

SEMICONDUCTOR CHIPS: THE ASX COMPANIES HELMING THE NEXT FRONTIER OF INNOVATION

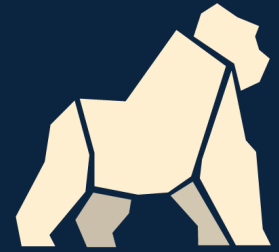
Alinda Gupta
August 2023

Stocks Covered:

- | | |
|----------------------|----------|
| - Archer Materials | ASX: AXE |
| - Brainchip Holdings | ASX: BRN |
| - 4DS Memory | ASX: 4DS |
| - Weebit Nano | ASX: WBT |

Contact:

The Sentiment
Level 2, 353 Flinders Lane, Melb VIC 3000
editor@thesentiment.com.au



INTRODUCTION: THE STATE OF THE SEMICONDUCTOR INDUSTRY

Picture a world without smartphones and microwaves, Facebook and Instagram, online bookings and Google Maps, tap-on payments and phone calls. If this made you feel uncomfortable, understandably so. Our lives and the internet are like conjoined twins. But this codependence with technology would not have been possible without an exceptionally tiny object (coming in at [one-billionth](#) of a metre)—a semiconductor chip. The semiconductor chip has been the bedrock of innovation in the past and is set to be the catalyst of a tech-forward future, enabling you easy access to augmented reality (AR), virtual reality (VR), artificial intelligence (AI) and much more on your smartphone and other smart devices.

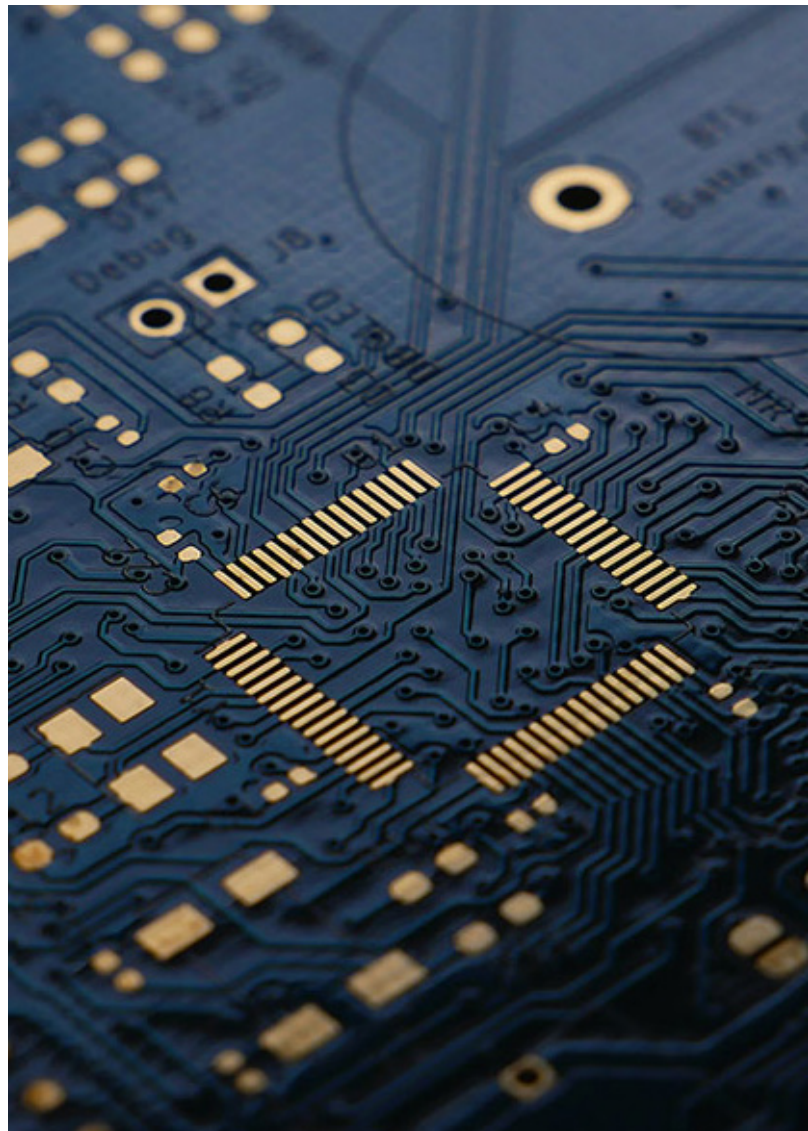
The global semiconductor industry is [poised](#) for a decade of growth and is projected to become a trillion-dollar industry by 2030. In 2022, semiconductor sales [reached](#) US\$580.13 billion (AUD \$868.5 billion) globally. While there are many frontrunners in the global semiconductor tech production race, one stands out: the US-based chipmaker Nvidia.

