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Non-Volatile Memory Market – Global Industry Size, Share, Trends, Opportunity, and Forecast Segmented by Type (Traditional Non-volatile Memory (Flash Memory, EEPROM, SRAM, and EPROM) and Next Generation Non-volatile Memory (MRAM, FRAM, ReRAM, 3D-X Point, and Nano RAM)), End-user Industry (Consumer Electronics, Retail, IT and Telecom, and Healthcare), By Region, Competition 2018-2028.

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Abstracts

Global Non-Volatile Memory Market has valued at USD 82.93 Billion in 2022 and is anticipated to project robust growth in the forecast period with a CAGR of 12.03% through 2028. In the flourishing consumer electronics industry, users expect their devices to continually become more powerful, provide new functionality with incredible speed, and store more movies, pictures, and music. While flash enabled substantial innovation during the past few decades, a new generation of memory is required as flash hits technology roadblocks, preventing it from scaling much further. The adoption of flash memories in consumer electronics due to their low price and power consumption is significant for the market's growth. NVM is used in smartphones and wearable devices to enable more storage and faster memory access.

The increasing research activities in this space are also driving the market's growth. For instance, in March 2021, Infineon Technologies LLC announced the launch of second-generation non-volatile Static RAMs that are qualified for QML-Q and high-reliability industrial specifications to mainly support non-volatile code storage in harsh environments, including aerospace and industrial applications.

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Key Market Drivers

Mobile Devices and SSDs

Mobile devices and Solid-State Drives (SSDs) are two key drivers propelling the global non-volatile memory market into a period of significant growth and innovation. These technologies are intertwined, with non-volatile memory playing a central role in enhancing the performance and storage capabilities of both. Mobile devices, including smartphones and tablets, have become an integral part of modern life. The demand for these devices continues to surge as consumers seek enhanced connectivity, advanced features, and more processing power. Non-volatile memory, particularly NAND flash memory, is the foundation of storage in these devices. The ever-increasing storage capacities and fast read/write speeds of NAND flash memory enable users to store extensive amounts of data, including photos, videos, apps, and documents, while also facilitating smooth and responsive user experiences.

Furthermore, the smartphone market is witnessing the evolution of 5G technology, which is expected to revolutionize mobile connectivity. 5G enables faster data transfer rates and reduced latency, creating opportunities for more data-intensive applications and services. Non-volatile memory is essential in 5G-enabled devices as it enables quick access to large datasets required for high-speed data processing, such as augmented reality (AR), virtual reality (VR), and real-time AI applications.

Solid-State Drives (SSDs) have also become increasingly popular in both consumer and enterprise environments. The transition from traditional Hard Disk Drives (HDDs) to SSDs is primarily driven by the latter's superior performance, reliability, and energy efficiency. SSDs rely on various types of non-volatile memory, such as NAND flash, to store data. As businesses and consumers seek faster data access, reduced power consumption, and enhanced durability, SSD adoption continues to grow, further boosting the non-volatile memory market. Moreover, the gaming industry has witnessed a surge in SSD adoption due to their ability to reduce loading times and improve in-game performance. This trend is expected to continue as gaming consoles, PCs, and cloud gaming services prioritize speed and responsiveness. In conclusion, the global non-volatile memory market is greatly influenced by the widespread adoption of mobile devices and SSDs. These technologies are driving the development of increasingly advanced and efficient non-volatile memory solutions to meet the growing demands of consumers and businesses for faster data access, higher storage capacities, and improved energy efficiency. As these trends persist and technology evolves, the non-

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volatile memory market is set to continue its expansion, offering benefits to a wide range of industries and applications.

Rising Demand for Data Storage

The global non-volatile memory market is experiencing robust growth, primarily fueled by the ever-increasing demand for data storage across various sectors. This insatiable appetite for data is being driven by several converging trends, and non-volatile memory technologies are at the forefront of meeting these burgeoning storage needs. First and foremost, the digital transformation of businesses and the proliferation of consumer electronics have led to an exponential increase in data generation. From e-commerce transactions and social media interactions to sensor data from IoT devices, the volume of data being produced is unprecedented. Non-volatile memory solutions, such as NAND flash memory and 3D XPoint, are essential in storing this data efficiently and reliably.

