UNIPIXEL™

Technology Brief

Time Multiplexed Optical Shutter (TMOS)

"A Revolutionary Flat Panel Display Technology"

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Overview

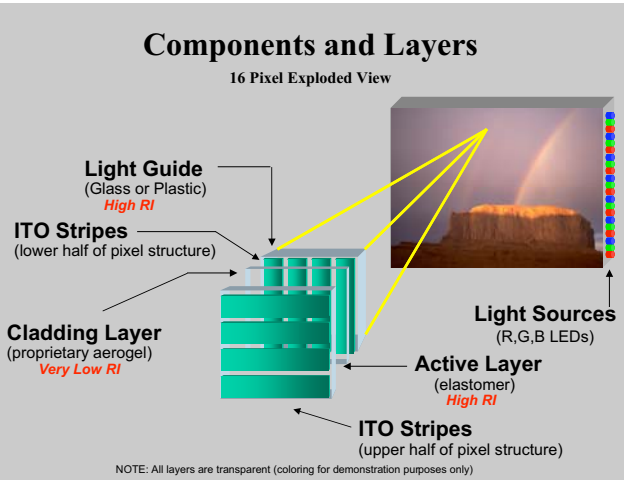
Time Multiplexed Optical Shutter (TMOS) is a flat panel, edge injected, light valve display technology that facilitates the manufacture of a full range of flat panel sizes, from .5" to over 100" diagonal, and offers significant advantages over current commercial display technologies, including:

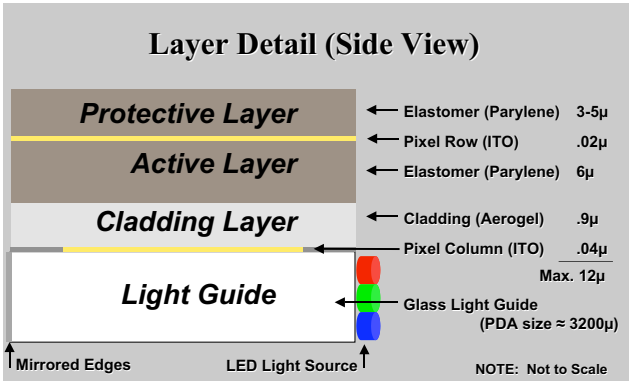
- Lower power consumption
- Simplified architecture (results in lower costs, higher yields, and higher reliability)
- Better visual quality (higher resolution, larger color range, and sharper image)

TMOS was developed to overcome the limitations and technical challenges that plague the current flat-panel display technologies (e.g., poor light efficiency, energy loss due to color filters and/or polarization, and size constraints due to yield and backlighting).

Uni-Pixel believes TMOS to be the most promising technology in the flat panel display marketplace today. TMOS-based displays will require less voltage and amperage, be lighter, less expensive, and provide the user with a superior visual experience over other state-of-the art flat panel displays. This technology is perfectly suited for HDTV and large screen applications and will quickly dominate the television, video conferencing, distance learning and educational marketplaces where a large screen format is desirable and value is important.

"Flat-panel displays are becoming key components in [all display-based] electronic products. Compared with the cathode ray tubes used in traditional televisions, flat-panel displays are thin, lightweight, and power efficient, presenting images without a bulky picture tube. As a result, flat panel-displays are expanding into a diverse set of systems, and driving a fast-growing global industry. The Uni-Pixel display has the potential to be the cost, feature, and market leader for devices using flat panel displays from the size of a watch face to over 100 diagonal inches (5' x 8')." (Uni-Pixel Displays Introduces UPD Technology, Mark Fihn *The Display Search Monitor)*



