Weebit Nano Ltd – Update Report

23.09.2021

Weebit signed first commercial deal to take its ReRAM technology to volume production with SkyWater and deepens its licensing with Leti, after achieving significant R&D milestones earlier this year; Price target remains unchanged at AUD 3.9.

Stock Exchange
ASX

Symbol
WBT

Sector
Technology

Sub-sector
Semiconductors

Stock price target
AUD$3.9

Closing price
AUD$2.9

Market cap
AUD$348.3 Million

No. of shares
123.9 Million

Average daily trading volume
778,068 stocks

Stock Performance (Since Jan. 2021)
+15.23%

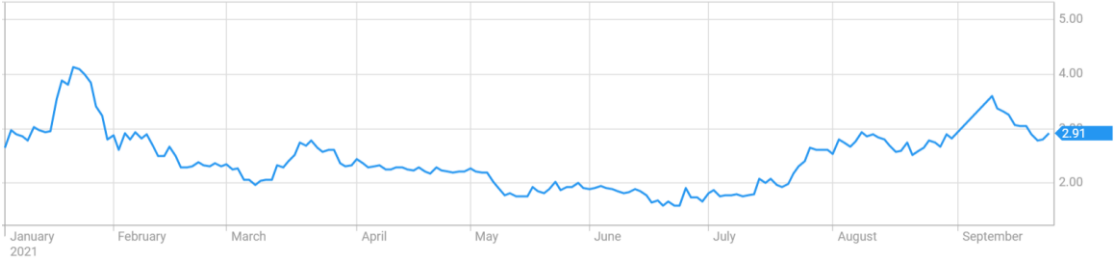
Weebit Nano Ltd. is a leader in the development of next-generation memory technology. Operating since 2015, Weebit addresses the growing need for data storage and embedded non-volatile memory (NVM) technology with its new resistive random-access-memory (ReRAM) technology.

Recent highlights:

- **Weebit signed first commercial deal to take its ReRAM technology to volume production with SkyWater.** The companies will collaborate to transfer Weebit's ReRAM technology to SkyWater's production fab and qualify it for volume manufacturing. Then, SkyWater intends to offer it to customers as embedded NVM IP on the company's 130nm CMOS process. We expect full commercialization starting in early 2023 through mutual collaboration. **We believe that SkyWater's unique access to the US aerospace & defense industry, along with its customized manufacturing capabilities, are ideal for facilitating Weebit's growth.**
- **A new agreement with CEA-Leti extends the partnership scope with enhanced technologies & IP, expected to further enhance Weebit's ReRAM technology performance (such as endurance, retention, and robustness).** This could position Weebit's technology at the forefront of the NVM industry and broaden its commercialization opportunities in industries such as automotive, which require high-temperature performance.
- **Demonstrated successful integration of selector with ReRAM cell for the stand-alone memory market**
- **Completed design and tape-out of embedded ReRAM module**

The NVM market is expected to reach around US$88 billion by 2025, with a steady growth rate of 10.6%. In April 2021, **Biden announced a $50 billion plan to invest in chips;** TSMC announced spending $100 billion to expand its chip fabrication capacity over the next three years.

Year	Revenues (000 US$)
2022E	1,000
2023E	4,000
2024E	10,000



*Conversion rates may change

Key points Regarding the SkyWater deal:

- As part of the mentioned licensing deal, SkyWater will pay Weebit upfront license fees and royalties.
- This deal opens the door to multiple additional agreements with chip companies interested to use Weebit technology in their designs, to be manufactured by SkyWater. Such deals would incur additional license fees and NREs payable to Weebit.
- This deal also opens the door to many other arrangements with other fabs and IDMs, as this serves as a strong endorsement by a unique fab with a high-profile R&D center.
- The deal allows SkyWater to further scale the usage of Weebit ReRAM technology into other unique processes they have, including SkyWater's 90nm and carbon nanotube platforms.
- SkyWater is a US-based US-owned fab that is getting significant support from the US government as part of the Biden administration drive for local semiconductor manufacturing. Given current tension between nations, and the ongoing disruption in shipments of materials/tools/equipment/chips/products, their position is unique. SkyWater serves multiple customers, including A&D, automotive, IoT, AI, medical, and consumer applications. We believe that that the opportunities SkyWater bring are significant and ideal for Weebit's growth.

