



MIT's Dudley Buck creates first semiconductor NVM from ferroelectric crystals

Bell Labs' Merz and Anderson create monolithic 256-bit FRAM ferroelectric NVM, the first monolithic memory chip

C.T. "Tom" Sah of Fairchild envisions floating gate NVM using charge storage on the gate electrode of a MOS tetrode transistor

Dov Frohman writes Berkeley PhD thesis "Charge Transport and Trapping in MNOS Structures and its Memory Applications" and builds a 9-bit prototype

Edgar A. Sack, Ting L. Chu and others of Westinghouse use a Metal-Nitride-Oxide-Silicon (MNOS) structure as a charge-trapping element

Dawon Kahng and Simon M. Sze invent the Non-Volatile Memory Floating Gate at Bell Labs; this is published as "A Floating Gate and Its Application to Memory Devices" (Bell System Technical Journal); Simon M. Sze went on to receive the 2014 FMS Lifetime Achievement Award

John R. Szedon and Ting L. Chu of Westinghouse propose using a charge trap as a nonvolatile memory bit at the IEEE Solid State Device Research Conference

Stanford R. Ovshinsky announces the Ovonic Memory Switch, the basis for 3D XPoint memory as later productized by Intel as Optane

Dov Frohman-Bentchkowsky invents the Erasable Programmable Read-Only Memory (EPROM) at Intel; this is presented at the 1971 IEEE ISSCC, and is published as "Memory Behavior in a Floating-Gate Avalanche-Injection MOS (FAMOS) Structure" in April 1971 (Applied Physics Letters), which cited the 1967 Kahng/Sze Bell Labs Floating Gate publication

After work with Stanford R. Ovshinsky, Intel's Gordon Moore co-authors article for Electronics Magazine on the first demonstration of Phase Change Memory (PCM), the NVM technique used by 3D XPoint as announced by Intel and Micron in 2015, and as later productized by Intel as Optane



Flash Memory Summit

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1972
Toshiba's Iizuka, Masuoka and others introduce first double-layered polysilicon memory cell (SAMOS) with Floating Gate electrical erase at International Conference on Solid State Devices and Materials

1974
General Instrument ships EAROM, the first commercial EEPROM

1975
Hitachi files patent for NAND-type MROM

1976
Hughes Microelectronics files Eli Harari patent for first practical floating gate EEPROM using thin SiO₂ and Fowler Nordheim tunneling for program and erase; Eli Harari went on to receive the 2012 FMS Lifetime Achievement Award

1977
Eli Harari of Hughes Microelectronics publishes "Conduction and Trapping of Electrons in Highly Stressed Thin Films of Thermal SiO₂" (Applied Physics Letters)
P.C.Y. Chen of Fairchild introduces SONOS charge trap NVM cell in IEEE Transactions on Electron Devices

1978
Eli Harari of Hughes Microelectronics publishes "Dielectric Breakdown in Electrically Stressed Thin Films of Thermal SiO₂" (Journal of Applied Physics)
Hughes Microelectronics introduces first CMOS NOVRAM 256-bit chip (non-volatile SRAM) employing Fowler Nordheim floating gate EEPROM at IEEE ISSCC
Intel's George Perlegos designs the 2816, the first commercially successful EEPROM; George Perlegos went on to receive the 2017 FMS Lifetime Achievement Award

1979
IEEE Solid State Circuits publishes paper titled "An Electrically Alterable Non-Volatile Memory Cell Using Floating Gate Structure" by Guterman, Rinawi, Chieu, Holvorson, and McElroy of Texas Instruments

1980
Hughes Microelectronics introduces the 3108, first CMOS EEPROM 8Kb chip employing Fowler Nordheim tunneling
Intel introduces the 2816, 16Kb HMOS EEPROM employing Fowler Nordheim tunneling
Fujitsu files patent with improvements to Hitachi's 1975 MROM
Hughes introduces 8K-bit EEPROM





