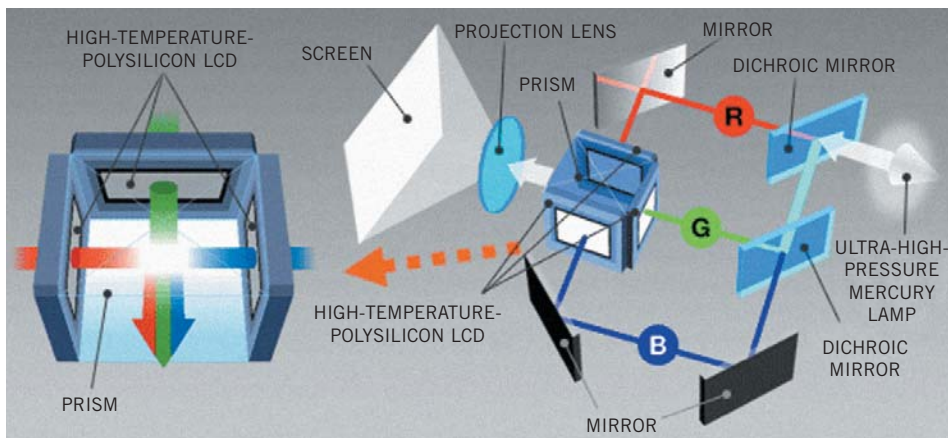


# Microdisplay technologies: Projection systems lose contrast

**THREE TECHNOLOGIES ARE JOCKEYING FOR MARKET SHARE IN THE PROJECTION-TELEVISION MARKET, EACH MAKING IMPROVEMENTS THAT ARE ERASING THE DIFFERENCES AMONG THEM.**



**Transmissive LCD microdisplays require three devices to form a full-color image—one each for red, green, and blue (courtesy 3LCD Group).**

**Figure 1**

**F**LAT PANELS, MOVE OVER. Microdisplay rear-projection-TV systems have come from behind to become the new “kings of the big screen,” growing an astounding 225% in dollar value from 2003

to 2004, according to market data from Quixel Research. Total sales exceeded \$4.7 billion, beating both plasma- and LCD (liquid-crystal-display)-TV systems in the market. At the same time, front-projection systems, all of which depend on microdisplays, saw their market grow 42% worldwide, according to Pacific Media Associates.

One key to this surge in popularity is the dramatic improvement in image quality that has arisen because of fierce competition among the three microdisplay technologies: DLP (digital light processing) from Texas Instruments, LCD, and LCOS (liquid crystal on silicon). Each technology has its advantages and drawbacks, but each has also made significant strides in overcoming its limitations. As a result, all three technologies are poised to address the upcoming high-definition-television market with only subtle differences to tell them apart.

According to Iain Penny, director of marketing at JDS Uniphase, which manufactures devices using all three technologies, four basic attributes of the technologies reflect their differences. One is the type of light-path control they use: reflective or transmissive. Second is the number of microdisplay chips the system needs. Third is the response time of the light-control element, and fourth is the pixel size each technology can achieve.

LCD microdisplays are transmissive; they control the light passing through them using the polarization effects of liquid crystals. DLP is reflective. The display consists of millions of micromirrors that deflect light into or out of the projection path. LCOS uses the polarization of liquid crystals to control light transmission, but a mirror at the bottom of the crystal matrix reflects light rather than transmits it, as with LCD microdisplays.

## ONE DEVICE OR THREE?

The nature of the light control affects how many devices a projection system needs. As

**Figure 1** shows, LCD-microdisplay projection systems use three devices: one each for red, green, and blue light. Dichroic filters, which pass some wavelengths of light and reflect others, split the light from a projection lamp into these primary colors. The light passes through the microdisplays and recombines to form the full-color image.

The DLP approach is completely different (**Figure 2**). With this technology, a single microdisplay handles all three primary

colors. A rotating color wheel sequentially provides red, green, and blue (and sometimes white) illumination onto the DLP device, which reflects the light out to the projection lens. The instantaneous images thus formed are of one color only, but the eye's response time is slow enough that the three images blend together to appear as a single full-color image.

LCOS displays can have either a three-chip or a single-chip configuration. The three-chip configuration, the most commonly available today, works with three primary colors, as in the LCD approach (Figure 3). However, the technology can use a single-chip configuration similar to the DLP. The key to this application of LCOS is decreasing its response time to the point that the display can project the three primary colors rapidly enough so that the eye combines them.

Response time is the speed with which individual picture elements (pixels) can alter the light path, and it essentially determines whether the technology can use a single microdisplay device or needs one for each color. LCDs are the most sluggish, with response times in the 10-msec range, forcing their use in a three-chip configuration. DLP, in comparison, is lightning fast, with microsecond response times.

