FEATURING

Reflective Liquid Crystal Display Technology for Use in Projection System

SXRD™ Creates Previously Unknown Smooth, Realistic Images

- **Extremely high contrast: 3000:1 or higher**
- **Realistic high resolution that supports full HD**
- **High aperture ratio: 92%**
- **High-speed response time: under 5 ms**
- **Superlative light resistance reliability provided by inorganic alignment film**

SXRD
Silicon X-tal Reflective Display

* “SXRD” and SXRD are trademarks of Sony Corporation.

In March 2005, Sony released the largest*1 Japanese-market consumer TV set, the 70V QUALIA 006 Projection TV “KDS-70Q006”. (See photograph 1.) At the same time as providing the first full HD support*2 in a projection TV (with a fixed pixel system) and faithfully reproducing dark scenes with its high contrast, this product achieves photograph-like smooth high picture quality images. This product adopts 0.78-type full HD SXRD (Silicon X-tal*3 Reflective Display) for each of the red, blue, and green color channels in the optical engine that forms the heart of this product. The high picture quality of the QUALIA 006 is created by the high resolution, high aperture ratio, high contrast, and high-speed response, which are the features of the SXRD technology.

*1: According to a Sony survey on February 9, 2005.
*2: According to a Sony survey on February 9, 2005 of fixed pixel system projection TVs in the Japanese market.
*3: X-tal means “crystal.”

■ **Photograph 1 QUALIA 006 “KDS-70Q006”**

■ **Table 1 SXRD Device Characteristics**

Display element	Full HD SXRD	4K SXRD
Display size	Diagonal 0.78 type	Diagonal 1.55 type
Number of pixels	2M pixels (1920H × 1080V)	8.85M pixels (4096H × 2160V)
Pixel pitch	9 µm	8.5 µm
Inter-pixel space	0.35 µm	
Liquid crystal mode	Vertical aligned liquid crystal	
Liquid crystal cell thickness	2 µm or less (1.5 to 2 µm)	
Alignment film	Inorganic alignment film	
Device contrast	3000 : 1 or higher	4000 : 1
Response speed (τ on + τ off)	5 ms or less	
Reflectivity (550 nm ± 35 nm)	75%	72%
Backplane process	0.35 µm MOS process with 0.25 µm features in some sections	

SXRD Device Technology

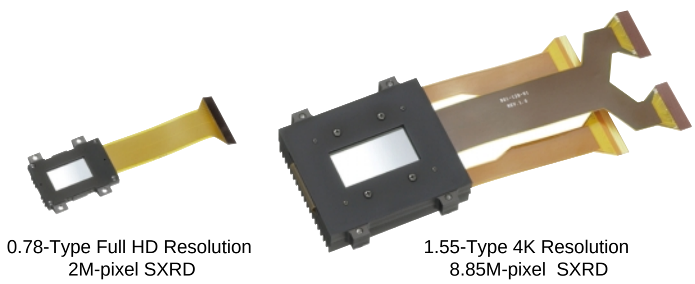
SXRD devices are reflective LCD devices that use the LCOS (Liquid Crystal on Silicon) silicon drive devices independently developed by Sony. These are projection display devices that enlarge and project an image onto a screen with an optical system and are included in front projectors and projection TV sets.
Currently, Sony has developed two devices, a diagonal 0.78-type full HD resolution (1920H × 1080V) panel and a diagonal 1.55 type with an 8.85M pixel resolution (4096H × 2160V) panel. These devices are already in the mass production stage. Table 1 presents the specifications of these panels and photograph 2 shows the products.