Annual Revenue > \$ 1,600,000 \$ 6,400,000

<p>British scientist and inventor Kane Kramer designs first digital audio player (IXI) based on magnetic bubble memory chips</p>	<p>SEEQ Technology introduces the 5213, first EEPROM with on-chip charge pump for in-system write and erase, an invention used in all flash memory devices</p> <p>Ramtron introduces first commercial FRAM NVM</p>	<p>Intel introduces 2817A 16Kb EEPROM</p>	<p>First paper describing flash EEPROM presented by Fujio Masuoka of Toshiba at IEEE International Electron Devices Meeting (IEDM) in San Francisco; Fujio Masuoka went on to receive the 2013 FMS Lifetime Achievement Award</p> <p>Intel begins flash process development</p> <p>ATMEL (Advanced Technology for Memory and Logic) is founded by George Perlegos</p>	<p>Exel files patent for first NOR Flash cell</p>	<p>Flash card concept introduced with ECC and on-card controller by Intel</p> <p>Intel forms unit focusing on solid state drives</p> <p>RCA's VLSI Tech Symposium paper on first NAND-type EEPROM</p>	<p>Toshiba's Fujio Masuoka presents IEEE IEDM paper on NAND flash memory</p> <p>Intel introduces NOR flash chips</p>	<p>SunDisk founded to develop new "System Flash" architecture combining embedded controller, firmware and flash memory to emulate disk storage</p> <p>SunDisk files first two MLC (Multi-Level Cell) flash patents</p> <p>JPEG and MPEG standards allowing economical production of digital cameras are published</p> <p>Intel samples 1Mb NOR flash</p> <p>Intel and Psion design flash-based mobile PC</p> <p>First flash-based digital camera, Fuji DS-1P, demonstrated</p> <p>150mm wafers used</p>
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SunDisk files System Flash patent
 M-Systems founded and introduces Flash Disk concept (precursor to flash SSDs); M-Systems co-founders Dov Moran and Aryeh Mergi went on to receive 2018 FMS Lifetime Achievement Awards
 Intel ships 512Kb and 1Mb NOR flash
 Psion flash-based PC introduced
 Microsoft introduces Flash File System in joint effort with Intel
 DigiPro introduces 8MB NOR Flashdisk at Comdex
 Western Digital and SunDisk pioneer NOR-based SSD fully emulating ATA HDD
 Personal Computer Memory Card International Association (PCMCIA) founded
 Silicon Storage Technology (SST) founded to produce NOR SuperFlash, compatible with a CMOS logic process

Sony introduces EReader using flash memory
 Kodak flash-based camera prototypes shown
 NOR flash pricing in parity with DRAM pricing
 PCMCIA sets standard on ATA PC Card form factor and pinout, using SunDisk "System Flash" specification for full HDD compatibility
 Intel 1MB and 4MB linear flash PCMCIA cards introduced
 Intel introduces 2Mb NOR chip
 SunDisk introduces world's first NOR flash SSD: 20MB 2.5", fully compatible with Conner peripherals 2.5" ATA HDD

Toshiba develops world's first 4Mb NAND flash
 Kodak ships DCS-100, its first DCS at \$13,000
 Zenith, Poqet and HP palm-sized notebook computers using flash memory cards shown at Spring Comdex

Information Storage Devices introduces flash-based voice recorder chip
 AMD introduces its first NOR product
 Fujitsu introduces its first NOR product
 M-Systems introduces TrueFSS, the first flash memory card FTL; this was later adopted by the PCMCIA as its FTL
 Intel launches second-generation FFS2
 Intel introduces 8Mb flash chip and 4MB-20MB linear flash memory cards
 Intel introduces 1Mb "boot lock" NOR flash with sectors for BIOS applications—first use of internal write state machine to manage flash write algorithm
 SunDisk introduces first serial 9Mb NOR Flash chip for SSD applications
 PCs begin using flash for BIOS storage
 Toshiba ships first mass-produced NAND (4Mb)