We also note that on June 25, 2021, the company announced it had created the industry's first commercial integration of a ReRAM cell with an OTS selector. We see this achievement as a significant step towards broadening the company's target market beyond embedded non-volatile memory to include discrete memory technology (stand-alone ReRAM chips) and will enable the implementation of 3D memory stacking and crossbar architectures in future developments. This milestone signifies that OTS and ReRAM can be merged together to form the smallest and fastest ReRAM array, enabling access to a huge market opportunity for the company's technology.

We view the abovementioned events as significant to the company's progress toward mass commercialization and achieving its strategic goals. We believe that the mentioned achievements will increase its customers' confidence in its vision, technology, and product development capabilities.

For additional information on the company and its market, please read our previously published coverage reports.

Executive Summary

Investment Thesis

Weebit Nano Ltd. is an Israeli company that is publicly traded on the Australian Securities Exchange (ASX: WBT). Weebit's vision is to disrupt the memory industry by replacing the reigning flash memory technology with faster, more reliable, and energy-efficient non-volatile memory (NVM) technology that is ideal for embedded applications. The company is revolutionizing NVM through resistive RAM (ReRAM) technology, in collaboration with CEA-Leti, a French research institute, after receiving licensing patents from Rice University in the United States.

The Global Emerging Memory Technologies Market

Size[i]

- The NVM market is expected to reach around US$88 billion by 2025, with a steady growth rate of 10.6%.
- Embedded memory:
  - The AI chipset market is expected to enjoy a rapid growth rate of 31.7% from 2020 to 2025.
  - Sales of multi-core system-on-chips (SoCs) are growing at a steady rate of 17.3% per year. Around US$45 billion is contributed by the mobile and automobile SoC market.
  - In 2019, 24 billion Internet of Things (IoT) devices were in service. According to Frost & Sullivan's analysis, there will be 58 billion IoT devices in service worldwide by 2026, with a growth rate of 15.5%.[ii]
- Discrete and persistent memory is expected to accelerate, with a growth rate of 11.8% from 2021 to 2025. Persistent memory is a type of non-volatile memory with performance equivalent to DRAM (dynamic RAM). Persistent Memory is introduced between DRAM, the primary storage and flash/disk, the secondary storage and acts like a high capacity cache memory capable of boosting the system performance significantly.

Current Challenges

- Cost-effectiveness—The key challenge for ReRAM companies lies in maintaining the competitive pricing of their memory modules' in comparison to other NVM technologies.

- Optimized Storage Capacity and Density—Achieving storage density and capacity optimization is important before integrating into a product design. The amount of available memory in a device is critical for its use with AI and IoT applications.
- The Competitive Landscape of Emerging New Technologies—NVM is a highly competitive market, with new technologies such as MRAM gaining momentum.

Weebit's Opportunities

- As a crucial element of edge AI chips, memory must have a small geometry while storing more data; ReRAM represents an ideal answer to this challenge, especially given its low-power consumption nature.
- Weebit's ReRAM offers a perfect memory alternative in SoCs as, unlike flash, it can scale to fit smaller geometries.
- IoT represents an excellent market opportunity for Weebit's ReRAM. IoT and other connected devices can be embedded with ReRAM because of its low power consumption and 10-year retention, even at high temperatures, which is a requirement for IoT field deployment.
- Various components of the wireless communication infrastructure of 5G, such as 5G chipsets, can use ReRAM as their embedded memory.
- Weebit's cost-effective back end of line (BEOL) solution, requiring only two added masks and no special fab equipment, is a good target for many cost-sensitive analog integrated circuits for smartphones, consumer electronics, industrial applications, and more.

Weebit's Value Offering

- Key application areas—Weebit focuses on three key areas—embedded, discrete, and neuromorphic computing—to commercialize its ReRAM technology.
- Technological advantages—Weebit's ReRAM is scalable to low geometries, offers high-temperature reliability, provides manufacturing flexibility, and enables a higher number of program and erase cycles than flash and other NVM technologies. The company has successfully demonstrated working 1 megabit (Mbit) arrays at 40 nanometers. The company has also demonstrated 10-year retention at 150°C, which opens opportunities for automotive and industrial applications.