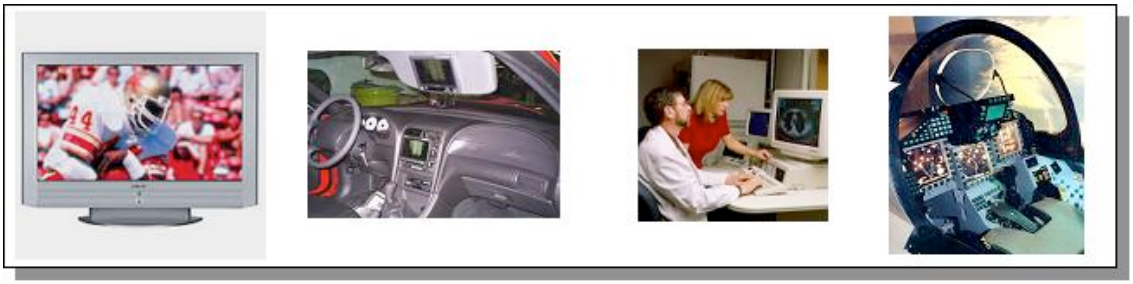


Applications

Applications and potential markets include (but are not limited to):

- Laptop Computers
- Cell Phones
- Desktop Personal Computer Monitors
- Large Screen Displays (over 21 in. diagonal)
- PDAs
- Television screens, ideally suited for HDTV
- Vehicle dashboard instruments and information displays
- Medical high resolution displays
- Aviation instruments displays
- Military (High value-added Features)
  - High definition-Common Picture of the Battlefield
    - Large-scale views, Tiling
  - Human Mounted Display/Weapon Mounted Display
    - Rugged, All-Weather
    - Weight factor-CRT replacement
    - Night vision-Infrared compatible
    - Low observable-Screen that can use filtered IR signals

Cell Phone PDA Tablet PC Notebook PC Desktop PC



TV/HDTV Automobile Medical Military

Competition

A variety of flat panel display technologies are being manufactured today. These traditional flat panel display technologies have matured despite cost and complex designs. Yet, these technologies are continually coming up short despite both a worldwide market in need of a viable flat panel solution, and record high funding of research directed towards "improving" existing technologies. The absence of a display leader in flat panel displays has rendered most alternative display systems unavailable, unaffordable, or unwanted by the majority of users, leaving a large segment of the potential market without a realistic solution.

Comparison of Flat Panel Display Technology

The chart below shows how other prevalent display technologies compare against Uni-Pixel's TMOS flat panel display technology.