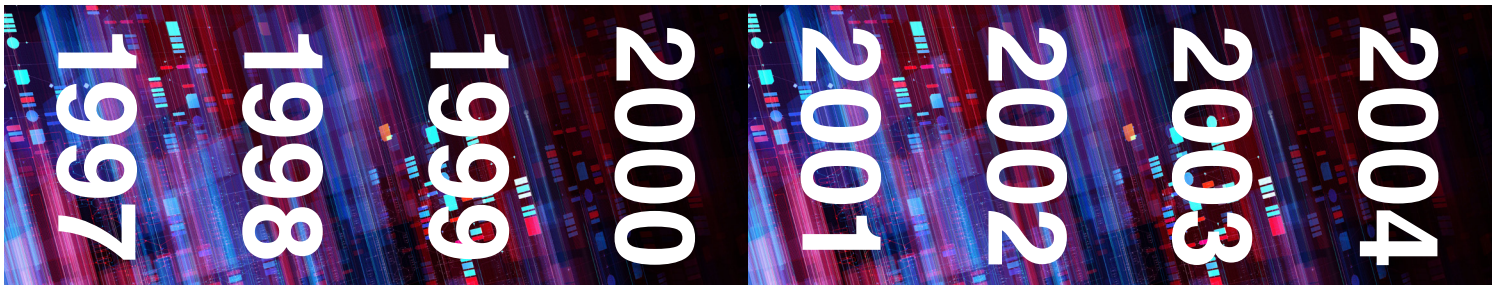
Datalight introduces "Card Trick" flash management software
 Apple introduces NOR flash-based Newton PDA
 Intel introduces 16Mb and 32Mb NOR flash
 Intel and Conner Peripherals introduce jointly-developed 5MB/10MB ATA flash disk drive
 AMD introduces 5-volt-only NOR using negative gate erase

SunDisk introduces CompactFlash card
 Norris Communications introduces Flashback, the first portable digital voice recorder with flash memory
 0.5 micron process announced
 SunDisk introduces 18Mb Serial NOR flash chip for SSD applications
 M-Systems introduces NOR-based DiskOnChip

Casio introduces the QV-11 digital camera with flash rather than film or floppy
 Mitsubishi introduces DiNOR
 SunDisk introduces 34Mb Serial NOR Flash—first MLC flash chip for SSD applications
 SunDisk changes name to SanDisk
 Flash (NOR and NAND) revenues exceed \$1B
 CompactFlash Association (CFA) founded

Toshiba introduces SmartMedia Memory Card (also called Solid State Floppy Disk Card)
 Samsung starts shipping NAND flash
 Kodak DC-25 is first DSC with CompactFlash card
 Datalight introduces "FlashFX" flash management software supporting NOR and NAND in a single driver
 SanDisk introduces first flash cards with MLC serial NOR
 Palm introduces flash memory-based PDA
 0.35 micron process announced
 \$2.6B in flash memory revenues, 163,063% growth in 10 years
 Lexar Media spins off from Cirrus Logic
 USB Association (USB-A) founded





\$ 2,701,678,000 \$ 2,492,552,000 \$ 4,560,493,000 \$ 10,637,231,000 \$ 7,594,502,000 \$ 7,766,797,000 \$ 11,739,282,000 \$ 15,610,575,000

SaeHan Information Systems introduces flash-based MPMan MP3 player

Sandisk and Siemens introduce MultiMedia Card (MMC and MMCplus)

Sony introduces the Memory Stick

First cell phones ship with flash memory

M-Systems introduces NAND-based DiskOnChip

200mm wafers begin production

500 million flash chips ship

Intel introduces 2-bit/cell 64Mb MLC StrataFlash

MultiMediaCard (MMC) unveiled by SanDisk and Siemens

250nm process announced

NOR revenues exceed \$2B

SaeHan Information Systems and licensee Eiger ship world's first mass-produced MP3 player (MPMan) with 32MB

Diamond Rio introduces PMP300 MP3 player

Panasonic, SanDisk and Toshiba launch SD card

MultiMediaCard Association (MMCA) founded by 14 companies

Toshiba and SanDisk create flash memory manufacturing joint venture

Micron announces NOR products

Over one billion flash chips ship

Dov Moran of M-Systems applies for patent on USB-based flash drive

NOR revenues exceed \$4B

Lexar Media introduces CompactFlash-to-USB JumpSHOT

M-Systems (working with IBM) and Trek Technology introduce USB flash drives

Intel ships its one-billionth flash unit

160nm process announced

Flash (NOR and NAND) revenues exceed \$10B

SD Card Association founded

Toshiba and SanDisk announce 1Gb MLC NAND

SanDisk introduces first NAND System Flash product

Hitachi introduces AG-AND

Samsung begins mass production of 512Mb flash memory device

NAND revenues exceed \$1B

Saifun develops NROM with charge trap flash structure, the basis for Spansion's MirrorBit

