Projection Image Quality Series
White Paper #2: The SXRD microdisplay
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Welcome

From data visualization to simulation, planetariums, museums, trade shows and theme park attractions, projection users are demanding higher picture quality. But what is picture quality? Does it result from one feature – or some combination? How is the onrush of 4K changing the field? What about High Dynamic Range, called by many professionalsi,ii,iii,iv,v the most important advance in picture quality? And how can today’s installation designers make informed choices?

To answer these questions, Sony has created a series of three white papers:

1. Resolution
2. SXRD® microdisplays
3. High Dynamic Range

Picture quality is advancing on every front, transforming the viewing experience.

In this paper, we’ll treat the subject of Sony’s SXRD microdisplay chip, crucial to so many aspects of picture quality:

- **Native resolution.** The chip determines the resolution of the projector.
- **Native contrast.** While dynamic iris and modulating the lamp level can create scene-to-scene contrast, they can’t help within a given scene. If the chip can’t produce contrast, no amount of external processing can add it back.
- **Black level.** Some chips can only achieve milky black. Others do better.
- **Dynamic range.** The ability to render all levels of brightness from deep shadows to bright highlights requires superb contrast and deep blacks.

We’ll also see that of the dozens of projector vendors, Sony is one of the very few that make their own microdisplay chips – a distinction that makes all the difference.
Types of microdisplays

With hundreds of video projectors on the market, the range of choice appears endless. Yet for all the superficial diversity, under the hood these projectors use only three basic types of projection chips.

- **Transmissive Liquid Crystal Display (LCD).** Sometimes called HTP-S, for High Temperature Poly-silicon, these chips work like the LCD panels common in televisions and other devices. Light shines through them to create the picture. The chips open and close down light transmission to create light and dark values for each pixel. Sony’s BrightEra® chips are examples of contemporary projection LCDs.

- **Digital Light Processor® (DLP®)** is the Texas Instruments trademark for a class of digital micromirror devices. These use tiny tilting mirrors to reflect light toward either the screen or a heat sink. The mirrors are essentially one-bit devices: fully on or fully off. To create shades of grey, the mirrors rapidly alternate between on and off states. The greater proportion of on-states, the brighter the pixel will be.

- **Liquid crystal on silicon (LCoS).** Like transmissive LCD, this system uses liquid crystal to control the flow of light for each pixel. As with DLP chips, the light reflects off a mirrored surface toward the screen. Where light passes through the transmissive LCD layer once, light must pass through the LCoS LCD layer twice, which makes for higher contrast. The SXRD® chip is Sony’s proprietary version of LCoS.

The issue of inter-pixel gaps

When Sony developed the SXRD panel, the dominant microdisplay technology was transmissive LCD. As the name implies, transmissive LCD requires the light to shine through. Because the pixel transistors are transparent, they don’t cause a problem. Unfortunately, the wires that address and power the pixels are not transparent. They must run alongside the pixels, creating substantial “inter-pixel gaps” that block the light. These gaps were so big that they occupied as much as 50% of the screen. This left an active picture area (or “fill factor”) of just 50%.

*Wide inter-pixel gaps can make it seem as though you're looking at the image through a screen door. Hence the name “screen-door effect.”*
A fill factor of 50% creates issues in projector design. It lowers image brightness, because so much of the projector’s lamp light is blocked. It creates “screen door effect” in the projected image, giving each pixel an individual outline. And in terms of system design, large inter-pixel gaps also require large pixels, which make high-resolution chips relatively expensive. Sony recognized that the transition to HD projection demanded a smarter approach.

The SXRD solution

Sony’s answer was the Silicon X-tal (crystal) Reflective Display (SXRD®), a proprietary version of LCoS technology. Instead of light shining through the chip, the light reflects off a polished aluminum surface, behind which we can hide the transistors and all the pixel address wires. The benefits are profound.
Photomicrograph of the first-generation SXRD panel. You can see that the inter-pixel gaps are quite narrow in comparison to the live picture area. Each pixel has a beveled edge and a “contact divot” in the center.