**LCOS SPLITS THE DIFFERENCE**

The LCOS devices fall between LCDs and DLP, depending on the manufacturer. Sony, for example, bases its SXRD (silicon-crystal-reflective-display) technology on high-temperature polysilicon liquid crystals; the display has achieved response times as fast as 5 msec but still requires a three-chip arrangement. Further improvements are possible, however, according to JJ Lee, president of LCOS foundry United Microdisplay Optronics. "One LCOS technology capable of extremely fast response times is ferroelectric liquid crystal," says Lee. "Using ferroelectric liquid crystal and a very thin cell gap, we have seen microdisplays achieve response times measured in tens of microseconds."

With that level of response, LCOS can work in a one-chip design. MicroDisplay Corp, for example, at the 2005 Consumer Electronics Show, demonstrated a 1920x1080-pixel high-definition rear-projection-television system in conjunction with Uneed Systems and Genoa Color

**AT A GLANCE**

▷ LCD, LCOS, and DLP—three technologies with the same goal—are fighting it out for the high-performance video-projection market.

▷ The prize in this competition is a share in a market poised to grow to \$8 billion in the next few years.

▷ Competition is fostering innovation that is erasing once-significant differences among the technologies.

▷ Ultimately, marketing and cost may be the deciding factors.

Technology. The system used a single LCOS panel to manipulate three primary colors.

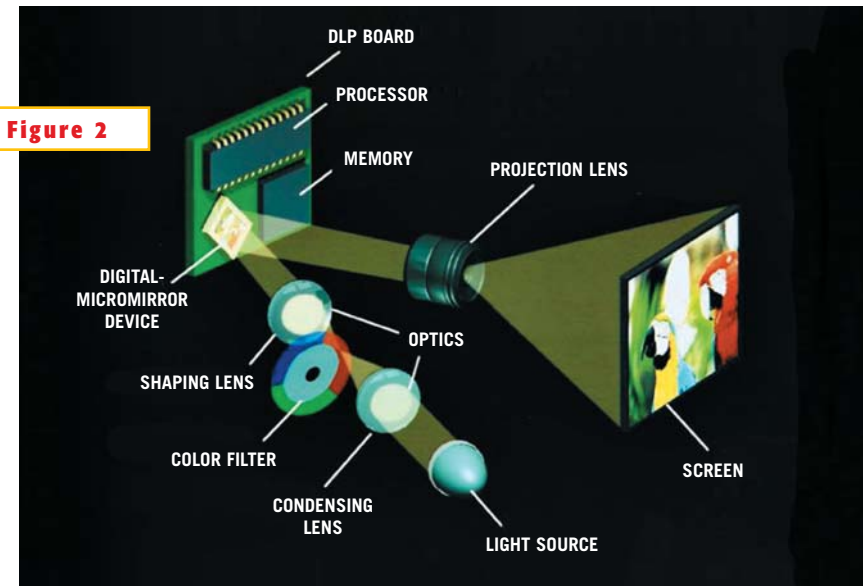
The resolution of 1920x1080 pixels (progressive scan) necessary for high-resolution television highlights the importance of the fourth differentiating factor in microdisplays: pixel size. The pixel size determines how large the device must be to achieve this resolution. LCD and LCOS microdisplays have been able to achieve a pixel pitch around 8 microns, and DLP weighs in closer to 11 microns. As a result of the larger pitch, it has been difficult for DLP to achieve high-definition resolution. The larger pitch results in a larger device die, which adds cost and lowers manufacturing yields.

The pitch limitation of DLP, like the limitations of the other technologies, has not remained an impediment for vendors, however. The fierce competition for the soon-to-be \$8 billion microdisplay-based-television market has prompted vendors of all three technologies to improve their offerings.

**COMPETITION FOSTERS INNOVATION**

With the DLP, for instance, Texas Instruments developed its Smooth Picture approach (Figure 4). The approach orients the digital micromirrors in a diamond pattern instead of the traditional rectangular one and uses an optical actuator that shifts the light path by one half-pixel sideways on alternate frames. The combination allows TI to reproduce all of the pixels in a high-definition image while using only half the number of micromirrors. The result is higher resolution and lower cost for the microdisplay.