Olympus and Fujifilm introduce xD-Picture Card

MMCmobile card introduced by MMCA (MultiMediaCard Association)

Sony and SanDisk jointly introduce the Memory Stick PRO and half-size Memory Stick PRO Duo cards

M-Systems introduces Mobile DiskOnChip, the first SSD in a chip; this was used in handsets by Nokia, Motorola and Ericsson

AMD introduces MirrorBit using hot electron injection-based charge trap flash

Cypress introduces Programmable System on Chip (PSoC) with first embedded SONOS using quantum mechanical tunneling-based charge trap flash

130nm process announced

SanDisk introduces miniSD card

Sony and SanDisk jointly introduce Memory Stick PRO Micro

Spansion spins out of AMD and Fujitsu

NAND revenues exceed \$5B

Samsung introduces TaNOS structure at IEEE IEDM, a technology later used in 3D NAND

U3 software system for USB flash drives introduced by SanDisk and M-Systems

NAND prices drop below DRAM prices

SanDisk and Motorola introduce TransFlash card, now the microSD card

Datalight introduces multi-threaded "FlashFX Pro" management software to support multimedia NAND devices

Spansion announces MirrorBit Quad 4-bit NOR

90nm process announced

Hynix and ST Micro form flash joint venture

Hynix NAND product introduced

Infineon NAND product introduced based on Saifun Charge Trap Flash

Panasonic and Sanyo introduce first flash-based camcorders

SanDisk introduces Flash Sansa MP3 players

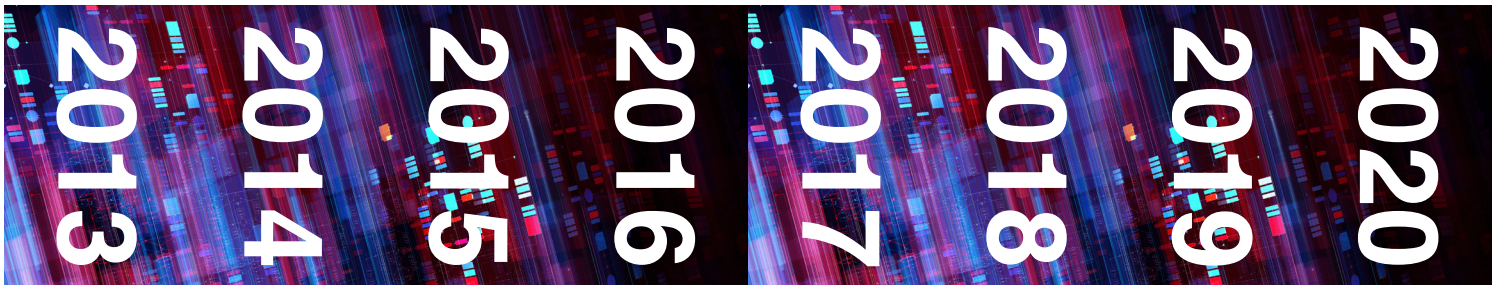
Freescall (later Everspin) ships first commercial MRAM NVM





\$ 18,568,940,000 \$ 20,076,313,000 \$ 22,182,405,000 \$ 18,435,970,000 \$ 19,302,693,000 \$ 26,734,247,000 \$ 28,123,615,000 \$ 28,213,759,000