- Cost-effective—The production cost of Weebit's ReRAM modules is lower than that of other NVMs owing to several disruptive features of its ReRAM technology, making the entire process fab compatible; its need for only limited masks; and the minimal number of steps incorporated in its fabrication process. As a result, the ReRAM technology can be considered a cost-effective memory solution compared to other NVM technologies.
- Strategy and business model—The company is adopting two licensing strategies. The flexibility of these business models can be leveraged by various electronic device original equipment manufacturers (OEMs) to incorporate Weebit's ReRAM in their product designs.

The memory industry is expanding exponentially, with the demand for high-speed and energy-efficient memory on the rise. While flash storage is the most prevalent technology, limitations related to factors such as scalability, endurance, and retention are opening an opportunity for emerging NVM technologies. Due to Weebit's positioning and technological solutions, we believe that the company will play a vital role in the growing NVM market, making it an excellent investment opportunity. However, because Weebit, like many technology firms, is still in the scale-up phase, with a proven technology but limited sales, its current challenge involves finalizing the qualification of its NVM ReRaM towards mass production of its products.

1. Company overview

Weebit Nano Ltd. (ASX: WBT), hereafter "the Company" or "Weebit," is an Israeli company publicly traded on the Australian Securities Exchange. Weebit's vision is to disrupt the computer memory industry by replacing the reigning flash memory technology with a faster, more reliable, and energy-efficient non-volatile memory (NVM) technology ideal for embedded applications. The Company is revolutionizing NVM through resistive RAM (ReRAM) technology, in collaboration with CEA-Leti, a French research institute specializing in electronics and information technologies, after licensing patents from US-based Rice University. The company operates out of its HQ in Hod Hasharon, Israel.

Weebit focuses on three key application areas to commercialize its ReRAM technology, with embedded applications being the prime focus in the near term. The company is developing a memory module that can be embedded within a system on chip (SoC) or a sensor.

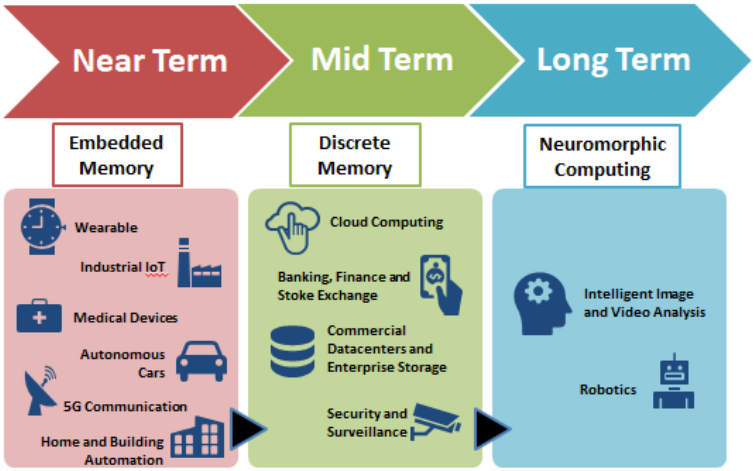


Fig 1: Application Landscape of ReRAM Technology

Flash memory has dominated the NVM industry because of its ease of use in various applications, ranging from smartphones to data centers. As a result, any new NVM technology faces stiff competition from flash memory. To prevail in the NVM storage's competitive landscape, Weebit Nano immediately realized that the fastest path to generating revenue is by investing in embedded applications. Initial adoption of ReRAM technology will be across embedded applications such as wearables, medical implants, and home and industrial automation. The company also realized the potential of ReRAM in emerging applications, such as 5G, AI, Big Data, and IoT, where flash storage cannot be deployed because of its scalability and power efficiency limitations.

Moreover, Weebit's ReRAM memory modules could make steady inroads into flash dominated discrete memory sector. The NOR flash memory cannot be stacked in three dimensions unlike NAND flash or ReRAM paving way for an opportunity for ReRAM to penetrate discrete memory sector. The ReRAM modules can be stacked in enterprise storage, cloud storage, and other commercial data centers used by hospitals, governmental bodies, and education institutes as data repositories. In the future, ReRAM can be used for brain-computer interface devices and advanced AI, making it a promising memory technology for neuromorphic computing.

Weebit realigned its vision by adjusting its offering based on the ever-changing memory industry's needs while strengthening its core technological offering, ReRAM, through constant research and indigenization.