Cloud computing is another major driver of data storage demand. Cloud service providers require vast data centers with high-capacity storage solutions to host and manage the data of individuals and organizations worldwide. Non-volatile memory technologies, including SSDs (Solid State Drives), have become the go-to choose for these data centers due to their speed, reliability, and lower power consumption compared to traditional hard disk drives (HDDs). Furthermore, the advent of 5G technology is poised to accelerate the demand for data storage. The faster data transfer speeds and reduced latency offered by 5G networks will encourage the development of data-intensive applications such as augmented reality (AR), virtual reality (VR), and autonomous vehicles. These applications rely on non-volatile memory to store and quickly access the vast amounts of data required for real-time processing.

Data security and regulatory compliance are also driving data storage requirements. Organizations are increasingly storing sensitive information, and they must adhere to strict data protection laws. Non-volatile memory plays a crucial role in data encryption and secure storage, making it indispensable for safeguarding critical data assets. Moreover, non-volatile memory manufacturers continue to innovate, increasing storage densities and reducing the cost per bit. This makes non-volatile memory solutions more accessible and affordable for a wide range of applications, further contributing to the growth of the global non-volatile memory market. In conclusion, the rising demand for data storage is an unstoppable force shaping the global non-volatile memory market. As our world becomes increasingly data-centric, the need for scalable, high-performance, and reliable non-volatile memory solutions will continue to grow, making this market a

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vital component of the digital age.

Artificial Intelligence and Machine Learning

Artificial Intelligence (AI) and Machine Learning (ML) are poised to play a pivotal role in driving the global non-volatile memory market to new heights. These transformative technologies are revolutionizing industries across the board, and their voracious appetite for data and need for rapid data access make non-volatile memory a critical component in their success. AI and ML algorithms require vast amounts of data for training and inference. Non-volatile memory solutions, such as NAND flash memory, SSDs, and emerging memory technologies like 3D XPoint, offer the speed and capacity needed to store and access these massive datasets efficiently. This is particularly crucial for deep learning, where neural networks with numerous layers demand extensive datasets for accurate modeling.

Furthermore, the low-latency characteristics of non-volatile memory are essential for AI and ML applications that require real-time or near-real-time processing. From autonomous vehicles to voice recognition systems, the ability to access data quickly is imperative for ensuring the seamless operation of AI-driven technologies. The scalability of non-volatile memory is another critical factor driving its adoption in AI and ML. As businesses and research institutions expand their AI and ML infrastructure, they require memory solutions that can scale with their growing data storage needs. Non-volatile memory can be easily integrated into existing data center architectures and can accommodate the increasing demand for data storage capacity.

Additionally, non-volatile memory technologies are being optimized for AI and ML workloads. Manufacturers are developing memory solutions that offer better endurance, power efficiency, and reliability to meet the specific requirements of AI accelerators and edge computing devices. In conclusion, AI and ML are at the forefront of technological innovation, and their influence on the global non-volatile memory market is undeniable. As AI and ML applications continue to proliferate in industries ranging from healthcare to finance and manufacturing, the demand for high-performance, low-latency, and scalable non-volatile memory solutions will only intensify. This symbiotic relationship between AI/ML and non-volatile memory is poised to drive innovation in both fields, with the memory industry adapting to meet the ever-evolving needs of artificial intelligence.

Key Market Challenges

Cost Constraints

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Cost constraints are a significant challenge that could potentially hamper the growth and development of the global non-volatile memory market. This challenge is multifaceted and impacts various aspects of the industry, from research and development to production and consumer adoption. Research and Development Costs: Developing new non-volatile memory technologies and improving existing ones requires substantial investments in research and development. Companies in the industry need to continually innovate to stay competitive and meet evolving market demands. High R&D costs can be a barrier for smaller players and startups, limiting the diversity of memory solutions in the market.