<p>Apple introduces first two flash-based iPods, iPod shuffle and iPod nano</p> <p>Microsoft introduces Hybrid Hard Disk Drive concept</p> <p>MMCmicro card introduced by MMCA</p> <p>70nm process announced</p> <p>Micron introduces NAND product</p> <p>Over three billion flash chips ship</p> <p>NAND GB shipments overtake those of DRAM</p> <p>NAND revenues exceed \$10B</p>	<p>Intel introduces Robson Cache Memory (now called Turbo Memory)</p> <p>Microsoft introduces ReadyBoost</p> <p>SanDisk announces 3-bit MLC NAND technology</p> <p>M-Systems announces 4-bit MLC technology</p> <p>SanDisk announces microSDHC card</p> <p>SanDisk acquires Matrix Semiconductor</p> <p>SanDisk acquires M-Systems</p> <p>Samsung and Seagate demonstrate first Hybrid Hard Disk Drives</p> <p>IMFT formed by Intel and Micron to manufacture NAND flash</p> <p>STEC acquires Gnutech</p> <p>Spansion introduces ORNAND flash</p> <p>56nm process announced</p> <p>300mm wafers begin production</p> <p>Micron acquires Lexar Media</p> <p>Flash revenues exceed \$20B</p> <p>First Flash Memory Summit held in San Jose</p> <p>Open NAND Flash Interface (ONFI) V1.0 spec published</p> <p>Numonyx and Samsung introduce phase change NVM</p>	<p>Toshiba introduces eMMC NAND</p> <p>IMFT begins shipping 50nm NAND flash</p> <p>Toshiba introduces first MLC SATA-based SSD</p> <p>Apple introduces the iPhone</p> <p>Fusion-io announces 640GB ioDrive MLC NAND-based PCIe X4 board</p> <p>BITMICRO launches 3.5" SSD with capacity of 1.6TB (for military applications)</p> <p>Spansion acquires Saifun</p> <p>Several laptop MLC SSDs introduced with up to 128GB storage</p> <p>Dell introduces SSD option for laptop models</p> <p>Sub-\$200 netbook computers introduced with flash memory storage</p> <p>Microsoft introduces flash-based Zune Player</p> <p>NAND revenues exceed \$14.5B</p> <p>Flash revenues exceed \$22B, almost 9 times 1997 revenues</p> <p>Seagate announces Hybrid Storage Alliance</p> <p>Seagate introduces first hybrid HDD, the Momentus PSD</p> <p>MMCA/JEDEC e.MMC spec published</p>	<p>SanDisk introduces ABL to enable high speed MLC, TLC and X4 NAND</p> <p>34nm process announced by Intel and Micron</p> <p>Toshiba introduces first 512GB MLC SATA-based SSD</p> <p>Intel and STMicro spin off Numonyx</p> <p>IBM demos first "Million IOPS" array</p> <p>EMC announces use of flash-based SSDs for enterprise SAN applications</p> <p>Apple introduces MacBook Air</p> <p>Micron, Samsung and Sun Microsystems announce high-endurance flash memory</p> <p>Violin Memory introduces first fully flash-based storage appliance</p> <p>Samsung announces 150GB 2.5" MLC SSD with SATA II Interface</p> <p>Several companies announce MLC flash SSDs with up to 256GB for notebook apps</p> <p>Micron introduces first serial NAND flash</p> <p>Toshiba develops 3D NAND structure, BiCS</p> <p>Apple sells one million flash-based iPhones in 3 days</p> <p>MMCA merges into JEDEC</p> <p>SNIA Solid State Storage Initiative (SSSI) formed</p> <p>HGST releases first SSD with a SAS interface</p>	<p>Intel and Micron introduce 34nm TLC NAND</p> <p>Samsung introduces first full HD camcorder with 64GB SSD</p> <p>Seagate enters SSD market</p> <p>SandForce introduces first