Timeline

Weebit is aggressively pursuing its' primary goals for 2021, aiming to demonstrate the finished memory module and sign a commercial agreement. Transferring the technology into a production fab would be a significant milestone that will enable Weebit to productize the memory cell, followed by a memory module's qualification process. By the end of September 2021, Weebit will demonstrate the company's first selector-one resistor (1S1R) memory cell that integrates the ReRAM cell with a selector, thereby creating a platform for the development of discrete memory modules in the near future. Such a selector is a crucial entity of 3DXPoint technology co-developed by Intel and Micron. The company has underlined 2023 as the milestone year for its ReRAM technology to be embedded in a full-fledged product, with 2022 focusing on quality improvements and volume production.

Milestone	Significance	Timeline
Weebit will tape-out its integrated memory module for embedded applications	**High**	**Achieved**
Weebit will demonstrate its first 1S1R memory cell that integrates the ReRAM cell with a selector	**High**	**Achieved**
First commercial deal in the embedded market	**High**	**Achieved**
Quality improvements of 1S1R cells	**Medium**	**2022**
Successfully embedding its ReRAM technology in a full-fledged product	**High**	**2023**
Demonstration of its 1S1R array	**Medium**	**Q1-2022**

Products and Technology

One of the key limitations of flash storage and other NVM technologies is their inability to scale below 28 nanometers (nm). In contrast, ReRAM has no problem going beyond 20 nm. With the future of semiconductor chipsets moving toward miniaturization, ReRAM's ability to fit within the smallest geometry could be disruptive. Moreover, while 3D NAND technology has provided a great reprieve for secondary storage devices, such as solid-state drives (SSDs), it is not feasible for embedded storage, thus making ReRAM an interesting proposition for applications relying on embedded NVM.

Unlike the traditional memory, where the data is stored in the form of an electrical charge, ReRAM technology leverages special resistive material sandwiched between two electrodes whose resistance is varied to record the binary data (0s and 1s) by applying an external voltage.

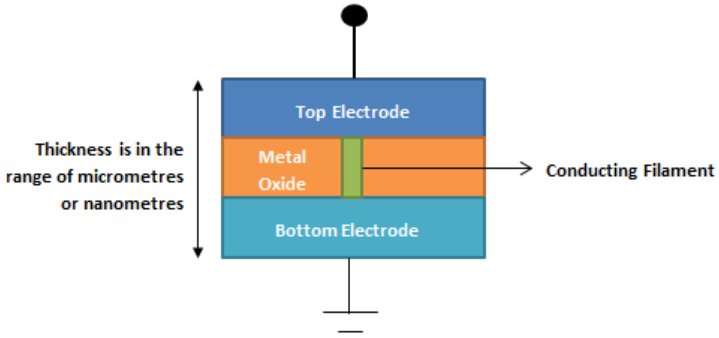
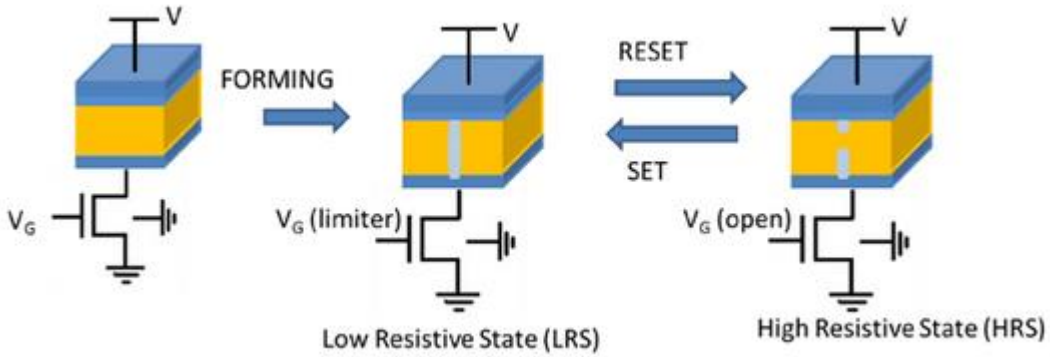


Fig 3: Schematic Representation of ReRAM cell

The ReRAM cell developed by Weebit comprises two metal layers separated by a layer of SiOx. On applying a positive voltage on the cell, a conductive filament is formed while the cell attains Low Resistive State (LRS). The filament is broken on applying negative voltage resulting in the cell attaining a High Resistive State (HRS). The transition from LRS to HRS and vice versa is used to store the data.