- **High fill factor.** Hiding the pixel address wires enables the inter-pixel gaps to be quite small. So the proportion of the chip surface devoted to active picture area can be quite high: 92% in our first-generation chips, compared to the 50% fill factor for the transmissive LCDs of the time. This enables Sony to deliver high resolution without sacrificing brightness.

- **High contrast, low black level.** From the outset, the SXRD panel achieved very high native contrast. Previous LCD projectors had used Twisted Nematic (TN) liquid crystal, which normally displays white. The SXRD panel uses a proprietary Vertically Aligned Nematic (VAN) liquid crystal, which normally displays black. The normally black state helps prevent stray light from washing out the image. This improves black levels and increases contrast. With succeeding generations of chips, Sony upgraded the chip-making process to drive contrast higher still. We refined the pixel surface, eliminating the center “contact divot” and beveled edges. We also improved the liquid crystal alignment. These upgrades dramatically reduced light scatter, optimizing black levels and maximizing contrast.
Improving liquid crystal alignment and eliminating both the contact divot and the beveled edge minimize stray reflections. The result: a substantial improvement in black levels.

• **High pixel density.** There are two ways to increase the native resolution of a microdisplay projector: larger chips or higher pixel density. Unfortunately, large chips are expensive; and they require larger, more expensive light engines, optical blocks and lenses. That’s why Sony went the other route, shrinking the pixels and increasing pixel density. Sony’s first generation SXRD achieved 12,000 pixels per square millimeter. In comparison, our current GTZ Series projectors achieve about 61,000 pixels per square mm – higher density than competing DLP® and transmissive LCD projectors. High pixel density leads to superb cost performance.

The secret of Sony’s success

Sony’s SXRD chip and the high pixel density it enables have proven to be foundational advances in projection technology. The SXRD chip has underpinned repeated “world’s firsts.”

• **2003.** World’s first microdisplay home theater projector with Full HD resolution (QUALIA® 004)
• **2005.** World’s first commercial 4K projectors (SRX-R110, SRX-R105)
• **2006.** World’s first 4K projector dedicated to Digital Cinema (SRX-R220)
• **2011.** World’s first 4K home theater projector (VPL-VW1000ES)

Not only has the high pixel density of the SXRD chip enabled Sony to deliver first, it also enables us to achieve true, native 4K resolution in product categories where others can only offer pixel-shifting “faux 4K.” No wonder SXRD projection has found success everywhere from cinema auditoriums to flight simulators, planetariums, oil & gas exploration and home theaters.

Color reproduction: One chip vs. three

High pixel density and its resultant high cost-performance has another advantage. While DLP projection vendors typically reserve three-chip color for their most expensive digital cinema and postproduction projectors, all of Sony’s installation projectors benefit from three-chip color.

The chip itself is essentially monochromatic. A single-chip projector creates colors one at a time via external control of light. Traditional lamp projectors use a rotating color wheel with three or more segments that filter the light to create Red, Green and Blue. The wheel
segments sync with the projection chip’s Red, Green and Blue sub-frames. Laser single-chip projectors use different methods to generate color. Regardless of method, only one color reaches the screen at a time. Unlike real life, the projector relies on the human visual system to blend all the colors together. The color is unstable across time, always cycling between Red, Green and Blue.

In contrast, three-chip projectors deliver constant streams of Red, Green and Blue light to the corresponding chips. Just as in real life, you see all the colors, all the time. Each pixel on the screen always shows the correct color.
The three-chip system has powerful advantages.

- **Color accuracy.** Projecting all the colors, all the time, 3-chip projectors achieve high color accuracy.

- **100% color stability.** Depending on viewing conditions and individual viewer sensitivity, single-chip projectors can reveal “color breaking” and “rainbow” artifacts. These tend to be especially notable on scenes with high contrast and high motion. Because 3-chip projectors display all the colors all the time, they are immune to these artifacts. You get a more continuous, more organic display of color, much closer to life itself.

![Color Brightness Comparison](image)

*Single-chip projection color light output is just a fraction of the white light output claimed in brochures and ads. In Sony’s 3-chip system, the two measures are identical.*

- **Color Brightness.** Projector light output is conventionally measured on an all-white screen – not exactly an accurate representation of viewing conditions. A more realistic (and more demanding) test is color light output, as standardized by the Society for Information Display (SID) in 2012. Unfortunately, the color light output of single-chip projectors is just a fraction of the white light output claimed in typical brochures. For every one of our 3-chip projectors, specified color light output is exactly equal to the specified white light output. As we will see, High Color Brightness is crucial for our next paper in this series: High Dynamic Range.