compression-based SSD controller</p> <p>Virident and Schooner introduce first flash-based application appliances for the data center</p> <p>Pillar Data converts Axiom SANs to SSD</p> <p>Pliant introduces first SAS SSD</p> <p>SanDisk and Toshiba present 4-bit/cell flash at IEEE ISSCC</p> <p>WD acquires SiliconSystems and gets into SSD business</p> <p>NVELO introduces first PC flash caching software "Dataplex"</p> <p>SanDisk introduces 100-year flash storage vault</p> <p>AgigA ships NAND-backed DIMM</p>	<p>Toshiba introduces 128GB SD card based on 16-chip stack</p> <p>Intel, Micron introduce 25nm TLC and MLC NAND</p> <p>Numonyx acquired by Micron</p> <p>Microchip acquires SST</p> <p>Samsung Electronics begins producing 64Gb 3-bit NAND</p> <p>Samsung Electronics introduces high-speed 512GB SSD utilizing toggle-mode DDR NAND memory</p> <p>Seagate announces first self-managed hybrid HDD, Momentus XT, with 4GB NAND flash and 500GB HDD storage</p> <p>Universal Flash Storage Association (UFSa) founded</p> <p>JEDEC publishes two specs for Solid-State Drives: "SSD Requirements and Endurance Test Method" and "SSD Endurance Workloads"</p>	<p>LSI acquires SandForce</p> <p>SanDisk acquires Pliant</p> <p>IMFT introduces 20nm NAND flash</p> <p>Intel announces Smart Response SSD caching for PCs</p> <p>Seagate announces second generation Momentus XT hybrid HDD with 8GB NAND flash and 750GB HDD storage</p> <p>Apple acquires Anobit</p> <p>Fusion-io acquires IO Turbine</p> <p>NVM Express organization established and NVMe Rev. 1.0 published</p> <p>Richard Pashley, Stefan Lai, Bruce McCormick and Niles Kynett formerly of Intel receive FMS Lifetime Achievement Awards</p> <p>JEDEC publishes first Universal Flash Storage (UFS) spec</p> <p>LSI acquires SandForce</p>	<p>SanDisk and Toshiba announce 19nm process in 128Gb chips</p> <p>Ultrabooks begin to ship with Smart Response SSD cache</p> <p>Macronix and Winbond enter NAND business</p> <p>Seagate introduces SSHD, combining flash and HDD</p> <p>Elpida introduces ReRAM</p> <p>Micron and Intel introduce 20nm 128Gb NAND chip using hi-k planar cell</p> <p>SK hynix formed upon SK Telecom's acquisition of controlling interest in Hynix Semiconductor</p> <p>MOSAID samples 333GB/s HL-NAND</p> <p>Adesto acquires ATMEL's Serial NOR business</p> <p>Spansion introduces 8Gb NOR chip</p> <p>DensBits Technologies introduces Memory Modem</p> <p>Proximal Data introduces AutoCache</p> <p>SanDisk acquires FlashSoft</p> <p>EMC acquires XtremIO</p> <p>OCZ acquires Sanrad</p> <p>Samsung acquires NVELO</p> <p>Intel acquires Nexev and introduces CacheWorks</p> <p>LSI introduces Nytro flash with MegaRAID CacheCade caching software</p> <p>Micron introduces 2.5" PCIe enterprise SSD</p> <p>IBM acquires Texas Memory Systems</p> <p>Cypress Semiconductor acquires Ramtron</p> <p>Western Digital acquires HGST</p> <p>Skyera launches 44TB flash array</p> <p>JEDEC and ONFI introduce toggle mode</p> <p>SanDisk founder Eli Harari receives FMS Lifetime Achievement Award</p>
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\$ 29,797,262,000 \$ 30,236,484,000 \$ 31,053,183,000 \$ 33,423,128,000 \$ 49,727,000,000 \$ 56,227,000,000 \$ 41,141,000,000 \$ 51,000,000,000 (est)