A key differentiator of Weebit's ReRAM technology that sets it apart from competing solutions is the use of SiOx, a standard fab-friendly materials used in fabrication of semiconductor chips unlike other ReRAM companies that rely on materials such as hafnium, praseodymium (Pr), manganese (Mn), Tantalum (TA), and tellurium (Te), which are uncommon in the semiconductor industry. SiOx has accelerated the company's product development phase while firmly placing Weebit in positioning to forge partnerships with global fabricators proficient in silicon, paving the way for a smooth technology transfer.

Weebit uses the standard tools and technology available in the semiconductor industry. To maintain this standardization, the company ensures that the devices and machines used in the cleanroom of Leti's in-house fabrication facility are common in any global fabrication facility. As a result, Weebit has successfully produced its memory cells on different process nodes associated with various fabrication facilities, thus providing an impetus to the company's goal of establishing a fabrication-friendly technology. Another key aspect of Weebit's ReRAM technology is its ease of integration into existing CMOS-fabricating facilities, which will significantly decrease the time to market and cost of production.

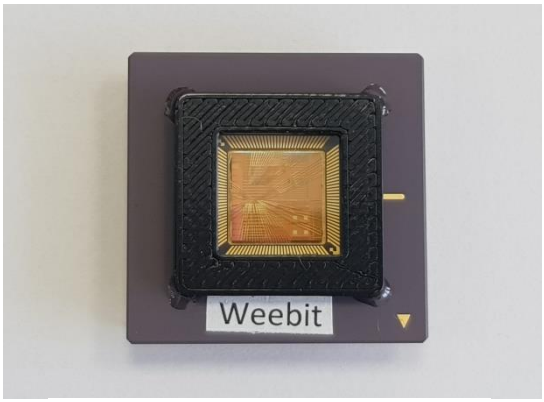


Fig 5: ReRAM Package
Image Source: Weebit Nano Ltd

Weebit has completed the stabilization process, which is an essential precursor for production. The uniformity through the cell and the die was validated as no changes were observed in the wafer characteristics. Moreover, the same level of endurance was observed across multiple wafers.

Additional Benefits of Weebit's ReRAM Technology include:

- **High Endurance:** The memory cell exhibits a very high endurance of one million cycles, unlike flash storage, which has a maximum endurance of few thousand cycles.
- **High Retention:** The memory cell can withstand high temperatures of up to 150 Celsius degrees, with data retention of 10 years.
- **Short Read/Write Time:** The time taken by the cell to read/write data is in the order of tens of nanoseconds, unlike flash, which offers a read/write time of few microseconds, thereby making ReRAM a high-speed memory.
- **Low Power Consumption:** The memory cell consumes around 0.1 Joule for writing one bit of data.

- **Scalability:** The ReRAM architecture could possibly be shrunk (full shrinking potential is still under research) to few nanometers of 20, 16, or 5, unlike flash, which doesn't shrink below 40 nm.
- **Futuristic Memory Technology:** The ReRAM architecture resembles biological synapses found in the human brain, making it an ideal starting point for the design of brain-inspired AI systems.

2. Emerging Memory Technologies Market Overview

The data storage industry is expanding exponentially, with the demand for high-speed and energy-efficient memory on the rise. Because of the revival of flash storage, major data storage participants, such as Samsung, Intel, Micron, Western Digital (WD), Toshiba, and SanDisk, are developing their own proprietary 3D NAND flash technology. As a result, the NVM industry has facilitated the growth of small and medium data storage companies focusing on emerging NVM technologies, such as MRAM, ReRAM, and FRAM. The semiconductor memory industry is pursuing research and development in the emerging NVM technologies to integrate notable features of conventional memory storage such as the high switching speed of static RAM, storage density equivalent to dynamic RAM, and non-volatile functionality of flash memory. The successful culmination of all the features mentioned above will result in an attractive NVM solution for computation-intensive workloads.