Manufacturing Costs: The manufacturing of non-volatile memory chips involves complex processes and expensive equipment. As technology advances and manufacturers strive to produce memory chips with higher capacities and faster speeds, the cost of building and maintaining fabrication facilities, also known as fabs, continues to rise. This cost is typically passed on to consumers, potentially limiting the affordability of advanced memory solutions. Economies of Scale: Achieving economies of scale is critical for cost-effective production. Smaller manufacturers may struggle to compete with larger, established companies that have the resources to produce memory chips in large volumes. This concentration of manufacturing power can lead to market dominance by a few players, potentially limiting competition and innovation.

Price Pressure: The non-volatile memory market is highly competitive, and consumers and businesses expect lower prices for higher-capacity memory solutions. Manufacturers often face pressure to reduce prices to remain competitive, which can impact profit margins and hinder their ability to invest in research and development. Consumer Adoption: The cost of non-volatile memory directly affects consumer adoption. In markets such as smartphones, consumers are price-sensitive, and the cost of memory components significantly impacts the overall price of devices. If memory prices remain high, it may slow down the adoption of devices with larger storage capacities.

Enterprise Solutions: In enterprise and data center environments, cost constraints can limit the deployment of high-capacity non-volatile memory solutions. Organizations may need to balance their storage needs with budget limitations, potentially delaying upgrades or expansion of their memory infrastructure. To address these cost constraints, the non-volatile memory industry must focus on improving manufacturing processes to reduce production costs and achieve better economies of scale. Additionally, continued innovation in memory technologies may lead to more cost-

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effective solutions in the long term. Strategic partnerships and collaborations among industry players can also help distribute costs and promote research and development efforts. In conclusion, while cost constraints pose challenges for the global non-volatile memory market, they also drive innovation and efficiency in the industry. Overcoming these challenges will require a combination of technological advancements, economies of scale, and market dynamics to ensure that non-volatile memory solutions remain accessible and affordable for a wide range of applications and consumers.

NAND Flash Scaling Limits

One of the significant challenges facing the global non-volatile memory market is the scaling limits of NAND flash memory technology. NAND flash has been the workhorse of the non-volatile memory market for many years, used extensively in various devices, from smartphones to data centers. However, as NAND flash approaches its physical scaling limits, it poses a potential roadblock to further advancement and expansion in the industry. The fundamental issue with NAND flash scaling is that as manufacturers attempt to shrink memory cells to increase storage density, several critical problems emerge Reduced Endurance: As NAND cells become smaller, they can endure fewer program/erase (P/E) cycles before wearing out. This reduced endurance can impact the reliability and lifespan of NAND flash-based devices, particularly in high-write-intensive applications like enterprise storage systems.

Increased Error Rates: Smaller NAND cells are more susceptible to errors caused by factors like electron tunneling and interference between adjacent cells. This leads to higher error rates, necessitating error correction mechanisms that can consume additional resources and power. Data Retention: Smaller NAND cells also tend to have shorter data retention times. This means that data stored in these cells may degrade more quickly, which is problematic for applications requiring long-term data storage. Complex Manufacturing Processes: Shrinking NAND flash cells requires increasingly complex manufacturing processes, leading to higher production costs and potential manufacturing challenges.

To address these issues, manufacturers have explored various techniques, such as multi-level cell (MLC), triple-level cell (TLC), and quad-level cell (QLC) NAND flash, to increase storage density while maintaining reasonable performance and endurance. However, these solutions come with trade-offs in terms of performance and reliability. To mitigate these scaling challenges, the industry has also been actively exploring alternative non-volatile memory technologies like 3D XPoint, resistive RAM (ReRAM), and magnetoresistive RAM (MRAM). These technologies offer advantages in terms of

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scalability, endurance, and performance but face their own set of development and adoption challenges.

In conclusion, while NAND flash memory has been a stalwart in the non-volatile memory market, its scaling limits pose significant obstacles to meeting the growing demand for higher-capacity and faster storage solutions. The industry's ability to address these scaling limitations and transition to alternative memory technologies will be critical in shaping the future of non-volatile memory and ensuring its continued growth and relevance in an increasingly data-driven world.

