LARGE DISPLAY REPORT

Volume 9 January 2011 Number 01

Technology, Product, Market and Business News and Analysis for Large Area Display Systems, Components, and Supply Chain

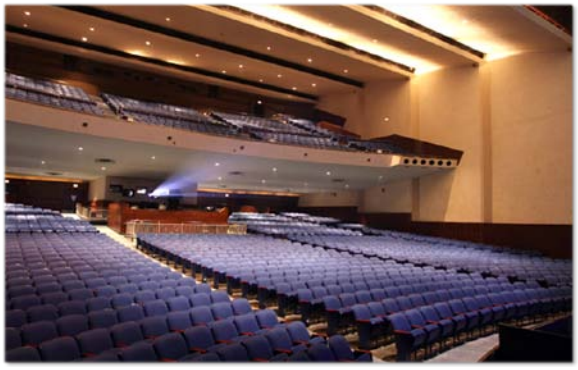
Kodak's Laser Cinema Projector Ready to Go

I have been hoping to see Kodak's new laser cinema projector (see the October LDR) for several months. On December 21, I finally had a chance to visit the company in Rochester and get a full briefing on the platform, technology and strategy, as well as a demonstration. The bottom line? The image quality is as good and sometimes better than a conventional Xenon-lamp-powered DLP digital cinema projector – especially the increase in contrast. Commercially available laser projection systems aimed at the theatrical environment could be available in the second half of 2012, if Kodak inks projection manufacturing license partnership deals in Q1'11. The price of the system will then be up to the brands who offer it for sale, but they do not have to be priced astronomically.

The Strategy

Our host for the visit was Barry Silverstein, a projection manager at Kodak. We began with a presentation covering Kodak's long history in digital cinema and the activities that have brought the company to this point. Kodak is not interested in manufacturing this projector, but is seeking industry partners to commercialize it, using the IP and innovation developed at Kodak.

But this is not what Kodak originally planned – it hoped to make the projector and offer a full service solution for the cinema industry. But that strategy changed about a year ago as



(left) Kodak's Barry Silverstein stands next to the laser projector on the projection booth. (right) a view of the 2000-seat Kodak theater where the laser projector is demonstrated

financial pressure lead to its withdrawal from providing cinema servers, theater management systems and more. Work continued on the laser projector, however.

Since Kodak had approached development of the laser projector fully intending to use this as the kingpin in its strategy, it took a very comprehensive view of commercialization, seeking to meet the needs of a number of constituencies in the industry including Hollywood, the theater owners and operators (the exhibitors) and rest of production ecosystem. As a result, the goals of the laser projector development process continued this philosophy. Silverstein boiled down the program goals into these four bullet points:

- Develop a projector that will provide a price / performance breakthrough for Digital Cinema
- Generate a high value product for the exhibitors
- Improve image quality, if possible, but not at the expense of cost
- Extend value creation through the motion picture chain

Perhaps the most surprising is the third point. Kodak felt that the laser projector had to at least be as good as a conventional lamp-based cinema projector, but if the total cost of ownership was lower, then it could indeed create a value proposition with the real customer – the exhibitors. This approach was later verified in the demonstration part in a side-by-side comparison with a lamp-based system. Kodak did not try to create a projector with a color gamut that was 200% of NTSC, although it has the potential to approach this. This expanded color gamut is not needed by the cinema industry, although it would be desirable if the laser projector was offered to the visualization and simulation industry. Instead, Kodak aimed for image quality match to the DCI specification and be "good enough", with the focus then on cost. Here, the goal was to offer a laser projector for about the same purchase price as a lamp-based version. But, the big cost saving comes in the consumables – there are no expensive lamps to replace, which saves nearly a thousand of dollars per lamp—and a cinema projector can go through more than one lamp in a year. Oh, and by the way, Kodak essentially throws in 3D operation for free – another significant cost savings. Smart strategy.

The Demo

In Kodak's massive 2000-seat theater, we first visited the projection booth where we saw a Barco DP1500 Digital Cinema projector standing side by side with the Kodak laser projector. The laser projector is an engineering prototype, which according to Silverstein, can be size-reduced to about the same footprint as the DP1500.

In the theater, we first saw the laser projector playing several clips in 2D on a white gain-1 screen. We were told that the laser projectors had been calibrated to the DCI color space to provide a true indication of the faithful reproduction of the content. While the lasers are capable of creating images that exceed this color space, the primary intent was to show equality with established digital cinema projectors.

The content we saw looked very good with no obvious color issues or speckle problems, but the side-by-side demo with the DP1500 was most instructive. Here, one could easily compare colors, contrast and black level. It was clear from all-black frames that the laser projector had a better (lower) black level than the DP1500, but this lower black level was not that obvious in the movie content due to current black level grading for distribution.

