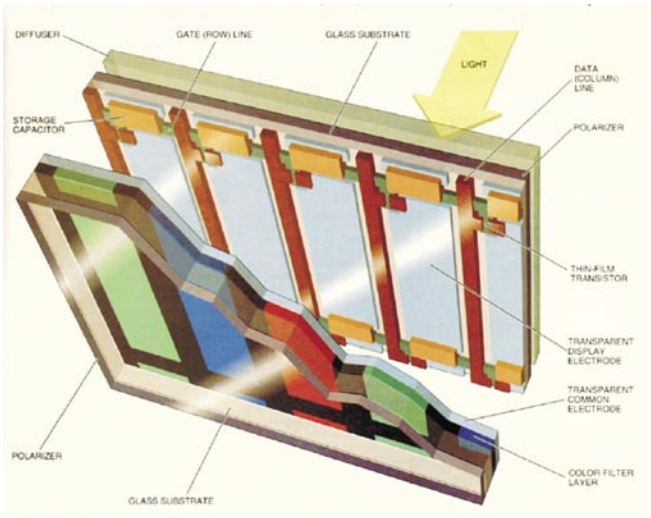
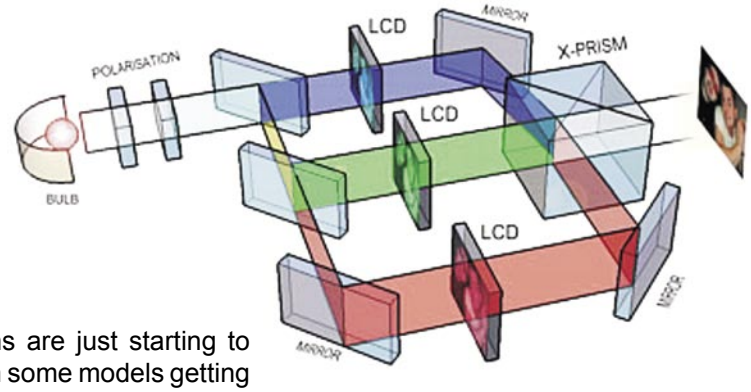
Display technologies

Together with the digital revolution we are experiencing in CCTV in the last half a dosen years, there is a more quite revolution under way in the display technologies. Perhaps not so obvious in our industry, but more so in the home based theatre systems there are a number of display technologies which are competing for our multimedia experience. Sooner or later we will use displays in CCTV so it is important to understand them better, and find out the pros and cons of each one of them. This article is courtesy of www.audioholics.com

Liquid Crystal Display (LCD)

Liquid Crystal Display, or LCD screens use a fluorescent backlight to send light through its liquid crystal molecules and a polarizing substrate. LCD TVs work passively, with red, green and blue pixels. By applying voltage to the pixels using a matrix of wires, the pixels can be darkened to prevent the backlight from showing through. Many LCD displays double as computer displays by allowing standard analogue VGA input, a great option if you need your display to pull double duty as a PC monitor to save money and space. Nearly all LCD TVs offer flexible mounting options including walls or under cabinets.



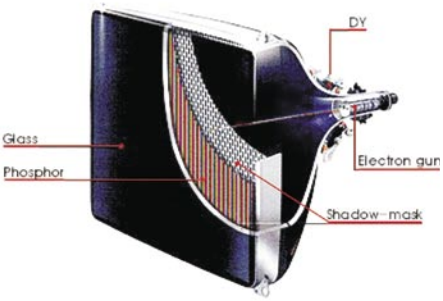


What's Next

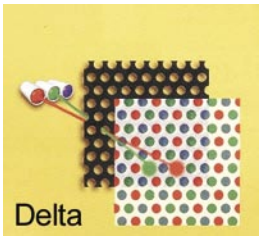
Bigger, faster, cheaper. Direct view LCD screens are just starting to break the size barrier that once held them back (with some models getting as large as 55") and it will be up to the manufacturing plants to convert or expand to the point where these larger screens become affordable and economical to produce. LCDs are not the best for contrast ratios, but they are getting better and the "blur" effect, where the pixels cannot refresh fast enough for the screen motion, is all but extinct in newer models.

