

Timeline: 25 Years of NAND Flash

- 1984 >**
NOR Flash Memory Invented
- First paper for the flash EEPROM was presented by Toshiba at IEEE International Electron Devices Meeting (IEDM) in San Francisco.
- Both NOR and NAND types of flash memory were invented by Dr. Fujio Masuoka while working for Toshiba in the 1980s. Originally called simultaneously erasable EEPROM, the name flash was suggested because the device could erase a large number of memory cells simultaneously in a 'flash', like the flash of a camera.
- 1987 >**
NAND Flash Memory Invented
- First NAND-type flash memory technology was presented by Toshiba at IEEE International Electron Devices Meeting (IEDM). The NAND-type flash was a new flash configuration that reduced memory cell area so that a lower bit cost could be achieved. Unlike dynamic random access memory (DRAM) chips, flash chips can retain the information they store even when the electric current has been switched off.
- 1991 >**
First 4Mb NAND-type EEPROM Introduced
- Toshiba developed the world's first 4-megabit (Mb) NAND-type Electrically Erasable and Programmable Read-only Memory (EEPROM).
- 1992 >**
First 16Mb NAND-type EEPROM Introduced
- 16-megabit (Mb) device which enabled PCMCIA Cards (Personal Computer Memory Card International Association) for portable data storage.
- 1995 >**
40MB Flash Memory Cards Introduced
- First generation standardized memory cards were introduced with a PCMCIA interface for data storage for portable computers and personal digital assistants. These cards were also used in some of the early digital cameras. A 40MB card would have cost several thousands of dollars, and would only have been able to store 9-10 pictures using today's 10-megapixel camera.
- 1996 >**
Forum Established to Promote Solid State Floppy Disk Cards (SSFDC) Memory Card Format
- Originally named Solid State Floppy Disk Card (SSFDC), SmartMedia was the first NAND-based removable media format. In 1996, it was established as an industry standard, enabling the digital camera market to develop.

1999 >
Toshiba and SanDisk agreed to jointly develop and manufacture gigabit scale flash memories

Industry's first NAND flash joint venture paved the way to today's megafab constructions. Large-scale production lowered the cost per gigabit, leading to the use of NAND flash storage in a wider range of products.

2000 >
SD Association Formed to Set Industry Standards for Secure Digital (SD) Cards

The SD card was introduced in 1999 by Matsushita, SanDisk and Toshiba. In 2000, Panasonic, SanDisk Corporation and Toshiba Corporation established the SD Association to develop and promote memory card storage standards. By standardizing the Secure Digital (SD) Card format, the digital camera market was able to develop more rapidly. Also in 2000, Toshiba introduced the world's first product designed to use the SD Memory Card, a mobile audio player (MEA110AS).

2000 >
Introduction of First Secure Digital (SD) Cards Offered to OEMs

8MB to 64MB SLC NAND-based Secure Digital (SD) Memory cards were introduced to OEM customers. A revolutionary universal flash memory storage device, SD Memory cards were developed to meet the converging security, capacity, and performance requirements of the emerging audio, video, data and multimedia consumer electronics markets.

2001 >
World's First Commercial 1Gb MLC NAND Flash Chip Introduced

Industry's highest density MLC NAND chip became available and paved the way to higher density storage at a lower cost-per-bit.

2002 >
Introduced 1GB CompactFlash cards Using MLC NAND Technology

First memory card form factor to use Multi-level Cell NAND technology, the 1Gigabyte (GB) CompactFlash card met the industry's need for higher-capacity flash cards demanded by the increased popularity of higher-resolution digital cameras.

2002 >
First Large Block NAND Flash Device Introduced

0.13 micron 1Gb monolithic Large Block NAND provided a high-performance embedded memory solution at an attractive cost-per-bit for digital cameras, PDAs and other emerging applications like MP3 players.

2003 >
Wider x16 NAND Flash Memory Developed

This new NAND flash memory configuration doubled the bus width, reducing the time required to transfer data. As a result, the overall system performance of cell phones and mobile devices was increased, and the mobility of content enabled, supporting the emergence of the Smartphone market.