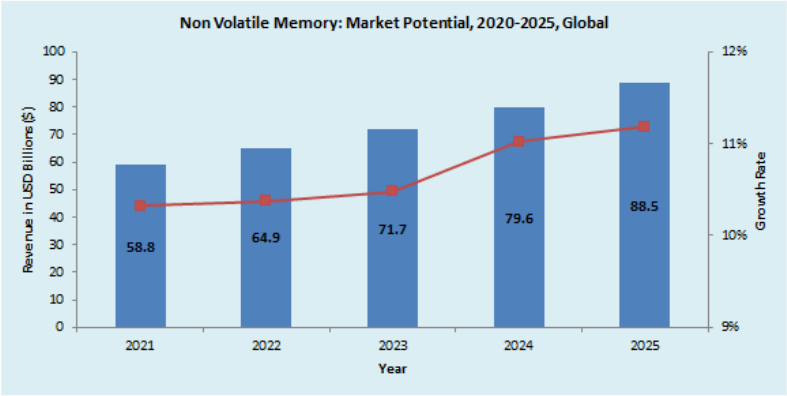
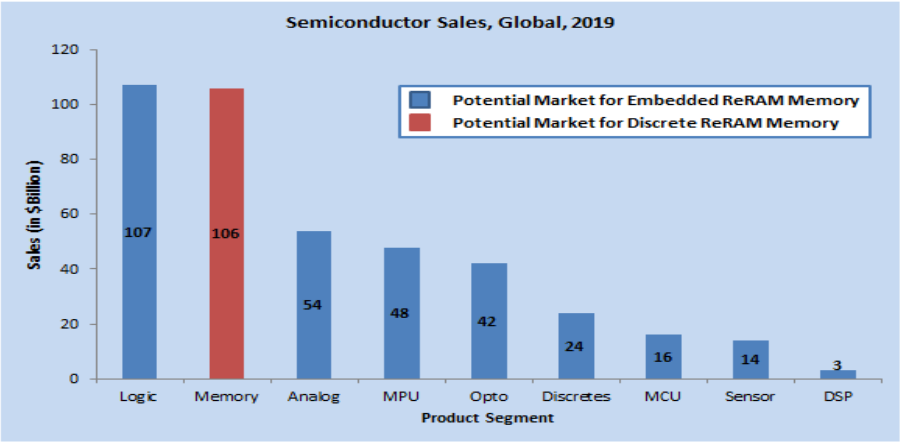


Fig 6: Market Potential of NVM

Source: Frost & Sullivan

NVM market is expected to reach around $88 billion by 2025, with a steady growth rate of 10.6%. The NVM market will be dominated by flash memory with new flash variants such as 3D NAND, NVMe (non-volatile memory express). Still, its limitations, such as scalability, endurance, and retention, will create a platform for emerging NVM technologies and companies like Weebit to play a vital role in the embedded device sector.

As per the SIA data (Semiconductor Industry Association), the global semiconductor industry reported sales of $414 billion in 2019, making it one of the highly lucrative markets at present. This will give an ample commercial drive for the growth of ReRAM and Weebit as its technology can be embedded in almost all of the semiconductor products ranging from logic, analog, MPUs (microprocessor units), MCUs (microcontroller units), sensors, and signal processors. Below is a split of various semiconductor products and their sales recorded, which will give a clear overview of the potential SiOx technology to disrupt the semiconductor industry while defining the market opportunity for Weebit.



* Discretes in the graph represent the discrete electronic components such as transistors

Fig 7: Global Semiconductor Sales for 2019 *Source: SIA*

Core Focus Areas of Weebit Nano Ltd

Embedded Memory

Today, AI has penetrated every mainstream industry, such as agriculture, automotive, finance, manufacturing, education, entertainment, and healthcare, thereby propelling intelligent chipsets' innovations. In particular, edge AI's demand is gaining momentum due to the special feature of edge intelligence. The data is processed locally on the device instead of the conventional method of cloud-based data processing. As a critical part of edge AI chips, memory needs to have a small geometry and store more data, which is where ReRAM can be an ideal solution. As per Frost & Sullivan's analysis, the AI Chipset market will be accelerating at a growth rate of 31.7% from 2020 to 2025. The growth rate will pick up pace by 2022 due to advancements in various technologies such as lithography, memory storage, display and software algorithms that form the core of the AI ecosystem. With the commercialized ReRAM modules of Weebit slated to be released by 2022, the

company will be looking forward to cash-in on the steep growth of the edge AI chips market as ReRAM can be an ideal embedded memory for various edge AI and smart devices.