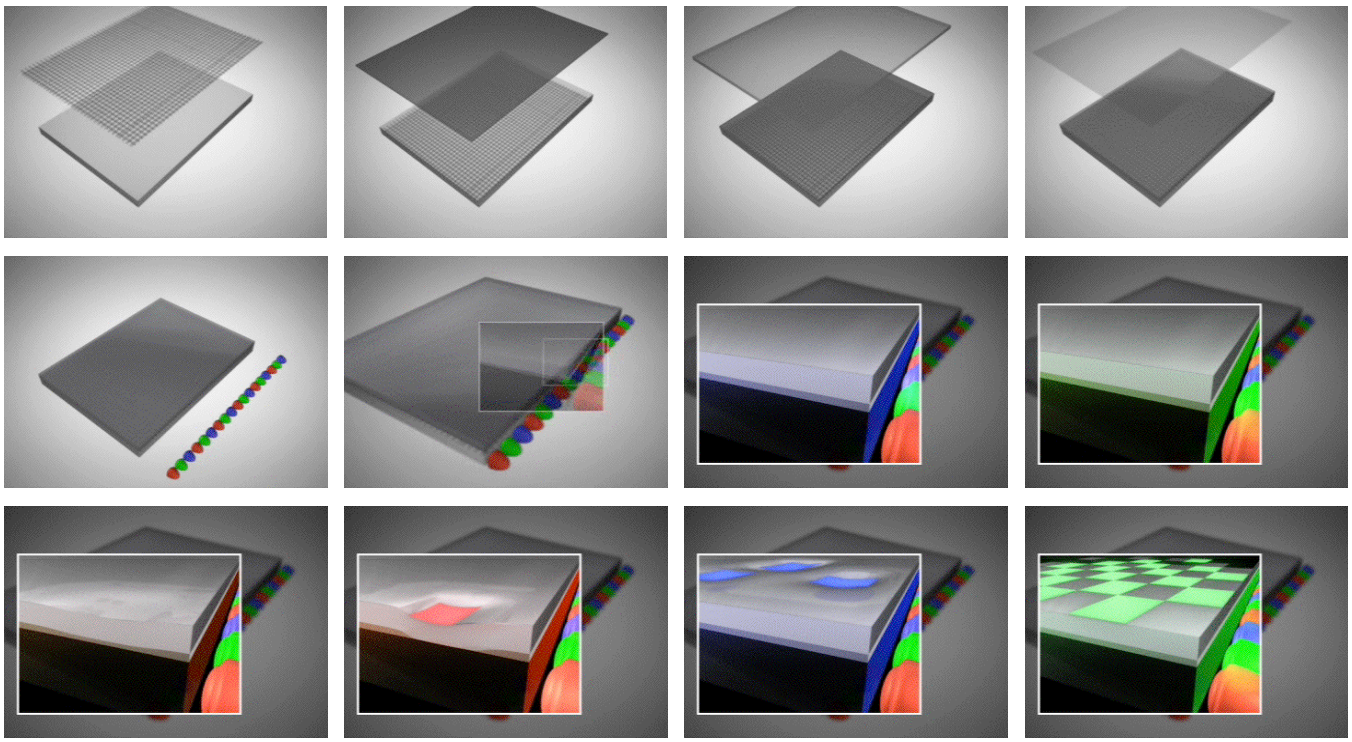
TMOS Competitive Advantage

	Uni-Pixel's TMOS	AM-LCD	OLED	Cathode Ray (CRT)	PDP
Size (Diagonal Inches)	**0.5 to 110**	0.7 to 54	0.66 to 20	0.5 to 42	25 to 63
Life Span (Hours)	**100,000+**	20,000 – 40,000	< 10,000	40,000	< 20,000
Brightness	**200–1000 nits**	170–400 nits	170–700 nits	80–300 nits	60–200 nits
Contrast	**4500:1–300:1**	150:1–450:1	150:1–450:1	300:1–700:1	100:1–400:1
Viewing angle	**> 170°**	90°-170°	**> 170°**	> 160°	> 160°
Gamma	**Better than photo quality**	Satisfactory	Satisfactory	Photo quality	Satisfactory
Uniformity	**Excellent**	Often brighter at edges	**Excellent**	Often brighter in the middle	Very good
Color accuracy	**Excellent**	Bad to mediocre	Good	Very good	Satisfactory
Pixel response time	**0.1-100 µs**	20–50 ms	< 1 ms	Not visible	< 1 ms
Power consumption	**0.2-110 W**	25–50 W	15–30 W	60–180 W	300+ W
Video	**Yes**	Slow	**Yes**	**Yes**	**Yes**
Colors	**16.7 million**	**16.7 million**	**16.7 million**	**16.7 million**	**16.7 million**
Cost	**Very low**	Medium	Medium	**Very low**	High

Best

Technology

The TMOS technology functions by feeding the three primary colors in rapid alternating succession to a single light-modulating element (Uni-Pixel). The TMOS screen is based on a single part pixel technology that will emit the full color spectrum from a single element pixel, or "Uni-Pixel". The construction of the display is simplified to contain fewer and larger on-screen features. This technology will reduce manufacturing registration problems and increase yield. Operational efficiency will increase because more surface area will be available to emit light. Unlike LCD technology that uses color filters to extract a primary color from white light, there are no filters on a Uni-Pixel. The color is emitted directly from the panel with a brighter output while consuming less energy. Opening and closing of the light modulator (i.e. optical shuttering) provides the synchronization that allows the desired amount of each primary color to escape. The human eye will integrate the varying intensity levels of the primary colors to create the resulting palette of colors.



