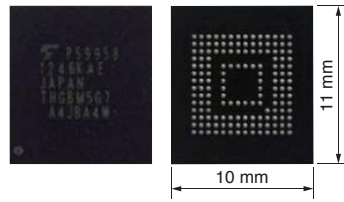


## Compact e•MMC™ Memories with High Performance Using 19 nm NAND Flash Memory Technology

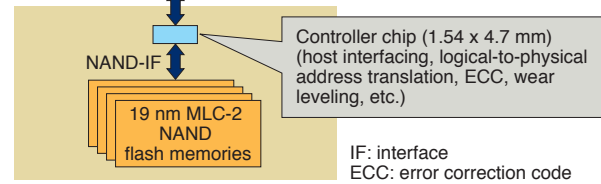
The e•MMC™ memory has come into widespread use as nonvolatile memory embedded in smartphones, tablets, and other mobile devices. In response to market demand, Toshiba has developed compact e•MMC™ memories with enhanced performance consisting of a newly developed high-performance controller and a stack of the world's smallest 64 Gbit or 32 Gbit two-bits-per-cell (MLC-2) NAND flash memories<sup>(\*)</sup> fabricated using the 19 nm process.



e•MMC™ package

By implementing unique firmware algorithms in the microprocessor unit (MPU) of the controller, significantly improved performance of the controller is achieved in addition to reductions in chip size and cost. The new e•MMC™ memories deliver the industry's top-class random write performance<sup>(\*)</sup>, which is more than four

e•MMC™-IF (compliant with e•MMC™ standard v4.41)



Block diagram of embedded nonvolatile memory compliant with the e•MMC™ standard

times faster than that of our 24 nm predecessor memory, and are expected to greatly enhance the end-user experience of smartphones and other devices.

We have a lineup of new e•MMC™ memories with large capacities from 16 Gbytes to 64 Gbytes in compact packages with dimensions such as 11 × 10 mm and 11.5 × 13 mm.

MLC: multilevel cell

(\*1) As of November 2012 (as researched by Toshiba)

(\*2) As of March 2013 (as researched by Toshiba)

e•MMC is a trademark of the JEDEC Solid State Technology Association.

## Visconti™2 Series High-Performance, Low-Power-Consumption Image Recognition Processors

With the advancement of camera-based sensing technologies in recent years, their application to various products, including surveillance cameras to automatically detect intruders and notify a security company and advanced driver assistance systems (ADAS) to avoid or mitigate vehicle collisions, is rapidly spreading. Particularly for human detection, high parallel computing performance is required to perform a huge amount of computations in real time. Furthermore, these systems need to operate with low power consumption even in

high-temperature environments.

Toshiba has developed the Visconti™2 series image recognition processors incorporating a multicore processor and image processing accelerators with low power consumption. Visconti™2 delivers excellent image processing performance that realizes simultaneous detection of multiple objects such as pedestrians and vehicles with low power consumption, allowing its use in embedded systems. Visconti™2 can simultaneously process video signals from up to four cameras in real time.

We have released engineering samples and a software development kit and are making efforts to provide additional products in the Visconti™2 series lineup to meet diverse market requirements.



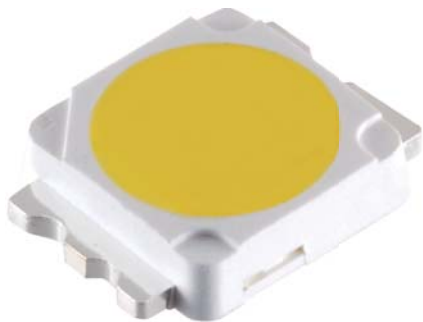
Application of Visconti™2 to ADAS

Performance and power consumption of on-chip modules of Visconti™2

Modules	Operational performance (GOPS)	Power consumption (W) at 1.1 V / 25°C	Operational performance per 1 W (GOPS/W)
Media processing engines	46.8	0.1206	388.1
Affine transformation accelerator	10.6	0.1082	98.4
HOG accelerator	25.5	0.1302	196.1
Histogram accelerator	5.3	0.0420	126.7
Filter accelerators	230.4	0.2931	786.2
Matching accelerator	145.2	0.0546	2659.3
Total	463.9	0.7486	619.7

GOPS: giga operations per second HOG: histogram of oriented gradients

## White LED Lamp Incorporating GaN-on-Si LED Chip



TL1F1 series flat-top type white LED lamp

Toshiba has developed 1 W-class white light-emitting diodes (LEDs), which incorporate a white LED chip developed in cooperation with Bridgelux Inc. and are housed in an industry-standard package, for general lighting applications.

