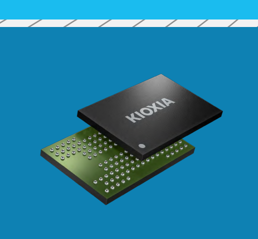
KIOXIA

INVENTOR OF FLASH MEMORY
35
YEARS OF INNOVATION

35 Years of NAND Flash

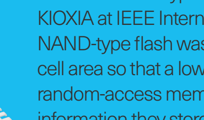
Timeline highlights of KIOXIA Innovations and Milestones



1987

Invented the World's First NAND Flash Memory

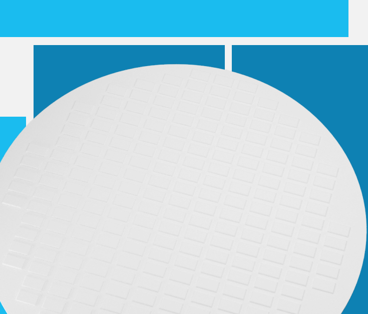
The first NAND-type flash memory technology was presented by KIOXIA at IEEE International Electron Devices Meeting (IEDM). The NAND-type flash was a new flash configuration that reduced memory cell area so that a lower bit cost could be achieved. Unlike dynamic random-access memory (DRAM) chips, flash chips can retain the information they store even when the electric current has been switched off.



1991 / 1992

First 4Mb NAND-Type EEPROM Introduced

KIOXIA developed the world's first 4-megabit (Mb) NAND-type Electrically Erasable and Programmable Read-only Memory (EEPROM); as well as a 16Mb device which enabled PCMCIA Cards (Personal Computer Memory Card International Association) for portable data storage.



1999

KIOXIA and SanDisk® Agree to Jointly Develop, Manufacture Gb 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 SD Memoriy Cards

The SD card was introduced in 1999 by Matsushita™, SanDisk and KIOXIA. In 2000, Panasonic® Corporation, SanDisk Corporation and KIOXIA Corporation established the SD Association to develop and promote memory card storage standards. By standardizing the SD Memory Card format, the digital camera market was able to develop more rapidly.

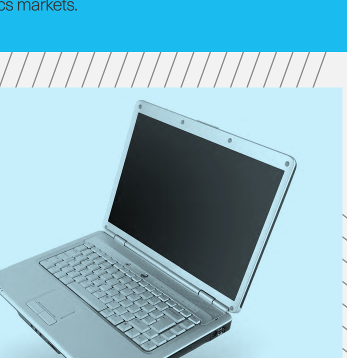
Developed SD Memory Cards

8-megabyte (MB) to 64MB SLC NAND-based 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

KIOXIA MLC NAND chips became available and paved the way to higher density storage at a lower cost-per-bit.



2005

Commenced Operation of Fab 3 – A State-of-the-art 300mm Wafer Fab

Fab 3, a 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.

8-Gigabit NAND Flash Memory Chip Developed

As developed by KIOXIA, 8Gb NAND flash memory chips ushered in the new era of 1GB 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. The chip utilizes multi-level cell (MLC) technology that allows two bits of data to be stored in one memory cell, doubling memory capacity.

2008

Industry's first 512GB MLC SATA SSD Introduced

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

2010

KIOXIA Launches Industry's Largest Embedded NAND Flash Memory Modules

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

2011

KIOXIA Celebrates Opening of Fab 5 Facility in Japan

Fab 5, the 3rd 300mm NAND flash megafab from KIOXIA, was developed to support strong global demand for NAND flash memory fueled by the growth of smartphones, tablets, enterprise and other electronic devices.

2007

Highest Capacity Embedded NAND Flash Memory for Mobile Consumer Products Introduced

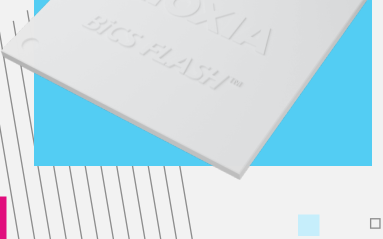
16GB e-MMC chip combined eight 2GB NAND chips with a controller chip in a standard single, small size package. The controller function minimized customer development requirements and eased integration into system designs. e-MMC is now the industry standard for embedded memory in smartphones and mobile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

First 128GB MLC SATA SSD Introduced

A 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.

First to Announce 3D Flash Memory Technology

KIOXIA first presented the concept for BiCS FLASH™ 3D flash memory at the IEEE VLSI Symposium in 2007.