Device Structure that Supports High Picture Quality

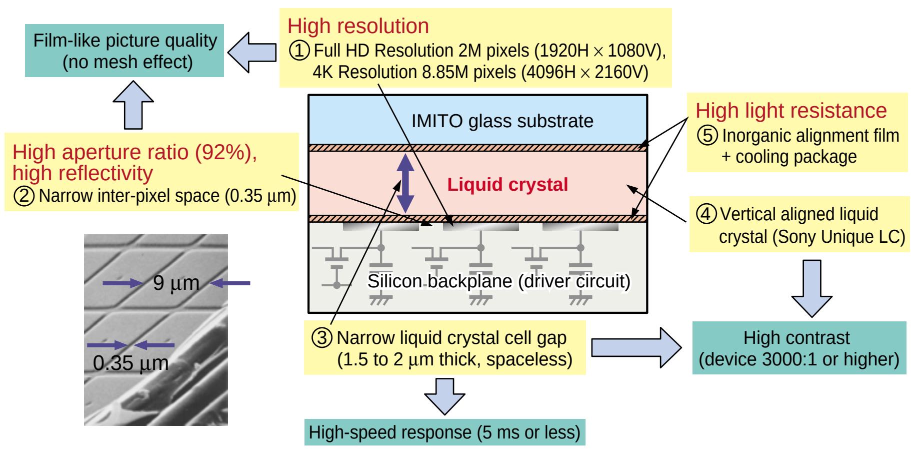
Figure 1 shows the structure of the SXRD device. The pixel pitch is 9 µm in the 0.78-type panel and 8.5 µm in the 1.55-type panel. Since the inter-pixel space is an extremely small 0.35 µm in both panels, they have high aperture ratios of 92% or higher. The features of the SXRD devices are smooth images made possible by the high aperture ratio and the high resolution that exceeds 2M pixels (full HD (1920H × 1080V)), the high device contrast of over 3000:1, the high-speed response time of under 5 ms, and the superlative light resistance reliability due to the inorganic alignment film.

High Resolution

Sony took advantage of the structural features of the reflective type devices and silicon fine fabrication technologies and achieved a 9 µm pixel pitch by embedding the drive circuits in the back side of the reflective mirror, and was able to lay out 2 million pixels in an area with a diagonal of about 2 cm. Furthermore, by achieving the industry's smallest class of 0.35 µm for the space between adjacent pixels in a reflective LCD device, Sony was able to minimize the "mesh effect" (the perception of looking at a scene through a screen door) and create devices that can provide smooth and natural images.



■ **Photograph 2　SXRD Panels**



■ **Figure 1　SXRD Device Structure and Features**

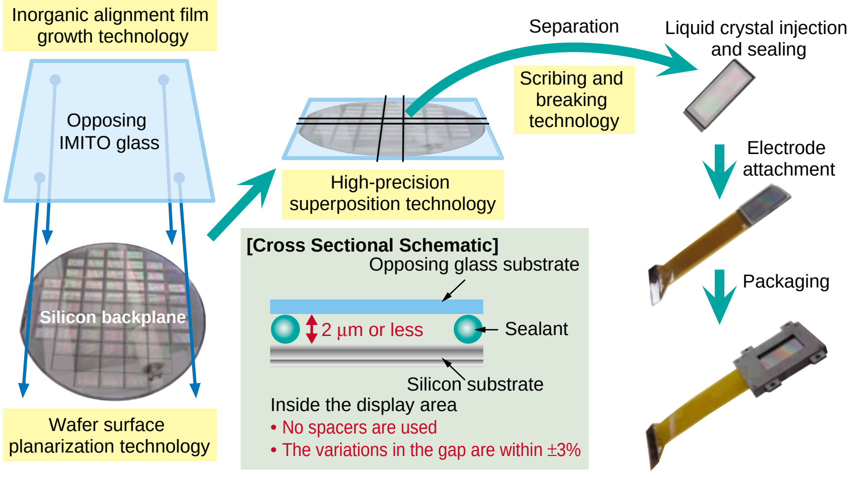
High Contrast and High-Speed Response

The performance of these devices is based on Sony's unique vertical aligned liquid crystal material and a device structure that has a narrow (2 µm or less) liquid crystal cell gap. Sony was able to minimize light leakage when black areas are displayed by using a vertical aligned liquid crystal that features normally black operation (the device displays black when no voltage is applied) and thus increase the device contrast characteristics. Sony increased the contrast even further by making the thickness of the liquid crystal section (liquid crystal cell) between the silicon drive substrate and the opposing glass substrate be 2 µm or less. Since the spacers normally introduced into the display area to keep the thickness of the liquid crystal cells even disrupt the alignment of the liquid crystal material and lead to light leakage that reduces contrast, Sony created a structure in which no spacers whatsoever are introduced into the display area. By developing this kind of optimal device structure, Sony was able to implement a practical device that achieves the contrast performance inherent to the vertical liquid crystal material.