**The SXRD advantage in professional installations**

Clearly, projectors equipped with the SXRD microdisplay can make a tremendous difference in data visualization, simulation, planetariums, museums, trade shows and theme park attractions.

- **More resolution.** Equipped with native 4K (4096 x 2160) resolution, Sony’s GTZ Series projectors can deliver more information, greater immersion and greater image smoothness/less-visible jaggies. Best of all, you can configure the screen size and viewing distance to optimize these parameters for your specific application. More information is vital in data visualization and simulation. Greater immersion can make a huge difference at trade shows, museums and theme park attractions. Greater image smoothness is particularly valuable for superior presentation of visual art and more
convincing, more involving simulations. In addition, compared to “faux K” projectors that use pixel-shifting techniques, SXRD projectors enable your end-users to see all the pixels, all the time. (For the full story on resolution, please refer to the first paper in this series.)

With apologies to Mies van der Rohe, sometimes more is more. If you need to convey detailed visual information, there’s no substitute for pixels.

- **Higher contrast.** While contrast is obviously a key component of picture quality, contrast works hand-in-hand with resolution to create the human perception of “sharpness.” Resolution alone is not enough. You need resolution and contrast together. And that’s precisely what SXRD microdisplays deliver. Because Sony’s liquid crystal is normally black, and because light must travel through the LCD layer twice, Sony’s SXRD microdisplay contrast is often visibly superior to alternatives. As a result, museum images have greater apparent depth, entertainment has greater impact, simulations are more convincing and important details in all your presentations appear sharper.

The resolution of both images is identical. Only the difference in contrast accounts for the higher perceived sharpness. Look at the rocks and boulders at the side of the trail, as well as the detail in the bushes.
• **Lower black level.** While some projectors can only produce milky blacks, Sony’s SXRD system does much better. This helps contribute to high contrast not only on extremely dark scenes, but also on normal pictures with the full range of tonal values.

• **High Dynamic Range.** The combination of higher contrast and lower black level contribute mightily to High Dynamic Range (HDR). HDR increases your ability to see detail in the brightest highlights and deepest shadows. And that's a benefit whether you're exhibiting at a museum, training pilots to land at sunset or communicating the corporate message. A sea change in electronic imaging, HDR is such a big story that we've devoted the third and final paper in this series exclusively to that subject.

**Sony and microdisplay projection**

Sony helped drive the transition from cathode ray tube (CRT) projection to microdisplays. We've been building microdisplay projectors since 1993. And we don't just build the projectors; we build the microdisplays inside. In fact, while there are dozens and dozens of projector brands, Sony is among the very few that designs and builds microdisplays in-house. This in-house panel manufacturing has enabled Sony to innovate, decade after decade.

**Sony, the video professionals**

In industry after industry, professionals who care about picture quality entrust their work to Sony. Our gear meets the most stringent tests, not only from engineers looking to maximize performance, but also from financial officers looking to maximize return on investment. We deliver the quality, reliability and sustained product life cycles that professionals know and trust.
Projectors for visualization, simulation and exhibits

VPL-GTZ280
4K SXRD laser projector with 2,000 lumens output (up to 5,000 lumens with optional license) and accurate reproduction of high-speed motion for simulations

VPL-GTZ270
4K SXRD laser projector with 5,000 lumens light output and superb image quality

VPL-GTZ240
4K SXRD compact laser projector with 2,000 lumens output and accurate reproduction of high-speed motion

The future
Stay tuned for further developments.

A final word
In this document, you’ll find a wealth of charts, diagrams and technical explanations. But reading about Sony’s projectors is a poor substitute for hands-on/eyes-on experience. Your Sony representative will be happy to arrange a demonstration.
iii  https://www.digitaltrends.com/home-theater/what-is-hdr-tv/
iv  https://mytechdecisions.com/video/high-dynamic-range-hdr-4k-uhd/
v  http://carltonbale.com/does-4k-resolution-matter/