Liquid Crystal Display (LCD) Fact Sheet

Company Overview -
Combining quality and flexibility with design engineering expertise, Toshiba America Electronic Components, Inc. (TAEC) brings a breadth of advanced, next-generation technologies to its customers. This broad offering includes semiconductors, flash memory-based storage solutions, a broad range of discrete devices, flat panel displays, medical tubes, ASICs, custom SOCs, microprocessors, microcontrollers and wireless components for the computing, wireless, networking, industrial, automotive and digital consumer markets.

TAEC is an independent operating company owned by Toshiba America, Inc., a subsidiary of Toshiba Corp. (Toshiba), Japan's largest semiconductor manufacturer and the world's seventh largest manufacturer in Fortune's ranking of electronic/electrical equipment makers[(1)]. In more than 130 years of operation, Toshiba has recorded numerous firsts and made many valuable contributions to technology and society.

In April 2002, Toshiba Corp. and Matsushita Electric Industrial Co., Ltd. merged their LCD businesses and began operation of Toshiba Matsushita Display Technology Co., Ltd. (TMD). The company is responsible for all of the partners' operations in LCDs and organic light emitting diode displays (OLEDs) including development, engineering, manufacturing and sales. The partnership was formed to build upon each other's complementary technological strengths in the display arena and to benefit from the economies of scale resulting from the unification of work for early standardization of design methodologies and manufacturing processes.

Liquid Crystal Display Overview -
Both Toshiba and Matsushita have been developing leading-edge liquid crystal display (LCD) technology since 1968. Today, TMD's diverse line of TFT LCD modules range in size and pixel resolutions from a 1.9-inch, 176 x 220 pixel display to 1,920 x 1,200 pixels in a 15.4-inch product. The company's LCD modules support a wide range of applications including mobile phones; portable computing devices (handhelds, tablet PCs, mini-notebooks, mobile-notebooks and notebooks); industrial factory automation equipment; point-of-sale; kiosk; automotive entertainment, navigation, and instrument clusters; and amusement, TV, and other video applications. TMD's award-winning, low temperature poly-silicon (LTPS) technology has enabled innovative products in many markets and can be found in leading edge mobile phones, mobile PCs, and many other products.

– more –

Product Offering

- ***Advanced Mobile Phone/Portable Electronics Displays -*** TMD is a leader in the development of small, high-performance advanced displays for mobile phones, handheld GPS, portable media players and other portable devices. The company offers a number of leading edge, high-resolution color mobile phone displays, including models in QCIF+ (176x220), QVGA (240 x 320), and WQVGA (240 x 400) resolutions, up to an ultra-high 2.4-inch VGA (640 x 480) model, and a 3.0-inch WVGA (800x480) panel. TMD also offers 2.4- 2.6- and 2.8-inch modules that incorporate thin glass and are only 0.99mm thick, including the backlight, to enable even thinner and lighter weight mobile phones. For improved outdoor legibility and impact resistance, TMD has developed Screen Fit transparent cover panel technology, in which a special resin is injected between the cover panel and polarizing film at the surface of the LCD panel, improving optical performance and durability. TMD introduced the world's first QVGA product for mobile phones in 2002, and went on to help establish QVGA as the emerging *de facto* standard in today's mobile phone market. TMD's products feature high luminance, thin and lightweight design, low power performance, and utilize either transmissive or transflective technologies in mobile phone applications.
- ***Mobile Computing*** - The portable PC line-up consists of conventional 4:3 and new wide-format TFT LCDs. The wide-format models range from 5.6-inch at WSVGA (1024 x 600) resolution to 15.4-inch at WUXGA (1920 x 1200) resolution, with additional sizes and resolutions in between. Recent advancements include the adoption of LED-based backlighting systems, combined with thin-glass displays, resulting in remarkably thin and lightweight LCDs for mobile PC applications. The company also offers the largest commercially produced LTPS TFT LCDs in large format sizes with high resolution for portable computing applications. TMD's LCD modules are ideal for highly mobile, thin, lightweight, compact, and low power portable applications and incorporate TMD's state-of-the-art technology advances in poly-silicon TFT technology.
- ***Industrial -*** The company's amorphous-silicon and poly-silicon high-brightness line, targeted for industrial applications, consists of TFT LCDs in sizes ranging from 3.5-inch at QVGA (320 x 240) resolution to 15-inch at XGA (1024 x 768) resolution. Specialized modules are also available, including a very high brightness, 12.1-inch, 900 cd/m^2 SVGA (800 x 600) module with improved viewability for vending machines, ticket dispensers and other equipment installed outdoors. A newly announced lineup of color active matrix TFT LCD modules for industrial applications incorporates long-life LED backlighting systems for a broad range of industrial applications, such as test and measuring equipment, medical equipment, portable handheld computing devices, and more. The new series includes five transmissive LCD modules ranging from 5.7-inch QVGA (320 x240) to 10.4-inch XGA (1024 x 768). Each has a replacable, long-life, mercury-free LED-based backlighting system, and is designed such that a resistive touch panel can be added as an option. The long-life LED-based backlighting systems provide an average backlight lifetime of 70,000 hours MTTF/MTBF [(2)], or approximately 8 years of continuous operation. Several new wide-format modules are also available, as are factory-installed touch panels on selected models. Most of the industrial LCDs either feature long-life, replaceable LED or long-life, replaceable cold cathode fluorescent lamp (CCFL) backlighting systems, and meet the specifications needed for products that are designed for AC-powered applications requiring superior front-of-screen performance, brightness, contrast and wide-viewing angles desired in industrial factory automation, retail point of sale, kiosk and other industrial applications. A broad selection of RoHS-