While it is commonly known that the liquid crystal response speed is proportional to the thickness of the liquid crystal cell, in the SXRD device, Sony was able to make the cell the extremely thin 2 µm or less, and thus achieve a rise time of 2.2 ms and a fall time of 2.3 ms. Thus these devices achieve the high-speed response of a total time under 5 ms. For video with a frame frequency of 60 Hz, a single frame has a period of about 16 ms. Since SXRD devices can be driven with a period that is sufficiently short relative to that time, they can provide crisp image quality even for video.

High Reliability

Normally, a polyimide organic alignment film is used for aligning (determining the direction that the liquid crystal molecules will tilt when a voltage is applied) the liquid crystal material. For the SXRD technology, Sony developed an inorganic alignment technology that matches the vertical liquid crystal material. Projection devices normally require the use of an unthinkably bright light to enlarge and project brightly an image created on a small area with a diagonal of about 2 cm. It is known that inorganic materials generally are highly reliable with respect to exposure to light, and in the SXRD devices as well, Sony was able to achieve superlative light resistance by developing an inorganic alignment technology. At the same time, Sony adopted a high-efficiency cooling structure that uses the feature of the reflective type LCD that allows it to be cooled from the back.



■ **Figure 2 SXRD Wafer Unit Panel Assembly Mass Production Process**

Sony's Unique Process Technologies

Sony developed the panel assembly technology shown in figure 2 that uses wafer unit superposition as a mass production technology to create narrow gap cells without using spacers as described previously. For normal projection devices, it is common to use a process in which the drive substrate and opposing glass are both cut into small sections with a diagonal of about 2 cm and then stacked together in individual units. However, if this method is used to manufacture liquid crystal cells with a thickness of 2 µm or less, various problems occur. These problems include an increased probability that the cell thickness will become uneven due to dust getting into the devices and an increased difficulty in controlling the cell thickness precision, since no spacers whatsoever are used in the display area. Compared to conventional processes in which panels are assembled after the chips are cut apart, this newly-developed 200 mm wafer unit process has the features that dust cannot get trapped in the panels when the chips are cut apart and the precision can be controlled evenly in the narrow gap created without the use of spacers by controlling the thickness across the whole wafer. This achieves an extremely high production efficiency.

There were several technologies whose development were keys to actually implementing this process: silicon wafer planarization technology, inorganic alignment film uniform growth technology, high-precision superposition technology, and high-efficiency scribing technology. Current Sony mass production is at the level of achieving a ±3% gap precision for 1.5 to 2 µm thickness narrow gap panels.

Future Developments

Sony's SXRD technology was first used in the industry's first full HD home use front projector, the QUALIA 004 (photograph 3) in December 2003. Following that, it was next used in the QUALIA 006 projection TV described here. Furthermore, the 8.85M-pixel 1.55-type 4K SXRD with a resolution over four times that of full HD was included in the "SRX-R110" (photograph 4) and the "SRX-R105", which were released as products targeted mainly for use in digital cinemas. With the rapid progress in the switch to high definition in satellite and terrestrial digital broadcasting and the market penetration of high picture quality media such as the next generation of large-capacity optical discs, there are strong demands for not only high resolution but for high picture quality displays that can reproduce content without picture quality degradation. To respond to these demands, at the same time as releasing more SXRD high picture quality products that target even wider markets, Sony will also continue to advance the development of technologies that strive for even higher picture quality.

■ Photograph 3 QUALIA 004 Home Use Front Projector "Q004-R1"

■ Photograph 4 "SRX-R110" Digital Cinema Projector