2012

Reported 19nm MLC NAND Flash Memory at IEEE International Solid-State Circuits Conference (ISSCC)

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

25th Anniversary of NAND Flash Memory

KIOXIA celebrates the invention of NAND flash memory 25 years ago.

2013

Introduced the World's Smallest 19nm Second-generation MLC NAND Flash Memory

This breakthrough 64-gigabit NAND memory chip represented the smallest and fastest 2-bit-per-cell NAND memory chip available.

KIOXIA Develops Industry's First Universal Flash Storage (UFS) Devices

KIOXIA begins shipping samples of 64GB embedded NAND flash memory modules equipped with a Universal Flash Storage (UFS) interface. These modules are an industry first and are designed for a wide range of digital consumer products.

2014

Commercialized the World's Smallest 15nm NAND Flash Memory

The new 15nm technology was applied to the world's first 2-bit-per-cell 128-gigabit (16 gigabytes) NAND flash memories.

2015

World's First 256Gb, 48-Layer BiCS FLASH™ 3D Flash Memory Commercialized

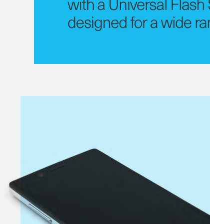
After announcing prototype BiCS FLASH™ technology in 2007, KIOXIA continued development to optimize the technology for mass production. With a 3D stacked structure that boosts capacity and performance, BiCS FLASH represents another industry first from KIOXIA.

KIOXIA Debuts Serial Interface NAND

In another example of the company's strategic innovation and development to meet the diverse needs of the market, KIOXIA introduced a Serial Interface NAND product family that is compatible with the widely used Serial Peripheral Interface (SPI).

KIOXIA Develops First Ever 16-die stacked NAND Flash Memory with TSV Technology

The world's first 16-die (max.) stacked NAND flash memory utilizing Through Silicon Via (TSV) technology was shown by KIOXIA at Flash Memory Summit 2015 in Santa Clara, California.



2016

KIOXIA Prototypes BiCS FLASH™3D Flash Memory with the World's Highest Density

Building on its reputation as leaders in the 3D flash memory arena, KIOXIA BiCS FLASH memory incorporates TLC technology and achieves a 256Gb capacity, underscoring the potential of the company's proprietary architecture.

2017

KIOXIA Enables BiCS FLASH™ 3D TLC Flash Memory 1TB Chip Solution

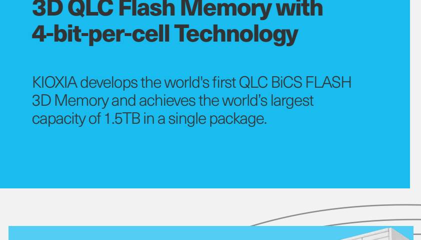
Continuing the refinement of its BiCS FLASH™ technology, KIOXIA 512Gb 3D flash memory features the industry's largest capacity. It enables a 1TB product with a 16-die stacked architecture in a single package.

KIOXIA Prototypes 96-layer BiCS FLASH™ 3D Flash Memory

4-bit-per-cell (QLC) technology boosts single-chip memory capacity to the highest level yet achieved - 1.33 terabits for a single chip

First to Introduce BiCS FLASH™ 3D QLC Flash Memory with 4-bit-per-cell Technology

KIOXIA develops the world's first QLC BiCS FLASH 3D Memory and achieves the world's largest capacity of 1.5TB in a single package.



2018

Achieved Industry's Highest Capacity for a Single Chip

KIOXIA develops 96-layer BiCS FLASH with QLC technology, boosting single-chip memory capacity to the highest level yet achieved - 1.33 terabits for a single chip. A 16-die stacked architecture in a single package realizes an unparalleled capacity of 2.66 terabytes.

Introduced XL-FLASH™ Concept at Flash Memory Summit

KIOXIA first unveiled the concept for XL-FLASH in an FMS 2018 keynote presentation. Based on the company's 96-layer BiCS4 3D flash memory, XL-FLASH makes use of shorter bit and word lines to build a die with more planes than currently common on NAND devices.

Introduced Native NVMe-oF™ SSDs

New NVMe-oF SSDs offer near-native performance of NVMe SSDs, combined with fan-out scalability to facilitate adoption of NVMe-oF technology.

Introduced KumoScale™ NVMe-oF Software

Demonstrating its commitment to helping cloud data center customers maximize flash and compute resources, KIOXIA debuted KumoScale™ Software. KumoScale™ enables operational and revenue agility and was the industry's first standards-compliant Kubernetes® integration with NVMe-oF target.