Compatible[3] displays, intended to meet the requirements of the RoHS Directive[4] are also available.

- ***Automotive*** **–** TAEC offers an extensive product lineup of 5.8-inch to 9.0-inch modules developed by TMD for automotive entertainment and navigation applications, as well as smaller, and larger, displays for instrument cluster applications, many of which will be exhibited at SID 2008. At the 2008 exhibition, TAEC will demonstrate OCB technology, which is particularly well suited for automotive instrument cluster applications, with its wide viewing angles and fast response speed that performs well even at extremely cold operating temperatures of -20°C and below. A prototype 12.3-inch double-VGA (1280 x 480) TFT module demonstrates the fast response, wide viewing angle, and color clarity of OCB technology. When integrated into an automotive instrument panel, such full-size displays can be used to switch among multiple views, such as speedometer and tachometer, navigation guides, meters and gauges, and rear-view camera systems images. A robust LED-backlit, 3.5-inch QVGA (240 x 320) instrument cluster display and a prototype round 2.4-inch (240 x 240) TFT LCD, both enabled by LTPS and LED backlight technologies, are also part of the automotive display family.

Technology

Amorphous-Silicon Technology TFT LCDs
TMD produces thin film transistor LCDs using both amorphous silicon (a-Si), and poly-silicon (p-Si). Amorphous silicon TFT LCDs have become the standard for mass-produced active matrix LCDs. TMD offers a wide line-up of amorphous-silicon TFT LCDs.

Low-Temperature Poly-Silicon Technology TFT LCDs
TMD demonstrates its continued leadership in the development of high information content displays through advances in LTPS TFT LCD technology for all sizes of displays. The technology enables higher electron mobility than amorphous-silicon technology, thus allowing for the patterning of the driver IC circuits directly onto the glass substrate. In some cases, this can eliminate the need for separate driver ICs as typically found in TAB or COG amorphous-silicon TFT LCDs. Poly-silicon technology can enable an overall reduction in component count by as much as 40 percent, signifying up to a 95 percent reduction in the number of connection locations required in the LCD module system as well as allowing a smaller circuit pitch, compared to conventional a-Si displays. All combined, poly-silicon technology provides for thinner, brighter, lower-power, higher-resolution, less complicated TFT LCD modules. LTPS is the core technology in TMD's system-on-glass endeavors, which already incorporate various functionalities onto the glass substrate, and is the basis of TMD's development in OLED and other system-on-glass advancements. The poly-silicon line-up generally features high resolution and low power usage, in thin and lightweight modules.

System on Glass
TMD continues to pursue adoption of LTPS as a core technology for future development of System on Glass (SOG) displays. The company's first step in developing SOG capability using LTPS technology was to fabricate peripheral driver LSI circuits directly onto the LCD. As a second step, TMD has successfully provided LCD modules with built-in static random access memory (SRAM) and digital analog converter (DAC) for the cellular phone market. In 2003 and

2004, TMD successfully developed prototype LTPS TFT LCDs featuring an input-display function that was able to capture an image of any item held in close proximity to the display, first in monochrome and then in color. The input capture function was achieved through photo sensor devices embedded in the LCD. This technology is now commercially available in mobile phone displays.

OCB Technology

By optimizing the liquid crystal cell structure, improving the bend alignment of the liquid crystal molecules, and using special optical compensation films, optically compensated bend (OCB) technology greatly improves response time, and achieves a much wider and all-around viewing angle, without color inversion. OCB's fast response time is also of great benefit in cold temperature conditions, such as those encountered and specified in automotive applications. TMD has optimized the manufacturing techniques for OCB, and is evaluating OCB technology for a multitude of display sizes and applications that may benefit from its performance capabilities.

Organic Light Emitting Displays (OLEDs)

OLED displays driven by low temperature polysilicon offer several advantages over conventional LCD technologies, including self-emitting light; thinner, lighter-weight displays (because no backlight is required); faster response times; and wider viewing angles. In May 2001, Toshiba announced the development of the world's first prototype of a full-color polymer-based OLED, 2.85-inch display supporting 260,000 colors in QCIF+ (176 x 220 pixels) resolution format. This breakthrough display was achieved by developing technology for forming a light-emitting polymer film on a LTPS thin film transistor (TFT) array. In April 2002, TMD announced the development of a 17-inch OLED prototype featuring the world's largest full-color screen. At the time, this OLED offered the largest-size and highest resolution available at 1280 x 768 pixels. In previous days, TMD also developed a 3.46-inch QVGA (320 x 240) OLED display for potential use in portable AV equipment, and a 2.5-inch OLED prototype for digital camera applications. The latest development, a 3.2" QVGA OLED, adopts a top-emission structure for improved power consumption, luminance, and product life, and will be exhibited at SID 2008.