Key Market Trends

Emerging Memory Technologies

Emerging memory technologies are poised to be a driving force in shaping the future of the global non-volatile memory market. These innovative memory solutions, which go beyond traditional NAND flash, offer a range of advantages that address critical limitations and meet the evolving demands of various industries and applications. One of the most notable emerging memory technologies is 3D XPoint, developed by Intel and Micron under the Optane brand. 3D XPoint is often referred to as storage class memory (SCM) due to its unique characteristics. It combines the speed and endurance of traditional DRAM with the non-volatile nature of NAND flash, bridging the gap between volatile and non-volatile memory. This technology is poised to revolutionize data storage and processing in multiple ways, High Performance: 3D XPoint offers significantly faster data access speeds than NAND flash, making it well-suited for high-performance computing applications, real-time analytics, and AI/ML workloads that require rapid data processing.

High Endurance: Unlike NAND flash, 3D XPoint does not degrade as quickly with repeated write cycles, ensuring a longer lifespan and better reliability. This characteristic is critical for enterprise and data center applications. Low Latency: Low-latency data access is essential for applications like in-memory databases and edge computing. 3D XPoint provides near-DRAM levels of latency, improving overall system performance. Another emerging memory technology is resistive RAM (ReRAM), which leverages resistive switching materials to store data. ReRAM promises advantages such as low power consumption, fast write speeds, and scalability. It has potential applications in IoT devices, neuromorphic computing, and storage-class memory solutions.

Phase-change memory (PCM) is another noteworthy technology that utilizes the

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reversible phase transition of materials to store data. PCM offers high data retention, low power consumption, and resistance to extreme temperatures, making it suitable for automotive electronics, aerospace applications, and IoT sensors. In the context of the global non-volatile memory market, these emerging memory technologies are diversifying the landscape and driving innovation. They cater to the demand for faster, more reliable, and energy-efficient memory solutions across industries like data centers, AI, IoT, and automotive. As manufacturers refine these technologies, improve production processes, and scale up manufacturing, they are likely to become more cost-competitive, further accelerating their adoption. In conclusion, emerging memory technologies such as 3D XPoint, ReRAM, and PCM are at the forefront of non-volatile memory innovation. They are reshaping the market by addressing the limitations of traditional NAND flash and providing tailored solutions for a wide range of applications. As industries continue to prioritize performance, endurance, and efficiency, these technologies are poised to play a pivotal role in the global non-volatile memory market's growth and evolution.

AI and Machine Learning Integration

The integration of Artificial Intelligence (AI) and Machine Learning (ML) technologies is a compelling force propelling the global non-volatile memory market into a new era of growth and innovation. These transformative technologies are profoundly data-driven, relying on rapid data access and storage, making non-volatile memory a pivotal component in their advancement. AI and ML algorithms are voracious consumers of data. They require massive datasets for training and real-time data access for inference, making high-performance, low-latency storage solutions a critical necessity. Non-volatile memory, such as NAND flash memory and emerging technologies like 3D XPoint, excels in meeting these demands by providing fast and reliable data storage and retrieval capabilities.

Key factors driving the synergy between AI/ML and non-volatile memory include, Data-Intensive Workloads: AI and ML applications, ranging from natural language processing to computer vision, generate and process vast amounts of data. Non-volatile memory technologies excel in storing and managing these massive datasets, ensuring that AI models have access to the information they need for accurate predictions and decisions.

Real-Time Processing: AI and ML often require real-time or near-real-time processing, such as autonomous vehicles making split-second decisions or speech recognition systems responding to user commands. Non-volatile memory's low-latency

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characteristics enable quick data access, facilitating the rapid response times necessary for these applications. Edge Computing: As AI moves toward the edge of the network, closer to IoT devices and sensors, non-volatile memory becomes essential for local data storage and processing. This edge computing paradigm requires memory solutions that can operate efficiently in resource-constrained environments.