System-on-chips (SoCs) are becoming an integral part of the system design of major electronic devices used across various industries, such as consumer electronics, automotive, healthcare, and energy. The next generation of multi-core SoCs will be embedded with features, such as AI, which will bring in automation capabilities to the process chain and significantly impact the manufacturing and processing industry. Multi-core SoCs bring the capabilities of multiple processing instances interfaced with other features, such as signal antennas, sensor interfaces, which are vital to embedded systems. With the devices becoming feature-rich and shrinking in size with each passing day, multi-core SoCs will play a pivotal role in realizing this transition. Frost & Sullivan analysis indicates that multi-core SoCs are growing at a steady rate of 17.3% due to technological advancements in circuit miniaturization and the introduction of multiple-core processors in the integrated circuits. Around US$45 billion is contributed by the mobile and automobile SoC market. Embedded memory would be a vital entity of SoCs as it will have to process multiple actions simultaneously. ReRAM can be a perfect memory alternative in SoCs as it can shrink to smaller geometries, unlike flash.

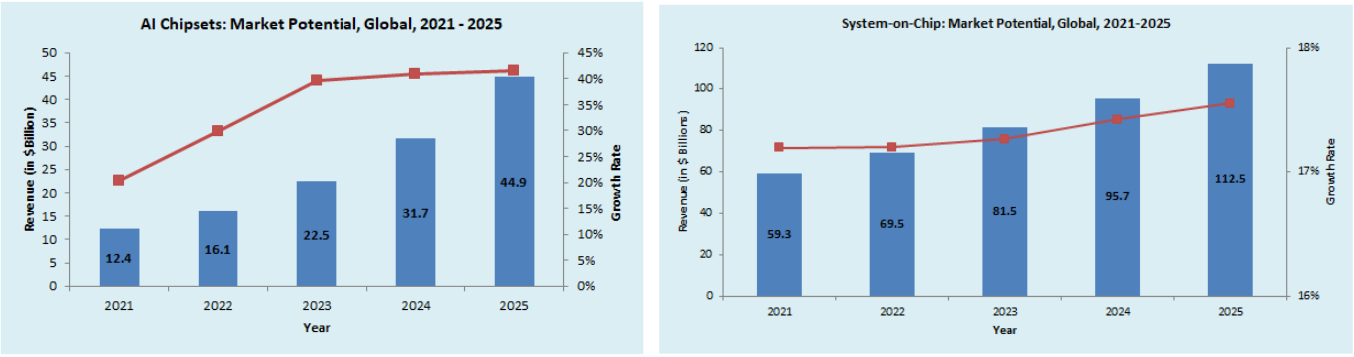


Fig 9: Market Potential of AI Chips and SoCs

Source: Frost & Sullivan

IoT is a critical component of digital transformation observed across various industries. Banking upon its core concepts that include real-time connectivity and advanced data analytics, IoT is making significant inroads across different application areas ranging from healthcare to manufacturing and retail. Frost & Sullivan's analysis indicates that 24 billion IoT devices were in service in 2019 and predicts there will be 58 billion IoT devices in service worldwide by 2026, with a growth rate of 15.5%. The key areas where IoT is being leveraged include asset monitoring and tracking, connected cars, automotive infotainment, smart grid, smart energy meters, smart home appliances, building automation, security and surveillance, digital signage, ATMs, retail outlets, industrial automation, and medical devices. In particular, the connected devices sector has undergone

a rapid transition owing to the constant upgrades and innovations observed in the IoT domain. Electronic gadgets are becoming intelligent day by day as they are now capable of automating various sophisticated tasks through wireless connectivity with Bluetooth and Wi-Fi. The intelligence of the electronic devices can be accredited to the growth of SoCs and NVM. As devices are shrinking, IoT poses a great market opportunity for Weebit's ReRAM as IoT and other connected devices, such as wearables, drones, robots and Bluetooth speakers that can be embedded with ReRAM because of its low power consumption and small geometry.