A single part pixel technology would:

- Emit the full color spectrum from a single element pixel
- Simplify construction of the display
    - Contain larger on-screen features
    - Contain fewer on-screen features
    - Reduce manufacturing registration problems
    - Increase yield
    - Increase operational efficiency
        - More surface area available to emit light
        - No filters, color emitted directly
        - Brighter output while consuming less energy

The manufacturing yields for TMOS screens are many times greater than conventional flat panel technologies for any given form factor. TMOS is the only screen in the world capable both of being manufactured in a completely transparent form factor, and of modulating non-standard primaries beyond the conventional red-green-blue (RGB) gamut.

TMOS display raw material costs are anticipated to be one fourth ($1/4^{th}$) that of equivalent sized LCD panels. In addition, TMOS enjoys a substantially lower manufacturing infrastructure burden. The price benefit increases with the size of the display, which is exactly the inverse of competing flat panel technologies. TMOS display technology uses a much simpler manufacturing process, leading to a dramatic reduction in manufacturing infrastructure costs over existing flat panel technologies. TMOS will directly benefit from the trend toward lower priced LEDs that double in efficiency every 18 months. TMOS offers superior image, scalability, and power specifications over LCD, OLED, and Plasma display technologies.

TMOS Attributes

- A light modulating shutter which does not let light escape when quiescent and becomes transparent when activated.
- The shutter is affixed to the surface of a thin light guidance substrate (a glass or polycarbonate sheet).
- Light is injected into the edge of the guidance substrate.
- The light is evenly distributed to the entire surface area.
- Light escapes equally well from any point on the surface when the modulating shutter is activated.

Total Internal Reflection (TIR)
Pixel shutter closed (TIR maintained)

Getting Light Out
Pixel shutter opened (TIR violated)

- TMOS displays are inherently transparent; they can be stacked to achieve redundancy or multi-layer data separation.
    - A transparent display 3/16" thick is an obvious candidate for applications requiring true redundancy, such as mission-critical displays. If display A should fail, display B, which occupies the exact same location in the instrumentation array, 1/4" behind Display A, would activate. This feature is unique in the realm of display architecture. All other technologies require placing redundant screens adjacent to one another, competing for instrumentation space. A TMOS unicellular display has no such shortcoming.

- TMOS displays can modulate non-visible light, such as infrared and ultraviolet.
    - For example, adding infrared LEDs to the LED suite permits a full-color screen to be switched instantaneously to an infrared screen, and back again. The images all arise from precisely the same display surface, again proving the extreme flexibility of unicellular architectures over existing architectures.
- TMOS unicellular architecture is not limited to the prevailing RGB stratagem, but can include additional non-standard primaries to create a display screen possessing a "super gamut" color range that produces far more realistic images than RGB devices.
- Complete digital control over color reproduction without nonlinearity or saturation effects native to analog approaches.
- Superior manufacturing yields.
- Form factor limitations begin in the range of 5 x 8 feet for single sheet displays. Near seamless joining of individual segments possible to achieve theater-size displays.
- Pixel densities up to 1000 dpi are theoretically feasible.
- Can be produced on flexible substrates.
- Can produce 3D holography.
- Can be used for non-display applications, such as optical processing (for example, an Optical Linear Algebra Processor (OLAP)).
- Each pixel is individually addressable.
- Refresh rate can far exceed 60 frames a second.
- Can support better than 16 million colors.

Summary

TMOS technology represents an important advance in light-handling technology both at the micro and macro levels. Its flexibility, permitting extension and augmentation of the palette of available colors, and inclusion of the non-visible spectrum, makes it unmatched in the world of display applications. Its digital reproduction of color provides both for linearity of optical response as well as immunity from saturation. TMOS is the candidate technology to break through the multitude of barriers that continue to hamper the world of flat panel displays.