2013	2014	2015	2016	2017	2018	2019	2020
<p>Samsung announces availability of 24-layer 3D V-NAND at FMS and demos it in a 1TB SSD</p> <p>Diablo Technologies announces Memory Channel Storage technology</p> <p>SMART Storage Systems incorporates Diablo Technologies designs into ULLtraDIMM</p> <p>SNIA NVDIMM SIG formed; many flash-based NVDIMM products introduced</p> <p>Western Digital and SanDisk introduce SSHD using iSSD combined with an SDD</p> <p>Toshiba introduces line of SSHDs</p> <p>Everspin Technologies announces shipments of STT MRAM</p> <p>Micron and others sample 16nm flash memory</p> <p>SanDisk releases CFast 2.0 professional video memory card</p> <p>M.2 PCIe interface formalized</p> <p>Western Digital acquires sTec, Virident, Velobit</p> <p>SanDisk acquires SMART Storage Systems</p> <p>NVMurance introduces software to extend flash endurance</p> <p>Micron acquires Elpida</p> <p>Intel introduces Intel Cache Acceleration Software</p> <p>First NVMe devices from Samsung and SanDisk</p> <p>Panasonic ships first commercial embedded ReRAM in an MCU</p> <p>Adesto ships Mavriq CBRAM: first commercial stand-alone ReRAM</p> <p>SNIA publishes NVM Programming Model V1.0</p> <p>Fujio Masuoka, formerly of Toshiba, receives FMS Lifetime Achievement Award</p>	<p>Samsung, SanDisk and Toshiba announce 3D NAND production facilities</p> <p>SanDisk introduces 4TB Enterprise SSD</p> <p>SanDisk announces 128GB microSD card, a 1000x increase in capacity on device's 10th anniversary</p> <p>IBM announces eXFlash DIMMs using SanDisk ULLtraDIMM's implementation of Diablo Memory-Channel Storage technology</p> <p>Samsung rolls out second generation 3D V-NAND with 32 layers</p> <p>Spansion introduces HyperFlash NOR with 333 MB/s HyperBus</p> <p>Toshiba acquires OCZ</p> <p>Everspin introduces and ramps production of ST-MRAM</p> <p>Samsung introduces 3-bit/cell 3D NAND SSDs</p> <p>Adesto ships one-millionth CBRAM</p> <p>SK hynix acquires Violin Memory's PCIe SSD business</p> <p>Seagate acquires LSI/Avago storage business</p> <p>SanDisk acquires Fusion-io</p> <p>HGST acquires Skyera</p> <p>Samsung acquires Proximal Data</p> <p>Simon Sze, formerly of Bell Labs, receives FMS Lifetime Achievement Award</p>	<p>SanDisk introduces InfiniFlash storage system</p> <p>Cypress Semiconductor acquires Spansion</p> <p>Toshiba, Samsung, and SanDisk announce 48-layer 3D NAND</p> <p>Intel and Micron announce 256Gb 3D NAND</p> <p>Samsung introduces first NVMe m.2 SSDs</p> <p>SanDisk introduces 200GB microSDXC UHS-1 card</p> <p>Cypress introduces 4MB serial FRAM</p> <p>Intel and Micron announce 3D XPoint Memory</p> <p>Intel announces 3D XPoint-based "Optane" DIMMs and SSDs</p> <p>Micron introduces device with CMOS Under 3D NAND Array (CUA)</p> <p>SanDisk introduces 200GB microSD card</p> <p>Mellanox and partners demonstrate pre-standard NVMe over Fabrics (NVMe-oF)</p> <p>Pure Storage has IPO</p> <p>JEDEC publishes first DDR4 NVDIMM-N Persistent Memory Module spec</p> <p>LightNVM and Open-Channel SSD support added to Linux kernel</p> <p>Flash Memory Summit's 10th Anniversary</p> <p>Bob Norman, formerly of SanDisk and Micron, receives FMS Lifetime Achievement Award</p>	<p>Micron, Intel, Toshiba, SanDisk and SK hynix ship 3D NAND</p> <p>XMC breaks ground on first China-owned NAND flash lab</p> <p>Micron introduces 768Gb 3D NAND</p> <p>Western Digital acquires SanDisk</p> <p>Everspin announces 256Mb MRAM chips</p> <p>IBM adapts TLC to PCM</p> <p>Samsung ships 48-layer 3D NAND</p> <p>NVMe-oF (NV Express over Fabrics) Rev. 1.0 published</p> <p>NVMe-oF products demonstrated by at least 12 vendors</p> <p>Toshiba introduces Through-Silicon Via (TSV) NAND</p> <p>Spin Transfer Technologies delivers fully functional ST-MRAM samples</p> <p>Micron launches Xccela Consortium</p> <p>Toshiba ships industry's first NVMe BGA "SSD on a chip"</p> <p>Western Digital demonstrates prototype of the world's first 