Energy Efficiency: AI and ML applications in mobile devices and IoT gadgets demand energy-efficient storage solutions. Non-volatile memory technologies are known for their lower power consumption compared to traditional hard drives, contributing to longer battery life in mobile devices and extending the operational life of IoT devices. Scaling Opportunities: The scalability of non-volatile memory aligns with the growth of AI/ML workloads. Organizations can easily expand their memory infrastructure to accommodate the increasing volume of data generated and analyzed by AI systems. Advanced Memory Architectures: Memory manufacturers are developing memory solutions optimized for AI and ML, with features such as improved endurance, reliability, and performance. These technologies are tailored to meet the specific demands of AI workloads.

In conclusion, AI and Machine Learning are at the forefront of technological innovation, and their deep integration with non-volatile memory technologies is driving the global non-volatile memory market to new heights. As AI/ML applications continue to proliferate across industries, the demand for high-speed, low-latency, and scalable non-volatile memory solutions will remain strong, fostering ongoing collaboration and innovation between these two transformative fields. The resulting advancements will further empower AI/ML-driven applications and shape the future of computing.

Segmental Insights

Type Insights

Flash Memory segment is expected to dominate the market during the forecast period. The growing demand and penetration of consumer electronics led to device flash memory applications. This memory type finds applications in laptops, GPS, electronic musical instruments, digital cameras, cell phones, and many others. Additionally, it is extensively adopted by data center solution vendors. With exponential growth in the adoption of cloud solutions, the demand for data centers is also surging.

Further, with increasing propensity toward AI/ML applications and IoT devices that require high low latency and high throughput cloud storage, flash storage and enterprise

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data centers are optimized to train deep neural networks. The growing number and size of data centers are expected to augment demand further.

To cater to the growing demand, vendors operating in the market focus on developing new solutions with better capabilities. For instance, in February 2021, Kioxia Corporation and Western Digital Corp. announced the development of a sixth-generation, 162-layer 3D flash memory technology. This was the company's highest density and most advanced 3D flash memory technology that utilizes many technology and manufacturing innovations.

Regional Insights

Asia Pacific is expected to dominate the market during the forecast period. The construction of new infrastructure, including data centers, has been growing across various countries of the Asia Pacific region, owing to a surge in demand for online entertainment, telecommuting, and video and voice call services. With the fast development of the digital economy, building large, big data centers in countries such as China and India is becoming necessary.

China has emerged as the leading country owing to its aggressive approach to the NAND memory business. For instance, Yangtze Memory Technologies Co. Ltd (YMTC), one of China's major memory companies, had shipped 64 layers of NAND domestically in low volumes, including SSDs, with 128-layer production in development and shipments in 2021.

Key Market Players

ROHM Co. Ltd

STMicroelectronics NV

Maxim Integrated Products Inc.

Fujitsu Ltd

Intel Corporation

Honeywell International Inc.

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Micron technologies Inc.

Samsung Electronics Co. Ltd

Crossbar Inc.

Infineon Technologies AG

Report Scope:

In this report, the Global Non-Volatile Memory Market has been segmented into the following categories, in addition to the industry trends which have also been detailed below:

Global Non-Volatile Memory Market, By Type:

Traditional Non-volatile Memory

Next-generation Non-volatile Memory

Global Non-Volatile Memory Market, By End-user Industry:

Consumer Electronics

Retail

IT and Telecom

Healthcare

Other

Global Non-Volatile Memory Market, By Region:

North America

United States

Canada

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Mexico

Asia-Pacific

China

India

Japan

South Korea

Indonesia

Europe

Germany

United Kingdom

France

Russia

Spain

South America

Brazil

Argentina

Middle East & Africa

Saudi Arabia

South Africa

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Egypt

UAE

Israel

Competitive Landscape

Company Profiles: Detailed analysis of the major companies present in the Global Non-Volatile Memory Market.

Available Customizations:

Global Non-Volatile Memory Market report with the given market data, Tech Sci Research offers customizations according to a company's specific needs. The following customization options are available for the report:

Company Information

Detailed analysis and profiling of additional market players (up to five).

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