2019

First to Sample UFS Ver. 3.0 Memory Devices

KIOXIA started sampling the industry's first UFS Ver. 3.0 embedded flash memory devices. With high-speed read/write performance and low power consumption, the new devices are suitable for applications such as mobile devices, smartphones, tablets, and augmented/virtual reality systems.

XL-FLASH Storage Class Memory 128Gb Die Introduced

With the introduction of XL-FLASH Storage Class Memory, KIOXIA delivered a cost-effective, lower latency storage solution that bridges the gap between DRAM and NAND performance.

Introduced Industry's First 512GB Automotive UFS

KIOXIA developed 512GB Automotive UFS memory, which integrates the company's BiCS FLASH 3D flash memory and a controller in a single package, to meet the growing demand for storage within vehicles.

2020

Commenced Operation of New Kitakami Plant (K1)

KIOXIA announced the expansion of its Kitakami manufacturing facility to increase production of its proprietary BiCS FLASH™3D flash memory devices.

Introduced UFS Ver. 3.1 Memory Devices

Further cementing its position as a leading provider of storage for next-gen mobile devices, KIOXIA started sampling UFS Ver. 3.1 embedded flash memory devices.

Introduced 5th Generation 112-layer BiCS FLASH™ 3D Flash Memory

KIOXIA successfully developed its fifth generation BiCS FLASH 3D flash memory with a 112-layer vertically stacked structure. This structure combines with advanced circuit and manufacturing process technology to increase cell array density by approximately 20% over the 96-layer stacking process.

Launched PCIe® 4.0 SSDs

The KIOXIA lineup of CM6 and CD6 Series PCIe 4.0 NVMe enterprise and data center solid state drives (SSDs) began shipping to customers, making the company the first to ship these next-generation drives.

2021

Introduced the Thinnest 1TB UFS Ver 3.1 Memory Devices

KIOXIA began sampling of its 1TB UFS Ver. 3.1 embedded flash memory devices. KIOXIA 1TB UFS brings the ultra-high speed read/write performance, low power consumption, shortened application launch times and storage capacity demanded by 5G and other digital consumer products. It is housed in a 1.1mm-high package – making it the thinnest 1TB UFS offering available.

Introduced 6th Generation 162-Layer BiCS FLASH™ 3D Flash Memory

KIOXIA announced the development of its sixth-generation, 162-layer BiCS FLASH 3D flash memory technology - its highest density and most advanced 3D flash memory technology to date. Utilizing CUA technology, sixth generation BiCS FLASH delivers 10% greater lateral density, a 40% reduction in chip size and a 10% improvement in read latency.

JEDEC Standardization of XFM Embedded and Removable Memory Device

JEDEC adopts the KIOXIA proposal for a small-thin removable form factor memory technology that is simple to implement with PCIe and NVMe protocols

2022

KIOXIA Celebrates the 35th Anniversary of NAND Flash Memory

The invention of the disruptive technology has had a far-reaching impact—fundamentally changing how we work, live and play.