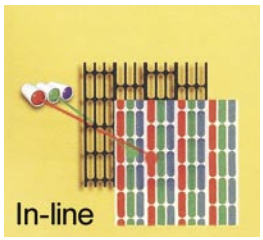
LCD Projection Advantages	LCD Projection Disadvantages
• Excellent color reproduction • Relatively inexpensive • Lightweight • Only 12-16" depth required for RPTVs • Newer units sporting better contrast levels	• Perceived "screen door" effect common in lower cost front projectors • Lamp life (2000 hours)

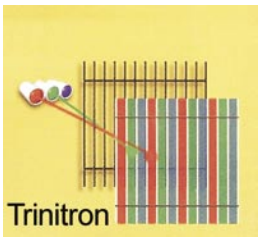
Cathode Ray Tube (CRT)



A cathode ray tube (CRT) is a specialized vacuum tube in which images are produced when a moving electron beam strikes a phosphorescent surface. There are three factors that limit the resolution on CRT display devices: screen dot pitch, electron beam size, and the bandwidth of the video amplifier. A typical TV CRT has a dot pitch around 0.8 - 0.9mm (much larger than a typical computer display). Lowering the dot pitch increases the display resolution, but increased dot pitch provides a brighter picture. Most CRT displays are configured to perform well with lots of ambient light, so dot pitch is typically higher.







Dot Pitch Explained: Dot Pitch, or phosphor pitch, is a measurement indicating the diagonal distance between like-colored phosphor dots on a display screen (they can be, as shown on the left, in Delta configuration, In-line and Trinitron). Measured in millimeters, the dot pitch is one of the principal characteristics that determines the quality of display monitors. The lower the number, the crisper the image. The dot pitch of color monitors for personal computers ranges from about 0.15 mm to 0.30 mm.

Rear projection TVs typically utilize 7” CRT guns, with some of the higher-end models using 9” guns (like the Mitsubishi WS-65813). 7” guns can typically resolve about 700-800 lines of resolution. The high end 9” guns can do upwards of 900 lines. Typical direct view televisions deliver just over 600 lines of resolution. Most RPTVs have at least 30Mhz of video amplifier bandwidth, which is good for just under 720p or 1080i. Better models have upwards of 75Mhz. Most direct view televisions have 20Mhz video amplifiers, with some higher-end units extending above 30MHz.

CRT televisions receive video signals at the rate of 25 frames a second (30 in NTSC). Each frame of video contains about 576 lines of information (480 in NTSC). A single frame is projected on the screen line-by-line in two passes (each pass is called a “field”). On the first pass, the beam projects all of the odd numbered lines from 1-575 (1-479 for NTSC) from top to bottom. On the second pass, it projects all of the even numbered lines from 2-576 (2-480 in NTSC). It takes 1/25 of a second to complete both passes (1/30 for NTSC). This process is called interlacing. CRT type TVs need time to reset the electronic beam to the top of the screen so it can get ready to paint the next sequence of lines. To accomplish, they build in an interframe gap that equals about 49 lines (45 in NTSC). There is no picture information here. So the total lines per frame are 625 (576 + 49) (for NTSC, 525 (480 + 45)). Thus standard definition TV (SDTV) is often referred to as 576i (interlaced) for PAL and 480i for NTSC.

What’s Next

Extinction. Front projection CRT-based systems are all but gone already. Rear projection CRT is soon to follow as soon as LCOS and DLP systems drop in price. As rival flat screen and digital projection technologies drop in price and increase in quality, there will become less and less reason to pay for the bulk and power consumption of CRT displays.

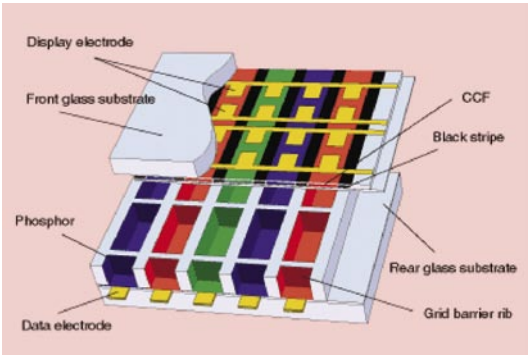
CRT Direct View/Rear Projection Advantages	CRT Direct View/Rear Projection Disadvantages
• Among the brightest and clearest alternatives • Excellent color and contrast potential • Relatively inexpensive • Excellent life expectancy	• Heavy • Very deep • Analogue connectivity or D/A conversion of digital input connections • Potential for screen burn-in

Plasma Screen

Plasma screens are basically a network of red, green and blue phosphors (each triad makes up a single pixel) mounted between two thin layers of glass. Plasma screens use a small electric pulse for each pixel to excite the rare natural gases argon, neon and xenon used to produce the color information and light. As electrons excite the phosphors, oxygen atoms dissipate and create plasma, emitting UV light. These rare gases actually have a life and fade over time.