2003 >
Complete MCP Solution Offered for Cell Phones with NOR Flash, NAND Flash, SRAM, Pseudo SRAM/LPDRAM

Multi-chip (MCP) stacking technology reduced board space for mobile/handheld applications, enabling smaller, more feature-rich phones. Stacking multiple die and technologies in a single package provided a low-cost, high-performance option for a complete cell phone memory subsystem.

2004 >

Construction Began on Fab 3 – A State-of-the Art 300mm Wafer Fab For NAND Flash Memory At Yokkaichi Operations

Fab 3, the first 300-millimeter (mm) NAND flash “megafab” was developed to meet the growing demand for flash memory in digital consumer devices, including digital still cameras, MP3 and music players. High volume production lowered the cost per gigabit, leading to the use of NAND flash storage in a wider range of products.

2005 >

8-Gigabit NAND Flash Memory Chip Developed

8-gigabit (Gb) NAND flash memory chip ushered in the new era of 1-gigabyte (GB) data storage capacity on a single chip. NAND flash is introduced in MP3 players, providing space, weight and power savings over hard disk based hardware.

2006 >

1GB microSD and 4GB SDHC Cards Launched

microSD card is launched to support storage requirements in cell phone applications. Today, microSD cards are the defacto removable storage standard for cell phones. The Secure Digital High Capacity (SDHC) format was introduced by the SD Association. The SDA 2.00 specification enabled SD cards to reach higher capacities: 4GB - 32GB.

2006 >

Toshiba and SanDisk Mark Construction Start of Fab 4, a 300mm Wafer Fab for NAND Flash Memory at Yokkaichi Operations

Fab 4, Toshiba's 2nd 300-millimeter (mm) NAND flash “megafab”, was developed to meet the growing demand for flash memory in a wide range of digital electronic applications, including MP3 music players, mobile phones and memory cards.

2007 >

Highest Capacity Embedded NAND Flash Memory (e-MMC) for Mobile Consumer Products Introduced

16GB e-MMC chip combined eight 2GB NAND chips with a controller chip in a standard single, small size package. The controller function minimized customer development requirements and eased integration into system designs. e-MMC is now the industry standard for embedded memory in Smartphones and mobile products.

2007 >

128GB MLC SATA SSD Introduced

First Multi-level Cell (MLC) SATA-based and largest capacity solid state drive (SSD) drive is launched. MLC-based SSDs lowered the average price per gigabyte of an SSD and helped achieve more acceptable price points for OEMs, accelerating adoption in the market.

2008 >

Industry's first 512GB MLC SATA Solid State Drive Introduced

Toshiba's second-generation SSDs bring increased capacity and performance enabling an improved computing experience and faster boot and application loading times.

2009 >

Toshiba Makes Major Advances in NAND Flash Memory with 3-bit-per-cell 32nm Generation and 4-bit-per-cell 43nm Technology

Advanced multi-bit per cell technology (3-bit-per cell and 4-bit-per-cell) enabled advances in chip densities and cost savings for next generation devices. In 2009, Toshiba's 3-bit-per-cell 32-gigabit (Gb) chip represented the smallest die-size yet achieved.

2010 >

**Toshiba Launches Industry's
Largest Embedded NAND Flash
Memory Modules**

128GB e-MMC uses a stack of sixteen 64Gb (64 gigabit, or 8 gigabyte) NAND chips, demonstrating Toshiba's advanced stacking capabilities.

2010 >

**Toshiba and Samsung Support
(DDR) NAND Flash Memory with
a 400 megabit-per-second (Mbps)
Interface**

Commitment to support the toggle DDR 2.0 specification enabled broad-scale acceptance of this new high-speed technology, and accelerated its use in SSD applications and enterprise storage.

2011 >

**Toshiba and SanDisk Celebrate
the Opening of Fab 5 NAND
Flash Memory Fabrication
Facility in Japan**

Fab 5, Toshiba's 3rd 300-millimeter (mm) NAND flash "megafab", was developed to support strong global demand for NAND flash memory fueled by the growth of Smartphones, tablets, enterprise and other electronic devices.

2012 >

**Toshiba Develops 19nm
Generation NAND Flash Memory
with World's Largest Density and
Smallest Die Size**

Toshiba was the first NAND manufacturer to develop a 1x nm process, representing a breakthrough in the industry in chip density and performance.