We were told that the current laser projector has an on/off contrast ratio of about 10K:1 whereas the DP1500 typical has about 2K:1. This was evident in the improved black levels, but Silverstein says they used to have 20K:1 contrast with the projector, which made the screen

blend into the black curtains at the edge of the screen. This is the level he expects commercial products to offer.

Speckle is always a concern with a laser projector and we are happy to report that it appears to have been reduced to a level that most will not object to. Only when we looked at the RGB and CMY color bars could we see any evidence of speckle. The cyan and yellow seemed to show a little speckle, but the green did not. This speckle was not visible in moving images.

Next, we saw some 3D content using a 2.3 gain silver screen. Here, we were able to see some screen structure in some of the images that looked almost like speckle, but was not. This content looked very good as well, but one of the key advantages with 3D is the ability to deliver content at about twice the brightness (7-8 fL) compared to the level it is current shown at today (3-4 fL). Silverstein noted that while exhibitors have can't show 3D at higher luminance levels, due to etendue limits in the projector. Even if the exhibitors could show brighter 3D they would be hesitant with Xenon as the operational costs go up significantly with larger lamp size.

In the very wide theater set-up at Kodak there was some noticeable brightness variation for the outermost seats due to this relatively high-gain screen. The far edge was a little darker than the closer edge of the screen. For seats in a typical movie theater set-up the uniformity of the screen was excellent, however.

Convincing Hollywood & the Exhibitors

The demo proved an important point – the image quality is as good as or better than the conventional approach, and speckle is not an issue. Kodak has been showing this demo to major studios and cinematographers for several months and Silverstein says the feedback has been very good. While we clearly don't have the Golden eyes of a Hollywood expert, we found nothing serious to complain about in the image quality, and I suspect most in Hollywood would find this an acceptable level too. And remember, the Kodak targets for this projector are the theater owners. The image quality in your local multiplex is typically significantly worse than a Hollywood expert would see in a perfectly set-up screening room.

One of Silverstein's slides summed up the exhibitor and post-production needs very well, as shown in the image below.

To address the needs and concerns of the exhibition community, Kodak has invited both large and small chain operators to their facility to get more information and a demo. Silverstein says they have been impressed with the image quality. Once this issue is satisfied, the discussions quickly turn to other concerns.

Industry concerns
- Time to market
- Cost to deploy
- Meet industry specs

Reliability
- Single points of failure
- Long life components

Image Quality
- Color gamut
- Contrast ratio
- Brighter 3D

Cost
- Upfront
- Total cost of ownership: consumables, service & support, power consumption, periodic maintenance

3D
- Cost effective
- Brightness
- Minimize special settings

On the cost of the projector, Silverstein estimates that it will cost about the same as a comparable lamp-based model today. The laser projector has a much more

costly light source, the lasers, but the projector maker can save a lot of money by using less expensive optics and a projection lens (more on this in technology section). He thinks this about balances out in terms of the cost of production for the projector.

However, there are two key elements that make this more favorable on the cost/performance side. One is the on-going consumable lamp expense that goes away with the laser projector. Xenon lamps are expensive to buy and operate (electrical power) and are not replaced as often as Hollywood would like because of the expense. The lasers are projected to have such a long lifetime that they will last for 10 years in a typical theater before they need replacing. And, the lasers degrade slowly, not the initial fast degradation of a Xenon lamp, so screen brightness can be maintained for a much longer time – enhancing the quality advantage.

For speckle reduction, the Kodak projector alternates between orthogonal polarization states even during 2D operation. Therefore, no additional polarization optics, with their attendant losses, are required for 3D operation. This light level advantage and avoidance of polarization losses translate into 3D operation that allows 3D images to be brighter and maintained at this higher brightness level for a longer time.

More importantly, exhibitors can save more money on the cost to outfit their theater for 3D with the Kodak approach. Inside the projector are polarization switching elements for each red, green and blue laser light channel. This is a standard component and allows 3D polarization switching without the additional cost of a retrofit 3D solution. And, this is controlled by a single button now instead of the manual intervention needed with today's solution.

Kodak also chose to use linear polarization switching instead of circular, which is what RealD does. Yes, linear polarization has more problems with head tilting, but it also has less ghosting than circular when your head is straight. Plus, Silverstein thinks that linear passive polarized glasses will be cheaper than circular ones. That cost will come into play soon as the studios stop subsidizing the cost of the glasses and this cost is transitioned to the exhibitors. If an exhibitor wishes to use circular polarization for 3D, all that is required is a quarter-wave plate at the output of the projection lens. If this is a wide spread requirement, a Kodak licensee can build the quarter-wave plates into the projector itself.

Are you getting the picture? Every little cost counts to the exhibitors as they don't make their money on ticket sales – they make it on popcorn sales. Since there is no real economic payback for better image quality as long as it is acceptable, they will save money on lamps, power consumption, glasses and equipment whenever they can.

(Left) projection lens for laser-based system and (Right) projection lens for conventional lamp-based digital cinema projector

The Technology

First, Kodak decided to use a DLP-based solution instead of an LCOS-based solution, primarily due to the robustness and commercial availability of the DLP chip sets for this market. No real surprise there.