1TB SDXC card</p> <p>Adesto launches CBRAM-based Moneta family of ReRAM</p> <p>SFF Committee becomes SNIA SFF Technology Affiliate</p> <p>Kinam Kim, President of System LSI / Semiconductor Business at Samsung, receives FMS Lifetime Achievement Award</p>	<p>Microchip ships its 75-billionth SST SuperFlash-based device</p> <p>SK hynix announces 72-layer 3D NAND</p> <p>Toshiba migrates all new SSDs to 64-layer BiCS FLASH TLC</p> <p>Intel ships Optane (3D XPoint) SSD</p> <p>Violin Memory goes private</p> <p>HPE acquires Nimble Storage and Simplivity</p> <p>Micron ships first string-stacked 3D NAND</p> <p>Samsung and Toshiba/WD announce 96-layer 3D NAND</p> <p>NGD Systems ships NVMe 24TB Computational Storage device</p> <p>Everspin samples 1Gb STT MRAM chip</p> <p>Global Foundries introduces embedded eMRAM</p> <p>Flash Memory market exceeds size of entire 1990 semiconductor market</p> <p>WD develops TLC on 64-layer 3D NAND</p> <p>JEDEC and SNIA win FMS Award for NVDIMM-N Standard</p> <p>ScaleFlux is first to deploy production-qualified Computational Storage</p> <p>2012 FMS Lifetime Achievement Awardee Eli Harari inducted into National Inventors Hall of Fame</p> <p>George Perlegos, formerly of Intel, SEEQ and ATMEL, receives FMS Lifetime Achievement Award</p>	<p>Cypress introduces 16Mb FRAMs</p> <p>Toshiba completes \$18B memory business sale</p> <p>Samsung launches high-speed Z-SSD</p> <p>Micron ships Enterprise SSD using QLC and 1Tb 3D NAND die</p> <p>Hyperstone introduces flash controllers with AI and Machine Learning</p> <p>Intel samples Optane (3D XPoint) DC Persistent Memory</p> <p>China's "Big Fund" Phase 2 targets over \$30B for semiconductor investments</p> <p>NVMe/TCP Transport Binding spec ratified by NVMe WG</p> <p>SNIA forms Computational Storage Technical Work Group (TWG)</p> <p>Gyr Falcon Technology ships AI accelerator incorporating first use of TSMC's eMRAM</p> <p>SNIA publishes Performance specs for Solid State Storage and for Real World Storage Workloads</p> <p>Dov Moran and Aryeh Mergi, M-Systems co-founders, receive FMS Lifetime Achievement Awards</p>	<p>NGD Systems ships industry's first scalable ASIC-based Computational Storage NVMe SSD</p> <p>Samsung announces commercial production of eMRAM on 28nm FD-SOI process</p> <p>Lightbits Labs ships industry's first commercial NVMe/TCP software-defined disaggregated storage solutions</p> <p>YMTC samples 32-layer "Xtacking" NAND</p> <p>Intel ships Optane (3D XPoint) memory on DIMMs</p> <p>Micron ships industry's first QLC enterprise SSDs</p> <p>Intel ships SSDs with both Optane (3D XPoint) and QLC NAND</p> <p>All major vendors ship or sample 96-Layer NAND</p> <p>All leading foundries produce embedded MRAM</p> <p>Trade tensions brew between US and China</p> <p>Open-Channel SSDs begin transition to NVMe Zoned Namespaces (ZNS)</p> <p>Computer Express Link (CXL) introduced, and Spec V1.1 published</p> <p>Eideticom ships first NVMe-based Computational Storage Processor</p> <p>SNIA publishes Key Value Storage API V1.0, and wins FMS Award</p> <p>Toshiba Memory becomes KIOXIA</p> <p>Sanjay Mehrotra of Micron, and formerly of Intel, SEEQ, IDT, ATMEL, SanDisk and WD, receives FMS Lifetime Achievement Award</p>	<p>WDC ships 112-layer BiCS 3D NAND as 512 Gbit TLC part</p> <p>KIOXIA ships first Automotive UFS at 512GB density</p> <p>Lightbits Labs ships first clustered, redundant, scale-out NVMe/TCP software solution</p> <p>Infinion acquires Cypress Semiconductor</p> <p>KIOXIA acquires LiteOn</p> <p>NVMe ZNS Command Set Spec V1.0 published</p> <p>NVMe Computational Storage Task Group formed</p> <p>Open Compute Project (OCP) publishes NVMe Cloud SSD Spec V1.0: first Cloud SSD reqs. spec</p> <p>JEDEC publishes first DDR4 NVDIMM-P Persistent Memory Module spec</p> <p>SNIA publishes specs for Native NVMe-oF and Cloud Data Mgmt. Interface (CDMI)</p> <p>KIOXIA ships first PCIe 4.0 Enterprise NVMe SSD</p>