Screen Fit Technology

TMD Screen Fit transparent cover panel technology for cellular phone and other mobile applications provides impact resistance and improves legibility, as a result of a special resin injected between the cover panel and the polarizing film at the surface of the LCD panel. The resin assures optical integrity between the two materials, minimizes interface reflections and strengthens the module structure. Compared to a conventional LCD design, in which the top polarizer film layer of the display is protected by an acrylic cover panel encasing the hollow space between the cover and the display, a Screen Fit LCD enhances the display's optical characteristics by eliminating two boundaries that reflect and scatter light, reducing reflections from the inner surface of the cover panel as well as the reflections from the surface of the LCD panel. Luminance is also improved with increased transmittance.

– more –

Mass Production Capabilities
TMD produces its amorphous-silicon TFT LCD display panels in Himeji, Ishikawa and Uozo, Japan. In addition, TMD manufactures its poly-silicon TFT LCDs at its Fukaya Works in Saitama Prefecture, Fukaya, Japan, at its fab (AFPD) in Singapore, and in a $500 million LTPS facility in Ishikawa Prefecture added in 2006, which is dedicated to mobile phone and automotive applications utilizing SOG and/or OCB technologies. On Sept. 4, 2006, the AFPD facility became the first LCD fab to produce a total of 10 million large-size (10-inches or larger) LTPS LCD panels. Both the AFPD and Ishikawa fabs utilize 730mm x 920mm glass substrates, currently the largest-size LTPS LCD substrate in production. The facilities are equipped with state-of-the-art manufacturing equipment to support large-size LTPS TFT LCD process technologies.

TAEC Management
Clayton Bond, senior vice president of the Display Devices and Components Business Unit
Sean Collins, vice president business development, Display Devices and Components Group for TAEC
Hiroshi Maeda-san, vice president, chief technology executive, LCD Product Line
Steve Vrablik, business development director, automotive, LCD Product Line

Location
2150 East Lake Cook Road, Suite 310, Buffalo Grove, IL 60089, (847) 484-2400

Internet Address
http://www.chips.toshiba.com

Company Contact
For additional information on Toshiba's LCD offerings, please contact Ms. Poloi Lin, Marketing Communications, TAEC, Irvine, CA, (949) 623-3098, poloi.lin@taec.toshiba.com

Public Relations Contact
MultiPath Communications International, Jan Johnson, (714) 633-4008, jan@multipathcom.com or Carol Bardia, (949) 481-5867, carol@multipathcom.com.

-###-

Information in this fact sheet, including product pricing and specifications, content of services and contact information, is current on the date noted below, but is subject to change without prior notice. Technical and application information contained here is subject to the most recent applicable TMD LCD product specifications. In developing designs, please ensure that TMD LCD products are used within specified operating ranges as set forth in the most recent TMD product specifications. This information is available from TAEC or from your TAEC representative.

(1)Fortune Magazine, 2006, Electronic/Electrical Equipment ranking

(2)Module MTBF (Mean Time Between Failure) 70,000 hours; backlight MTTF (Mean Time To Failure) 70,000 hours. MTBF and MTTF are not guarantees or estimates of product life; they are statistical values related to mean failure rates for a large number of products which may not accurately reflect actual operation.

(3)RoHS-Compatible – Toshiba Matsushita Display Technology Co. Ltd. defines "RoHS-Compatible" LCD products as products that either (i) contain no more than a maximum concentration value of 0.1% by weight in Homogeneous Materials[5] for lead, mercury, hexavalent chromium, polybrominated biphenyls (PBBs), and polybrominated diphenyl ethers (PBDEs) and no more than 0.01% by weight in Homogeneous Materials(5) for cadmium, or (ii) fall within one of the stated exemptions set forth in the Annex to the RoHS Directive.

[(4)]RoHS Directive – Toshiba Matsushita Display Technology Co. Ltd. defines the "RoHS Directive" as the Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

[5]Homogeneous Materials – Toshiba Matsushita Display Technology Co. Ltd. defines "Homogeneous Materials" to mean a material that cannot be mechanically disjointed into different materials. The term "homogeneous" is understood as "of uniform composition throughout," so examples of "Homogeneous Materials" would be individual types of plastics, ceramics, glass, metals, alloys, paper, board, resins and coatings. Toshiba Matsushita Display Technology Co., Ltd. defines the term "mechanically disjointed" to mean that the materials can, in principle, be separated by mechanical actions such as unscrewing, cutting, crushing, grinding or abrasive processes.

###

5/16/08