Laser sources are also the ideal solution for a projection system. They are very small light sources and they are also polarized, have narrow emission wavelengths and long life. All these factors allow designers much more flexibility in the design and optimization of the system.

For example, the small etendue of the laser sources allows the f-number of the design to be reduced from the typical f/2.4 of a DLP system to f/6 in the Kodak system. This allows much less complex optics that influence the cost significantly. Take a look at the two projection lenses in the photo to see the difference f-number makes on the size, complexity and cost of a projection lens for a digital cinema projector. Pretty amazing.

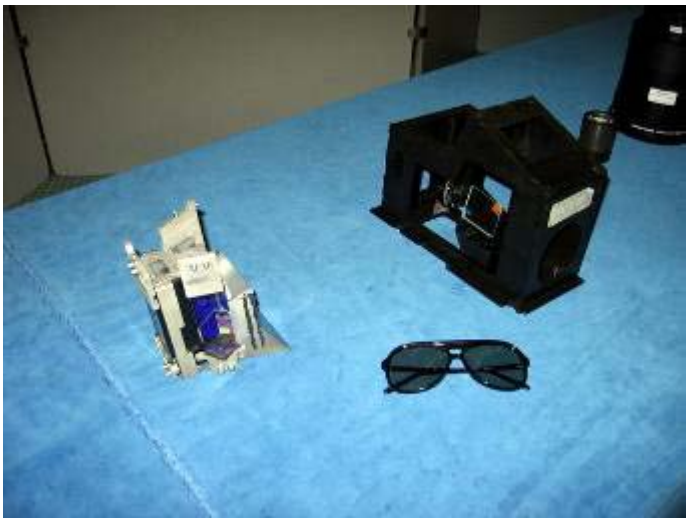
The f/6 system also allows Kodak the ability to improve contrast, vignetting and other issues, which are limitations with fast f-number systems. In fact, they opted to eliminate the convention TIR prism assembly of a conventional DLP Digital Cinema projector in favor of a new design that is much simpler and yes, less expensive. The optic and housing for this module, which is used to combine the images from the three DLP modulators, is shown in the photo.

The narrow emission wavelengths also allow the dichroic filters and other optical coatings to be much less complex, saving money.

Lasers can create more uniform images, but they also come with the potential to create distracting speckle. Kodak says they implemented multiple techniques to eliminate speckle including angular and spatial mixing (stationary and time varying), unphased lasers, RF laser driving, polarization rotation and spectral spreading. As noted earlier, this has reduced the speckle to acceptable levels.

The lasers themselves are supplied by NECSEL. Lasers from other suppliers could be used in the projector too, but the choice of lasers will be up to Kodak's licensee, not Kodak.

As mentioned earlier, 3D is accomplished with linear polarization switching of the red, green and blue laser channels. According to Silverstein, the resulting efficiency of this is a marked improvement over current solutions. He claims 65% higher efficiency over a standard 3D system and 25% higher efficiency compared to the doubled systems.



New image combining optics and housing for the Kodak laser projector

What does that mean to an exhibitor? That means the current Kodak laser projector (about 10K lumens) shining on a 40-foot silver screen with a gain of 2.3 will produce a 2D brightness level of 23 fL. This is above the desired standard of 14 fL, but the laser can be easily turned down to lower outputs. In 3D mode, 8 fL is easily achievable, which is much higher than what most 3D theaters are running at today.

As for the cost saving, Kodak estimates a 30-50% savings in energy use and over a 30K-hour laser lifetime to half brightness – orders of magnitude longer than a Xenon lamp.

Laser Safety

What about laser safety you ask? Well, inside the laser, the power levels are clear in class 4 ranges, so safety interlocks on the projector doors are likely to be needed. This is nothing new because all cinema projectors with xenon lamps have interlocks already. But, the big concern has been the safety rating of the laser when used in the theater.

We learned in our meeting that Kodak has been working with the FDA for two years on this issue and is now "weeks away" from approval. According to Silverstein, the FDA has been used to dealing with high power lasers for laser light shows, so had to be educated on the use of lasers in a projection system. This two-year effort has now culminated in the FDA agreeing to look at laser projection as a different type of device with a different rating system. The agreement apparently calls for the FDA to issue a special class 3 variance that laser projector makers can apply for. If approved, this variance would be passed to the exhibitor with the purchase of the laser projector. It would mean that the laser is treated in a way that is similar to the Xenon-based projector, clearing a major potential hurdle in the commercialization of this technology.

Conclusion

What Kodak has done and is now revealing to the industry is very impressive. It is in active negotiations with a number of potential manufacturing partners and hopes to make announcement concerning this in early 2011. Laser-based digital cinema, e-cinema and large venue platforms could now be in the market by the end of 2012. And, the FDA would actually approve of them. Hats off to Kodak. – *Chris Chinnock*