A second perceived drawback to DLP was what is known as the "rainbow effect." Because the image consists of sequential RGB frames, some viewers were able to perceive the alternation when their gaze moved across the screen. The images appeared to break up into the primary colors during rapid eye movement. Not all viewers could perceive the effect. Enough could, however, so that DLP technology needed to address the effect to stand against the criticism that makers of three-chip systems leveled. Such systems simultaneously provide all pri-



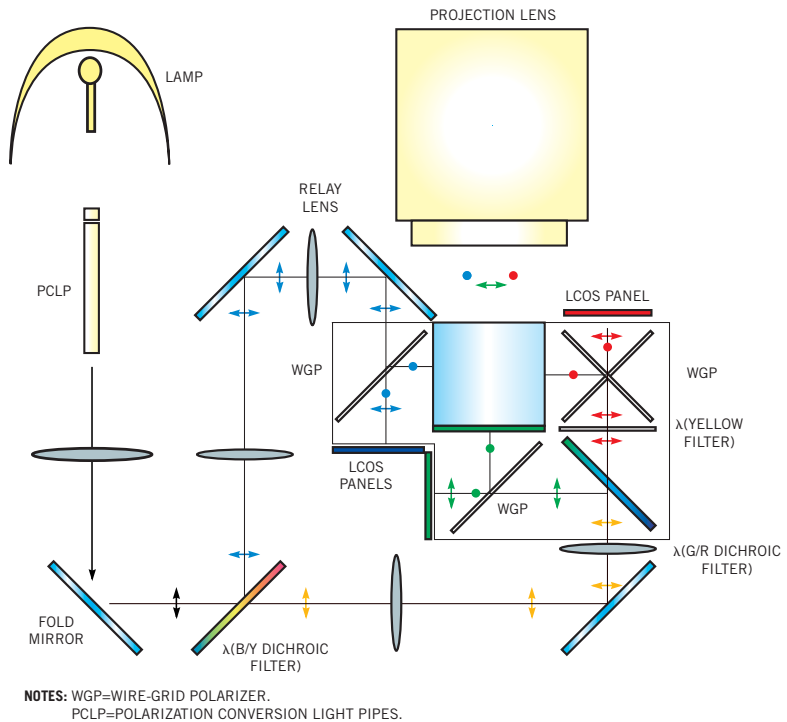
**Figure 2**

**TI's DLP (digital-light-processor) microdisplay allows a single device to project all three colors of an image sequentially, eliminating the need for pixel alignment (courtesy Texas Instruments).**

mary colors and so do not produce this effect. Increasing the speed of the color wheel's rotation and doubling the number of color panels in the wheel to increase the rate at which the primary-color images cycle have all but eliminated the rainbow effect for most viewers.

The DLP approach is not the only one with challenges it had to overcome. LCD microdisplays suffered from the "screen-door" effect. Because the devices transmit light, they had to be transparent. The transistors and interconnection traces on the panels, however, are not transparent. Thus, the display pixels needed opaque boundaries to separate them where the circuitry resided. The resulting projected image had noticeable spaces between pixels, giving the appearance of an image seen through a screen door. LCD-microdisplay makers rose to the challenge, however, decreasing the size of the opaque sections. The most recent generation of high-resolution LCD microdisplays has almost no screen-door effect at normal image-viewing distances.

LCOS, being a reflective technology, does not have the screen-door effect, but it has had its own share of troubles. "LCOS has had several false starts over an extended number of years," says JDS Uniphase's Penny. "There were technical and scaling challenges that created limitations such as display lifetime." These challenges, together with a market that appears to be quickly moving toward commodity status, were partly responsible for the recent departure of industry giants Intel and Philips from the LCOS-microdisplay market. The reliability of



**Figure 3** LCOS (liquid crystal on silicon) combines the reflectivity of DLP with the three-unit optics of LCDs (courtesy JDS Uniphase).

LCOS panels has increased with new materials, Penny notes, so the technology is now ready to compete with the established players.

The result of all this competition-induced technology advancement has been to erase many of the differences that existed among the technologies. "They are all quite different and have their strengths and weaknesses," says Penny, "but none of the issues is big enough to knock one

technology out of the market. They all seem to be good enough."

**MARKETING WILL MAKE THE DIFFERENCE**

In the end, then, it will not be performance that dictates how these technologies will play out in the market; it will be branding, marketing, and cost. To that end, TI has been pursuing a vigorous campaign to make sure that consumers know the DLP brand. The mak-

**FOR MORE INFORMATION...**

For more information on products such as those discussed in this article, contact any of the following manufacturers directly, and please let them know you read about their products in *EDN*.