Here's the cool part: because all the phosphor-excited pixels react at the same time, there is never any flicker apparent to the viewer. There's also no backlight and no projection of any kind, so the light-emitting phosphors, result in a bright display with a penchant for rich color and a wide viewing angle.

What are phosphors? Phosphors are chemical compounds on back glass that emit the visible light that makes up the picture we see. Hit them with light and they react by producing an amount of red, green or blue. On a direct-view television (CRT, or cathode ray tube) the phosphors are on the front glass and are excited by a beam of electrons from the cathode-ray. On plasma monitors the phosphors are excited by UV light produced by electromagnetically charged plasma.



Plasma screens are sometimes viewed as a wonder of the modern world, and most of their attention comes from their flat presentation and large screen sizes. They are able to be produced in sizes up to 80" (though not common) and yield a very nice picture. The downside is that they are power-hungry (not to be confused with the environmentally-friendly LCD screens) and typically benefit from being professionally installed. You may enjoy watching commercials with plasma screens hanging on the ceiling.

What's Next?

At one time we stated: extinction. While we are now reconsidering that statement (and a good scientist won't go down with the ship when new evidence is presented) We maintain that LCD panels are on a trend to become almost a commodity. The manufacturing process is getting better, additional manufacturing plants open up each year to turn out more and more panels and performance is increasingly getting better. Add to that the low cost of manufacturing and you have a compelling technology that is hard to beat. Hard, but not impossible. Plasma displays are indeed competing in terms of longevity, brightness, (true) contrast ratio, power consumption and burn-in. Their black levels and color saturation are very impressive. Due to these advancements it is very likely that plasma and LCD will maintain parrallel development for some time. As LCD displays become cheaper, faster and more competitive, perhaps plasma will become obsoleted - until that time we have to retract our original prediction as being too far-reaching to be practical.

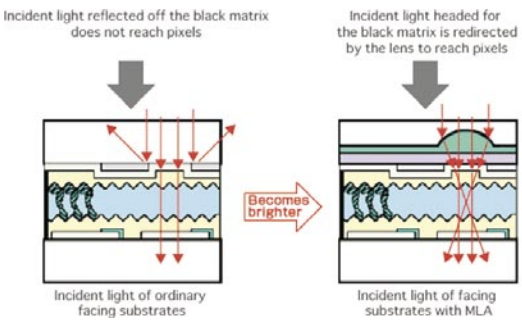
Plasma Advantages	Plasma Disadvantages
• Excellent (real) contrast ratios and black levels • Excellent color reproduction • Excellent life expectancy • Excellent viewing angle with no real loss of color or contrast	• Fixed resolution • Although thin, plasma TVs are fairly heavy and fragile • Susceptible to screen burn-in (new models compensate with various screen-saving methods) • Gaps between pixels render a sort of "screen-door effect" on lower resolution models • Low peak brightness • Uses a lot of power compared to LCD

High Temperature Poly-Silicon (HTPS) LCD

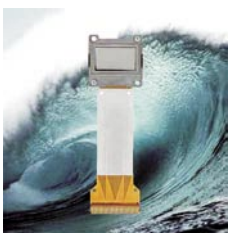
HTPS is an active matrix transmissive LCD. It's advantage over LCDs using other systems is that it is smaller, has higher resolution and higher contrast, and can embed drivers.

A Thin Film Transistor (TFT) display is used for the light valves. Light from an ultrahigh pressure mercury lamp is split into red, green, and blue using a special mirror called a dichroic mirror, which passes light with a certain wavelength while reflecting a specific wavelength. After the image is created by LCDs for each color it is rejoined with a prism and projected. Light usability is better in a 3-Light Valve System than a 1-Light Valve System as you can achieve greater color depth and contrast. This transmission method is utilized in both LCD front projection and rear projection systems.

LCD projection technology dominates the low-end projector market and is almost exclusive to the office projector market. Newer LCD projectors include special optics enhancers like micro-lens array that minimize pixelization known as the "screen door effect." New LCD projectors have contrast ratios as high as 800:1, though as we found during our ISF certification classes, contrast ration numbers are largely just marketing gimmicks (we'll try to provide fairly accurate "real-world" measurements on any displays we review). The portability and brightness of LCD projectors have made them a popular choice for portable presentations. The lightest LCD projectors weigh-in at less than 4 lbs.