1987	"New ultra high density EPROM and flash EEPROM with NAND structure cell," presented at International Electron Devices Meeting, Washington, DC, 1987 (https://ieeexplore.ieee.org/document/1487443)
1992/1991	http://www.toshiba.co.jp/worldwide/about/history_chronology.html
1999	https://www.electronicsweekly.com/news/archived/resources-archived/toshiba-and-sandisk-form-gbit-flash-joint-venture-1999-10/
2000	http://www.toshiba.co.jp/about/press/2000_01/pr0602.htm
2001	http://www.toshiba.co.jp/about/press/2001_11/pr1202.htm
2004	http://www.toshiba.co.jp/about/press/2004_04/pr1301.htm
2005	https://www.global.toshiba/ww/news/corporate/2005/02/pr0802.html
2006	http://www.toshiba.co.jp/about/press/2006_08/pr0401.htm
2007	https://www.global.toshiba/ww/news/corporate/2007/04/pr1702.html http://www.toshiba.co.jp/about/press/2007_12/pr1001.htm "Bit Cost Scalable Technology with Punch and Plug Process for Ultra High Density Flash Memory," presented at IEEE Symposium on VLSI Technology, Kyoto, Japan, 2007 (https://ieeexplore.ieee.org/document/4339708)
2008	http://www.toshiba.co.jp/about/press/2008_12/pr1801.htm
2010	https://www.global.toshiba/ww/news/corporate/2010/06/pr1701.html
2011	http://www.toshiba.co.jp/about/press/2011_07/pr1201.htm
2012	http://www.toshiba.co.jp/about/press/2012_02/pr2301.htm "A 19nm 112.8mm2 64Gb Multi-Level Flash Memory with 400Mb/s/pin 1.8V Toggle Mode Interface" – presented at 2012 IEEE International Solid-State Circuits Conference, San Francisco, CA (https://ieeexplore.ieee.org/document/6177073) KIOXIA invented NAND flash 25 years ago
2013	https://www.businesswire.com/news/home/20130520006616/en/Toshiba-to-Start-Mass-Production-of-Next-Generation-NAND-Flash-Memory https://www.prnewswire.com/news-releases/toshiba-ships-samples-of-industrys-first-universal-flash-storage-devices-190309341.html
2014	https://www.global.toshiba/ww/news/corporate/2014/04/pr2301.html
2015	https://www.businesswire.com/news/home/20150803005552/en/Toshiba-Develops-Worlds-First-256Gb-48-layer-BiCS-FLASH%E2%84%A2 https://www.prnewswire.com/news-releases/toshiba-debuts-nand-flash-memory-products-for-embedded-applications-300163428.html https://about.kioxia.com/en-jp/news/2015/20150806-1.html
2016	https://www.global.toshiba/ww/news/corporate/2016/07/pr2701.html
2017	https://business.kioxia.com/en-us/news/2017/memory-20170224-1.html https://business.kioxia.com/en-us/news/2017/memory-20170627-1.html
2018	https://business.kioxia.com/en-us/news/2018/ssd-20180320-1.html https://business.kioxia.com/en-us/news/2018/memory-20180719-1.html XL-FLASH introduced during a presentation at Flash Memory Summit 2018 https://www.businesswire.com/news/home/20180806005714/en/Toshiba-Memory-Corporation-Develops-Ethernet-Attached-Native-NVMe-oF%E2%84%A2-SSD-Prototype
2019	https://business.kioxia.com/en-us/news/2019/memory-20190122-1.html https://business.kioxia.com/en-us/news/2019/memory-20190805-1.html https://www.businesswire.com/news/home/20191114005198/en/KIOXIA-America-Introduces-Industry%E2%80%99s-First-512GB-Automotive-UFS
2020	https://about.kioxia.com/en-us/news/2020/20201209-1.html https://business.kioxia.com/en-us/news/2020/memory-20200225-1.html https://business.kioxia.com/en-jp/news/2020/20200131-1.html https://business.kioxia.com/en-us/news/2020/ssd-20200220-1.html
2021	https://business.kioxia.com/en-us/news/2021/memory-030221-1.html https://business.kioxia.com/en-us/news/2021/20210219-1.html https://www.businesswire.com/news/home/20210825005582/en/JEDEC-publishes-XFM-Embedded-and-Removable-Memory-Device-Standard-to-Expand-Storage-Solutions-in-Embedded-and-Automotive-Applications

KIOXIA

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NVM Express, NVMe and NVMe-oF are trademarks of NVM Express, Inc.

"Kubernetes is a registered trademark of The Linux Foundation in the US and/or other countries"

Universal Flash Storage (UFS) is a product category for a class of embedded memory products built to the JEDEC UFS standard specification

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In every mention of a KIOXIA product: Product density is identified based on the density of memory chip(s) within the Product, not the amount of memory capacity available for data storage by the end user. Consumer-usable capacity will be less due to overhead data areas, formatting, bad blocks, and other constraints, and may also vary based on the host device and application. For details, please refer to applicable product specifications. The definition of 1KB = 2^{10} bytes = 1,024 bytes. The definition of 1Gb = 2^{30} bits = 1,073,741,824 bits. The definition of 1GB = 2^{30} bytes = 1,073,741,824 bytes. 1Tb = 2^{40} bits = 1,099,511,627,776 bits.

In every mention of a KIOXIA product: Definition of capacity - KIOXIA Corporation defines a megabyte (MB) as 1,000,000 bytes, a gigabyte (GB) as 1,000,000,000 bytes and a terabyte (TB) as 1,000,000,000,000 bytes. A computer operating system, however, reports storage capacity using powers of 2 for the definition of 1Gb = 2^{30} bits = 1,073,741,824 bits, 1GB = 230 bytes = 1,073,741,824 bytes and 1TB = 2^{40} bytes = 1,099,511,627,776 bytes and therefore shows less storage capacity. Available storage capacity (including examples of various media files) will vary based on file size, formatting, settings, software and operating system, and/or pre-installed software applications, or media content. Actual formatted capacity may vary.