**3LCD Group**  
www.3lcd.com

**Aurora Systems**  
www.aurora-sys.com

**Brilliant Corp**  
www.brilliantcorp.com

**CRL Opto**  
www.crlopto.com

**eLCOS Microdisplay Technology**  
www.elcosmicro.com

**Fujitsu**  
http://edevice.fujitsu.com/en/foundry/technology/lcos.html

**Himax**  
www.himax.com.tw

**Integrated Microdisplays Ltd**  
www.hkimd.com

**JDS Uniphase**  
www.ocli.com

**JVC**  
www.jvc-victor.co.jp/english/pro/dila/index-e.html

**MicroDisplay Corp**  
www.microdisplay.com

**Pacific Media Associates**  
www.pacificmediaassociates.com

**Quixel Research**  
www.quixelresearch.com

**Reflectivity Inc**  
www.reflectivity.com

**Sony**  
www.sony.net

**SpatialLight**  
www.spatiallight.com

**Texas Instruments**  
www.dlp.com

**TMDC (Taiwan Micro Display Corp)**  
www.tmdc.com.tw

**UMO (United Microdisplay Optronics) Corp**  
www.umo-lcos.com

**Varitronix Ltd**  
www.varitronix.com

ers of LCD-microdisplay systems have responded by launching an industry-education effort, the 3LCD Group. Formed by Epson, Fujitsu, Hitachi, Sanyo, Panasonic, and Sony, the group will be promoting the approach and using its 3LCD logo in an effort to form technology brand awareness to counter TI's DLP.

Meanwhile, the LCOS camp is counting on lowered costs and widespread availability to attain its market share. Although DLP technology belongs solely to TI and its licensees, and the 3LCD group members are mostly vertically integrated microdisplay- and projection-system manufacturers, LCOS vendors are mainly following the fabless-semiconductor approach.

There are exceptions. Sony has its own LCOS technology, SXRD, that Senior Vice President Mike Fidler says the company hopes will become "the Trinitron of the 21st century," referring to Sony's highly successful cathode-ray-tube products. Similarly, JVC has its own LCOS spin, the D-ILA (direct-drive image light amplifier). But many companies, such as Aurora Systems and MicroDisplay Corp, depend on the availability of foundry services from companies such as UMO and TMDC.

The strength of branding may ultimately not be enough for companies to

retain high margins in this increasingly competitive market. Start-up companies that are developing micromirror devices, such as Reflectivity Inc, are replicating TI's DLP. If they are successful in bringing their technology to market, TI will face price pressure without a technology differentiator to fall back on. Similarly, if the single-chip LCOS technologies prove their worth, there will be additional pressure on the TI franchise.

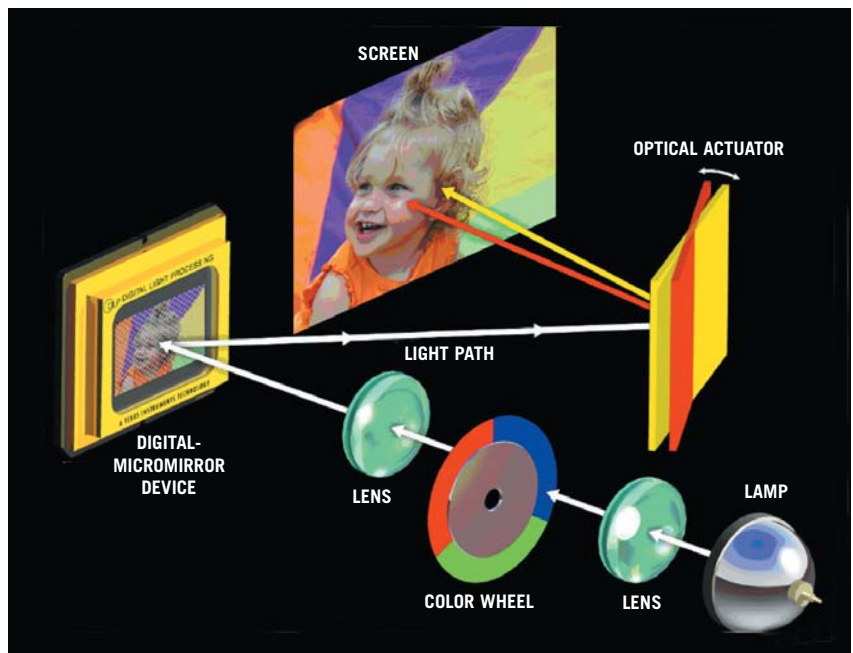
With all this competition, it is inevitable that more companies will follow the lead of Intel and Philips and leave the market. The good news, however, is that in the meantime, the competition will foster even more innovation and bring the technologies closer in performance. Commodity prices will prevail while performance continues to increase. Some companies may lose the race, but the consumer will ultimately win. □

**AUTHOR'S BIOGRAPHY**

*Contributing Editor Richard Quinnell was a practicing engineer, designing embedded systems for more than 15 years. He then switched to covering high technology for the last 15 years.*

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**Figure 4** The Texas Instruments DLP technology has improved its pixel resolution with a combination of diagonal placement and actuator manipulation, achieving high definition and reducing device size (courtesy Texas Instruments).