What's Next



In HTPS microdisplays, the aperture ratio is defined as the ratio between the bright pixel area and the pixel area that is blocked by the transistor required to drive each pixel. The aperture ratio must be maintained in order to preserve display brightness. Due to technical difficultly of shrinking the intra-pixel transistors, HTPS pixels cannot be made smaller without lowering brightness and reducing picture quality. A lower aperture ratio worsens the pronounced "screen door effect" often seen with LCD technology. Adding more pixels without shrinking each pixel maintains the aperture ratio, resulting in an enlarged panel and added cost.

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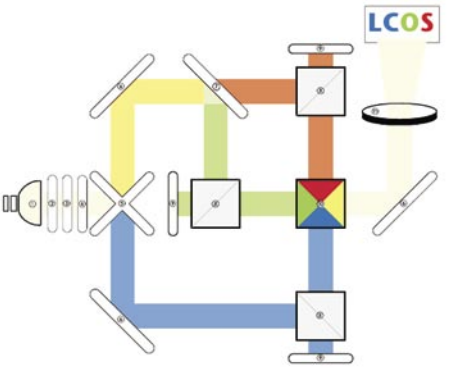
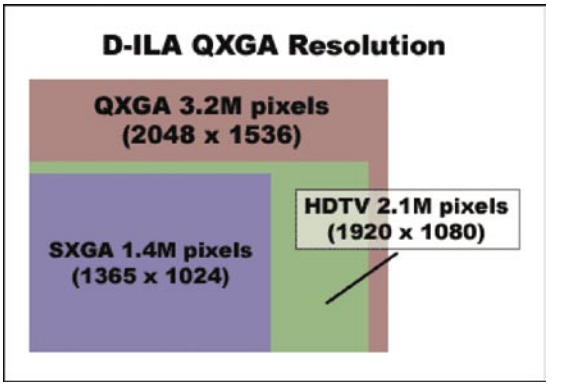
Liquid Crystal on Silicon (LCOS / D-ILA)



One of the newest rear-projection display technologies, LCOS (or LCoS), also known as D-ILA, is similar to LCD (HTPS) and consists of a liquid crystal layer which sits on top of a pixelated, highly reflective substrate. Below the substrate exists another layer containing the electronics to activate the pixels. This assembly is combined into a panel and packaged for use in a projection subsystem. Currently LCOS light valves are manufactured in 1280 x 768 (720p) and 1920 x 1080 (1080p) chip configurations.

LCOS is a reflective LCD display panel with high open area ratio. Basically, by placing the wiring area and switching elements under the reflection layer, there is no black matrix area – so it is possible to view a near-seamless image. LCOS systems can be created as 1 chip and 3 chip systems.

At the moment, LCOS technology is fairly competitive in terms of price and performance advantages compared to HTPS and DMD (DLP) systems. Pixels on LCOS panels can be made smaller than is possible with other microdisplay technologies, without compromising picture quality or manufacturability. LCOS displays can be scaled to 1080i/p resolution (1920x1080 pixels) and beyond, without increasing the size and cost of the panel and other optical components in the light engine.



The D-ILA device (Digital Direct Drive Image Light), is a special LCOS technology developed by JVC, which is also a reflective type of LCD that delivers a greater amount of light than a transmissive LCD panel and is comprised of groups of pixels which correspond to each image dot. Also, unlike conventional LCD panels (in which the switches and electronics are mounted on the same surface as the pixels), the D-ILA's driving IC substrate is located behind the liquid crystal layer. Because of this, the "screen door effect" found in many LCD projectors is eliminated almost entirely, leaving a nearly-seamless picture which is very impressive.

The D-ILA technology is based on an innovation in microchip design that packs 2048 x 1536 pixels on a single 1.3" chip (labeled a QXGA device). This makes possible display of HD images at full-spec resolution of 1920 x 1080 (with support for 1080p possible). Overall, D-ILA projectors produce higher resolutions, better contrast ratios, less image artifacts, and better tonal and color information than just about any LCD front projection device. In combination with the high-speed response of the vertical alignment liquid crystal, JVC's D-ILA® technology makes it possible to reproduce smooth, noiseless motion pictures with clear, sharp high definition and film-like picture quality.

D-ILA and DLP will be battling it out for the next several years, something that will undoubtedly be good for the market and will result in some excellent "trickle-down" technologies for the home theater user.

