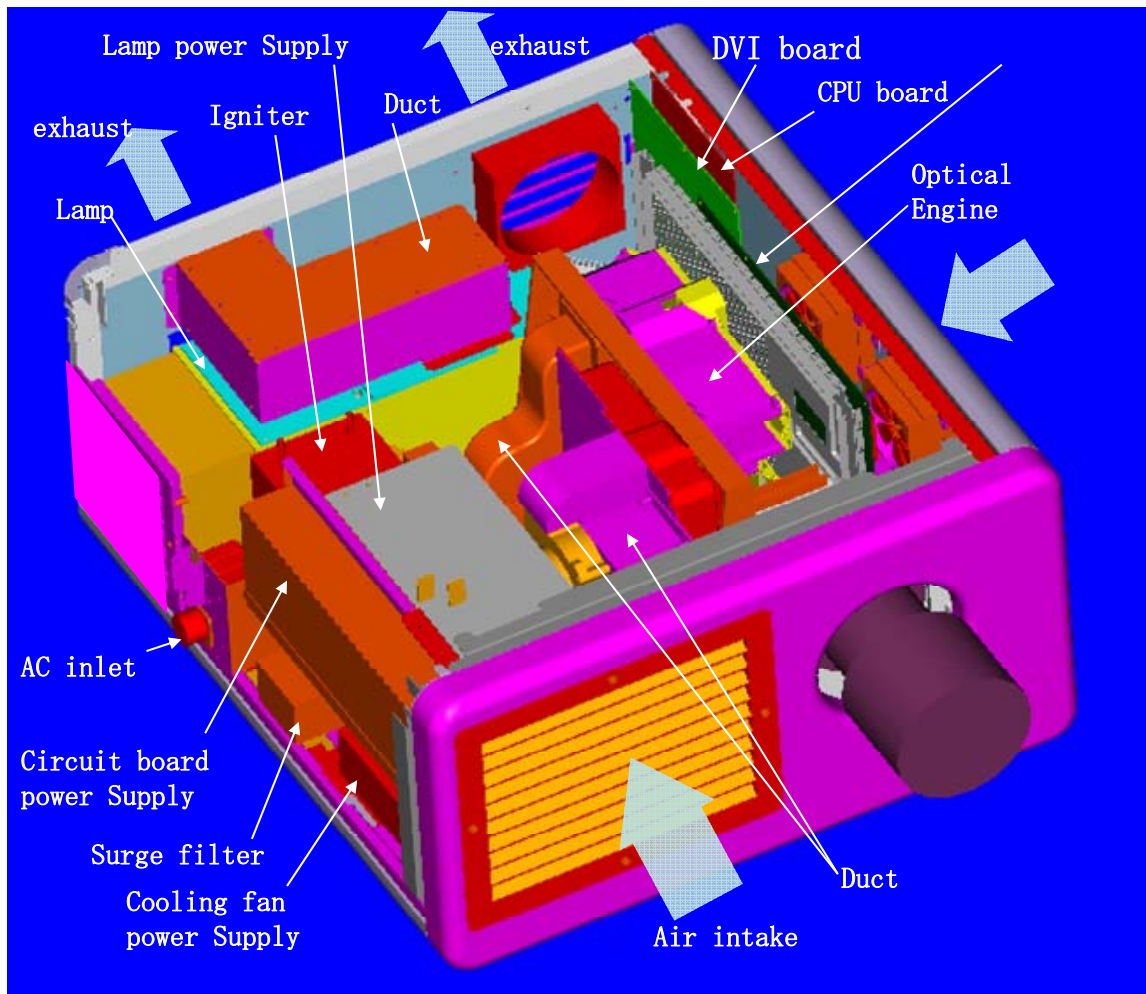


Figure 14 Projector layout

Conclusion

JVC has set a new standard in resolution and contrast ratio with the introduction of the latest 4K projector. With a long history of building robust LCOS devices⁷ and quality award winning projectors, this next introduction is just a step for newer, lower cost, higher performance projection systems. The future will see a broadening base of D-ILA applications as the new illumination technologies and system concepts including 3D display will provide the basis for display realism in many different venues.

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