To reduce material costs, the newly developed white LED chips are fabricated by epitaxially growing a gallium nitride (GaN) layer on top of a silicon (Si) substrate instead of the sapphire substrate that is most commonly used for white LEDs. We have realized mass production of GaN-on-Si chips using 200 mm wafers, the industry's largest diameter wafers for LED production<sup>(\*)</sup>, by applying our advanced wafer fabrication manufacturing technologies. The GaN-on-Si process using 200 mm wafers makes it possible to drastically reduce the chip cost compared with the sapphire-based process using 50 mm to 100 mm wafers.

Furthermore, in order to promote the strengthening of our LED business, we entered into an agreement with Bridgelux Inc. to purchase its GaN-on-Si technology and related assets in April 2013. We will increase our lineup of white LED products and expand manufacturing capacity in order to strengthen their competitiveness.

(\*) As of May 2013 (as researched by Toshiba)

## TC35770XBG 4K Ultra HD Scaler IC

The REGZA 55X3 liquid crystal display (LCD) TV developed by Toshiba, which is equipped with a 4K ultra-high-definition (Ultra HD: 3 840 × 2 160 pixels) panel, has recently been attracting increasing interest in the market. We have now developed the TC35770XBG 4K Ultra HD scaler integrated circuit (IC) for application to 4K Ultra HD TVs and other high-end applications.

The TC35770XBG upscales full HD videos with a resolution of 1 920 × 1 080 pixels to those with 4K Ultra HD resolution, and realizes sharp images by using an

on-chip enhancer. As it requires no external memory, it can be used as an add-on to the inter-IC (I<sup>2</sup>C) bus in a conventional digital TV to upgrade it to a 4K Ultra HD TV. The TC35770XBG can also reduce jagged edges in images (commonly referred to as *jaggies*) produced as a result of normal upscaling and support three-dimensional (3D) capabilities.

We started manufacturing of the TC35770XBG in commercial quantities in August 2012.



(a) Picture upscaled by conventional technology  
(Jaggies appear on diagonal lines.)



(b) Picture upscaled by TC35770XBG  
(Jaggies on diagonal lines are improved.)

Comparison of 4K Ultra HD upscaled pictures using conventional technology and TC35770XBG

\*Part of the *Hi-Vision Test Sequences 2nd Edition*, released by the Institute of Image Information and Television Engineers, was used in this comparison.

## Hybrid Drive as New Alternative Storage Device for PCs

Toshiba has developed the MQ01ABD100H hybrid drive, consisting of a 2.5-inch hard disk drive (HDD) with a capacity of 1 Tbyte and an 8 Gbyte NAND flash memory that serves as a cache memory. The hybrid drive is a new type of storage device that combines the bit cost advantage of rotating media with the high performance of NAND flash memory.

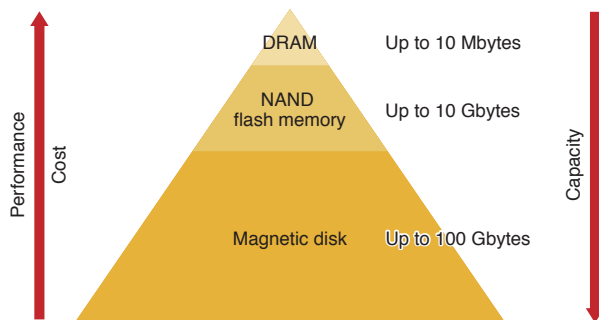


Overview of hybrid drive

It has a three-tiered storage architecture that consists of dynamic random access memory (DRAM), NAND flash memory, and magnetic disks. To effectively utilize this memory hierarchy, the MQ01ABD100H incorporates a unique cache algorithm that dynamically studies the pattern of data accesses by the host device and stores frequently accessed data in the NAND flash memory. The new hybrid drive achieves higher performance than that of conventional HDDs by using the NAND flash memory as a secondary cache.

For example, use of the MQ01ABD100H makes it possible to reduce PC application boot times by approximately 40%(\*). Due to the use of the 2.5-inch form factor and a standard interface, the MQ01ABD100H is an ideal replacement for a conventional HDD to improve PC performance.