What's Next

Better, faster, cheaper LCOS technology is still relatively expensive compared to LCD and DLP, and with Intel opting out of mass production last year that can be expected to remain for some time. Right now the contrast ratios on these projectors is greater than LCD, but far less than even single-chip DLP projectors. This means that HDTVs based on LCOS technology may remain more expensive than the competition (right now the players are JVC, Sony to name a few.)

LCOS Projection Advantages	LCOS Projection Disadvantages
• Excellent color reproduction • Excellent contrast ratios • Nearly seamless images	• Very expensive • Currently geared towards high-end home theater and commercial uses

Digital Light Processing (DLP)

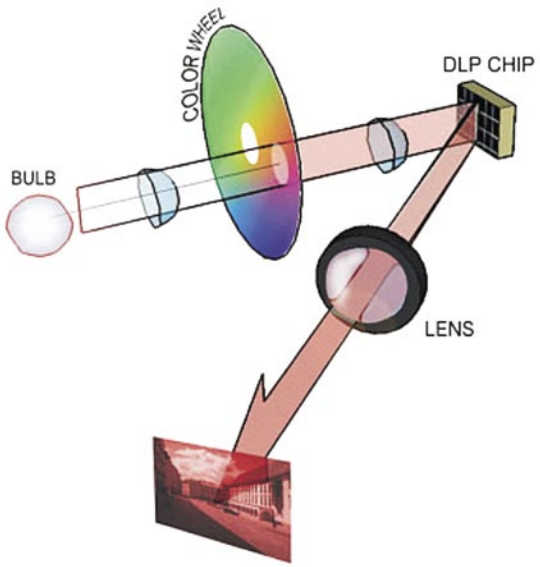
DLP™ technology is based on an optical semiconductor called a Digital Micromirror Device, or DMD chip which was invented in 1987 by Texas Instruments. The DMD is basically an extremely precise light switch that enables light to be modulated digitally via millions of microscopic mirrors arranged in a rectangular array. Each mirror is spaced less than 1 micron apart.

These mirrors are literally capable of switching on and off thousands of times per second and are used to direct light towards, and away from, a dedicated pixel space. The duration of the on/off timing determines the level of gray seen in the pixel. Current DMD chips can produce up to 1024 shades of gray.

By integrating this grayscale capability with a 6 panel color wheel (2x RGB), the DLP system is able to produce more than 16 million colors. A DMD system can be made up of a single chip or 3 chips, resulting in even greater color reproduction. For example, DLP Cinema systems can reproduce over 35 trillion colors.

What's Next

Advances are being made in the single DMD design. For example, Texas Instruments' new HD2+ design incorporates an additional color (dark green) into the color wheel, allowing for contrast ratios greater than 3000:1 for much improved color reproduction and contrast. The xHD3 technology was due out in late 2004 which takes the single chip technology to even greater heights by adding a new rear coating to the mirrors and eliminating more of the latent brightness when in the "off" position. Another upcoming technology is called Sequential Color Recapture (SCR) whereby DLP systems will replace the traditional color wheel with essentially, a "Spiral of Archimedes" RGB color pattern. This new technology has been mathematically projected to rival the current quality of 3-modulator DLP Cinema systems.



Adding more pixels to DMD-based systems may prove to be challenging as this requires larger and more costly microdisplays. Currently, shrinking the size of each mirror/pixel makes the DMDs impossible to mass-produce at reasonable cost. Right now, DLP is the front-runner in the technology war and, except for on the price-front, is pretty much cleaning the clock of the likes of CRT and LCD rear projection.

LCOS Display Advantages	LCOS Display Disadvantages
• Excellent color reproduction • Excellent contrast ratios • High resolutions • No "screen door" effect • No screen burn-in issues	• Fairly expensive • Difficult to obtain (new technology for rear projection)

So Which Display Technology is Best?

LCD vs. Plasma Screen TVs: The Flat Picture

As mentioned previously, the Plasma TV has the edge in terms of size, black level and refresh rate advantages. It also remains a less expensive option for larger display sizes. Of those parameters, LCD is quickly dropping in price, catching up in terms of refresh rate and black levels and will eventually support larger sizes (the largest LCD display is 82" and is manufactured by Samsung). Once this happens, Plasma may lose its edge and LCD technology could win out. Note: "could", "might", "may"... you get the idea... We might be going back and forth a long time - which is only to our advantage. As many of the CRT manufacturing plants are slated to convert over to LCD (Sony and other CRT manufacturers have quietly phased out their 17" and 19" CRT displays), you can imagine that the technology as a whole will benefit from smarter, more efficient manufacturing processes. As this happens, prices will continue to drop and the smaller LCD market will likely drive larger flat panel display products into the homes of consumers.