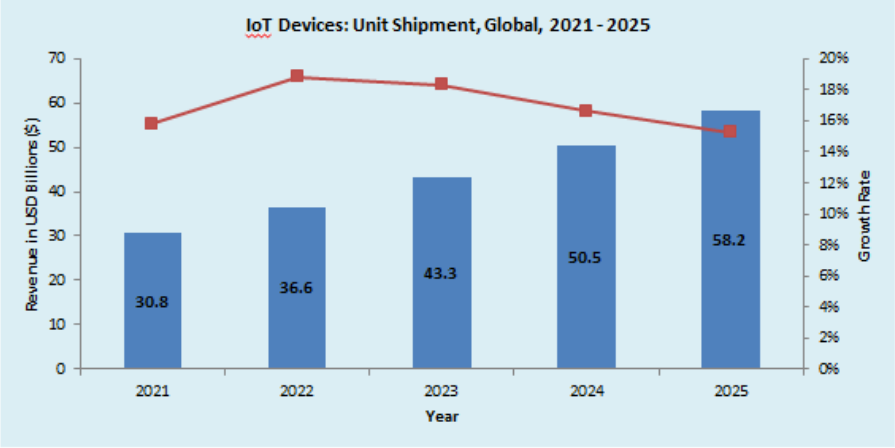


Fig 10: Unit Shipment Forecast of IoT Devices *Source: Frost & Sullivan*

Finally, the wireless communication market inclusive of 5G communication is on the verge of commercialization pose a potential opportunity for Weebit's ReRAM technology. Wireless technology is used to establish connectivity between different communication networks located in and around enterprises, public places, and residential premises. 5G will be a key enabler for the digital transformation in the near future. It brings in faster speed, high bandwidth, and low latency, which will spur innovations and the deployment of billions of connected devices globally. The key application segments for this market are automotive, consumer electronics, healthcare, public safety, wearable devices, energy, etc. Various components of the wireless communication infrastructure of 5G, such as 5G chipsets, can use ReRAM as its embedded memory.

Discrete and Persistent Memory

In the discrete memory sector, Flash memory (in particular, NAND flash) has been enjoying a global supremacy in terms of market share, which is further boosted by developing 3D architecture of NAND Flash. But the major area wherein Flash usage has seen a rapid growth is the cloud storage and data centers. As massive data processing using AI and machine learning increases, the storage demand has to be met accordingly. Weebit's ReRAM offers great benefits for endurance and retention in comparison to Flash memory. We expect the company to target the NOR Flash and EEPROM replacement by 2024 -2025, enabling Weebit to enter the

discrete memory market comprehensively. Moreover, the ability to scale in three dimensions will enable Weebit to develop 3D ReRAM in the future, thereby aiming to acquire a significant NAND flash market share.

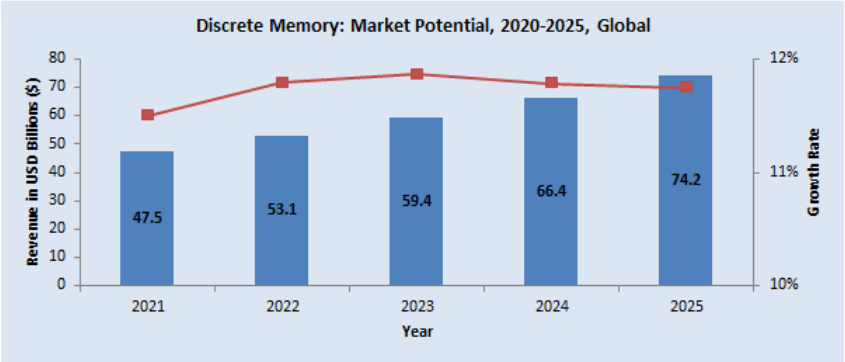


Fig 11: Market Potential of Discrete Memory *Source: Frost & Sullivan*

Another key memory segment targeted by Weebit is the standalone memory chips that offer better endurance, speed, and retention in comparison to flash memory. One of the major limitations found in today's data storage industry is the void found between DRAM (dynamic RAM), the primary memory which is very fast and volatile and the secondary memory, which is slow and non-volatile, hampering the overall processing capabilities of systems in data centers and cloud computing networks. An emerging memory technology called persistent memory, which is non-volatile, is gaining momentum due to its ability to accelerate secondary storage. Weebit's ReRAM offers high read/write speed and low power consumption, making it a perfect solution for persistent memory. In collaboration with CEA-Leti, the company has launched a three-stage program to develop ReRAM based discrete memory modules by 2024.

Disclaimers, disclosures, and insights for more responsible investment decisions

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Endnotes

[i] Frost & Sullivan annual reports: Top 50 Emerging Technologies: Spawning Growth Opportunities of Strategic Imperative, 2018, 2019, 2020

[ii] Frost & Sullivan annual reports: Total Internet of Things (IoT) Device Forecast, 2017-2025