(\*). In comparison with Toshiba's conventional HDDs



Basic configuration of hybrid drive

## CANVIO™ SLIM, World's Thinnest and Lightest Portable HDD



CANVIO™ SLIM

Toshiba has released a new external storage device called the CANVIO™ SLIM, which is the world's thinnest and lightest 2.5-inch portable HDD(\*), featuring a capacity of 500 Gbytes in a chassis of approximately 9 mm in thickness and 115 g in weight.

The CANVIO™ SLIM contains a 500 Gbyte HDD of 7 mm in thickness equipped with a universal serial bus (USB) 3.0 interface to significantly improve data transfer performance. The brushed metallic finish provides the CANVIO™ SLIM with an attractive and sophisticated appearance. Being slim and lightweight, it is easy to carry with a tablet or mobile PC such as an Ultrabook™ PC.

Additionally, as the CANVIO™ SLIM comes with a password protection tool, users can take it outside the home without concerns about data security by installing this tool in their PC or tablet and setting the password in it.

(\*). As of September 2012, for portable 2.5-inch HDDs (as researched by Toshiba)

*Ultrabook is a trademark of Intel Corporation in the United States and other countries.*

Note:

1 Mbyte is  $10^6 = 1\,000\,000$  bytes;

1 Gbyte is  $10^9 = 1\,000\,000\,000$  bytes;

1 Tbyte is  $10^{12} = 1\,000\,000\,000\,000$  bytes.

## Multidiffusion Globes for LED Lamps



LED lamps with wide light distribution and multidiffusion globes

Conventional LED lamps have several problems such as narrow distribution of the light angle and dazzle when looked at directly. Toshiba has developed multidiffusion globes for use with LED lamps that offer not only dispersed light over a wide beam angle, even to the backside of the lamp, but also soft light distributed over the entire surface of the globe with less dazzle.

These features were realized through the development of our proprietary polycarbonate plastics with low light absorption and high light diffusion, as well as a new optical analysis technology that allows accurate simulation of light scattering inside plastic globes. Although these multidiffusion globes have a very simple structure, they can light up even the backside of an LED lamp, effectively reflecting the emitted LED light inside the entire surface of the globe.

Multidiffusion globes have been adopted by Toshiba Lighting & Technology Corporation for its LED lamps released in both the Japanese and international markets, and are expected to be widely used in various lighting products.

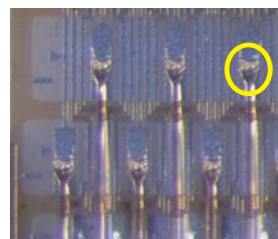
## Second-Generation Thermal Print Head with 1 200 dpi Resolution

A thermal print head (TPH) is an information recording device used to print characters and image information on media. Toshiba Hokuto Electronics Corporation has already commercialized a TPH with a 1 200 dots-per-inch (dpi) heater, which achieved the highest resolution in the industry for products with a print width exceeding 4 inches<sup>(\*)</sup>. It has been widely used in platemaking for offset printing and in sticker printing machines.

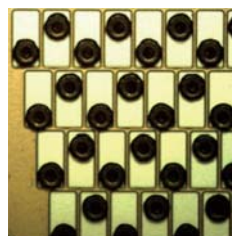
To accelerate the dissemination of TPHs with 1 200 dpi resolution, we have developed a new TPH designed to achieve a lower price level. Cost reduction was achieved primarily through structural changes without affecting the printing quality. The key technological advancements adopted in the newly developed TPH are a fine-pitch wire bonding process and dedicated IC implementation of the driver. Generally, the wire bonding pitch and bonding reliability are mutually exclusive relationships. To overcome this problem, we utilized a bond stitch on ball (BSOB) process to reduce the wire bonding pitch to 19  $\mu\text{m}$  without compromising reliability. Consequently, the new BSOB process requires only one-third the mounting area compared with that of its predecessor, reducing the heater substrate area by half.

With its low cost and high reliability, the new TPH is expected to open up new markets that have been undeveloped so far due to the high price of conventional TPHs.

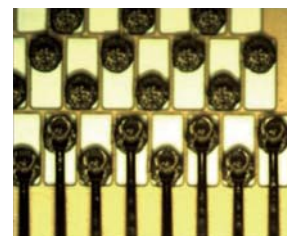
(\*) As of January 2013 (as researched by Toshiba Hokuto Electronics Corporation)



Normal wire bonding on second bonding side



BSOB process



Second bonding on bumps

Outline of BSOB process