DLP vs. LCD vs. LCOS Rear Projection Televisions

This is where the competition gets interesting. This is essentially a battle between Texas Instruments and all of the LCD manufacturers (Sharp, Sony, JVC, Philips, Toshiba, Samsung). Many companies are hedging their bets on this one (Samsung manufactures all 3), however the real winner will be the one who can produce the best picture at the lowest cost. Our bet is on DLP. DLP is currently in its fourth iteration (xHD3) and has increased black levels and contrast ratios with its new "Dark Metal" technology. The advances in DLP both current and forthcoming are exceptional, but so is LCOS which is essentially a densely-packed LCD – creating a finer picture without any of the "screen door" artifacts found in many LCD displays. Still, Intel's drop out of the LCOS market has left that technology a bit stalled in the marketplace.

3LCD rear projection does have some advantages, however. It is being developed further and further and will benefit from rapid price drops as manufacturing ramps up and technologies improve. Right now you can find large, HD-ready LCD-based Rear Projection TVs for under $2000. A similar DLP or LCOS version (currently) will cost you at least $1500 more. 3LCD front projection is fantastic at the proper viewing distances, however DLP seems to be quickly eating up the entry level projector market.

The Cost Factor: How Much Do I Spend?

How much do you have?

Seriously, though, budget and intended use will determine the direction you take in what technology you choose. Those with the strictest budgets will want to break into HDTV via LCD rear-projection or DLP front projection. At this price range ($2000 - $3000) CRT rear projection will most likely be the better performer, but at the cost of weight and power consumption. We also really no longer recommend CRT-based Rear Projecyion TVs as they represent a dying technology and we feel the advantages they once had are now far outweighed by the digital competition.

If you are desperate for flat panel, it's going to be a question of size. LCDs cost more than Plasma TVs at equal sizes. The reason for this is production yields and undersupply. There is currently a condition of undersupply for many sizes of LCD displays due to the number of manufacturing plants available and the current configuration of those plants. Couple this with lower yields on larger display sizes due to burned out pixels and quality control, and you have

Displays comparison table

	D-ILA	DLP	LCD	Plasma	LCOS	RP LCD	RP CRT	CRT
Contrast Ratio****	1500:1	5000:1*	1300:1*	3000:1**	2000:1	800:1****	5000:1****	4000+:1††
Max Brightness	7000+ lumens	750+ cd/m2	450 cd/m2	700 cd/m2†††	750+ cd/m2	450 cd/m2	NA	1000 cd/m2
Longevity (hours)	2-4k (lamp)	2-4k (lamp)	50-75k***	60k***	2-4k (lamp)	2-4k (lamp)	20k+	20k+
Burn-in	No	No	No	Yes	No	No	Yes	No†

a demand situation which forces LCD prices up for larger displays. A fair estimate would be that above 30" an LCD TV costs at least 20-30% more than a comparable Plasma display. If you want the benefits of LCD you will have to pay for it – and we thought Plasma was expensive!

If you are made of money and want the biggest flat panel around, Samsung and LG have been battling it out for years, but Samsung has won largest LCD award this year with the unveiling of a 82" LCD TV. Not to be outdone, LG released a 24k gold accented 71" plasma display. Both are top in their category and are priced at… well, more than you want to know.

So, as always, the choice is up to you. Spend your money wisely, and keep your eyes peeled for the new technologies as they break into the marketplace. Competition is always good and should do well to make all the technologies strive for better performance and lower costs to the consumer. [•]

(courtesy of - Clint DeBoer - http://www.audioholics.com)

Editor's note: *In addition to this brilliant insight of the various technologies, I would like to add that in CCTV applications (and this also applies for home-theatre setup) the size of the room as well as the optimum viewing distance is the important consideration. A rough rule of thumb is the viewing distance should be 7X the monitor height for SDTV, and 4X the display height for HDTV. In other words, it is pointelss having a 110 cm diagonal size plasma screen in front of the operators that are only 1 m away, as it is having a 15" monitor 5 m away.*

For more explanation - read the article "Psychophysiology of viewing details" on page 40.