In October 2022, Nvidia became the first semiconductor company valued at [a whopping trillion dollars](#), joining the likes of Amazon and Apple. Nvidia's stock value tripled in the eight months since October 2022, surging by 200%. Besides Nvidia, the US's largest chip manufacturer Intel is also gearing up [to spend big](#) on the semiconductor boom. It plans on dishing out about US\$40 billion (AUD 60 billion) on new chip fabrication plants in Ohio and fabrication plants in Arizona. This renewed interest in semiconductor chips—and their potential with AI—following trade wars, global chip shortages and more has paved the way for semiconductor companies to thrive

worldwide, thus encouraging investors to be part of the boom.

It's no wonder then that the Australian Strategic Policy Institute, the national security think-tank, [demanded](#) that the Australian Government invest \$1.5 billion to set up a domestic industry to manufacture semiconductors, which, in turn, would rake in \$5 billion worth of manufacturing activity.

The ASX is home to many small-cap companies making big moves in the semiconductor space. Here, we look at some of the most high-potential ones worth watching based on their inventions, progress and finances.



ARCHER MATERIALS

ASX: AXE | Market Cap: \$145.2m



A promising semiconductor company on the index, Archer Materials' (ASX: AXE) quantum computing chip won [the favour](#) of the largest chipmaker in the world, Taiwan-based semiconductor foundry TSMC, in 2023.

TSMC [supplies](#) chips to some of the biggest global tech companies, like Apple and Qualcomm, making its stamp of approval a big win for Archer. With this partnership, Archer has access to the world's leading manufacturing capabilities used in producing smartphones and other mobile devices to develop its qubit processor chips.

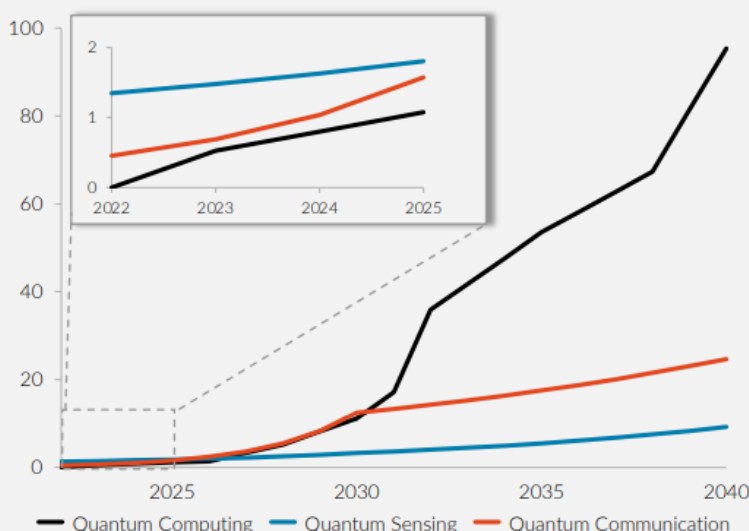
Background

Archer is known for pushing the boundaries on the potential of chipmaking. The Company is developing advanced semiconductor devices to support the growing quantum computing industry. Most notably, Archer is one of the few companies developing a qubit (a unit of quantum computing) processor. It does so by making breakthrough advancements in building quantum hardware devices previously limited to scientists' imagination.

Plus, it helps that Archer is led by a trained scientist with business acumen. The leadership of CEO Mohammad Choucair, with his extensive educational background and expertise in nanotechnology and management, solidifies Archer's potential. As CEO, Choucair, who is Alumni of the World Economic Forum, emphasises Archer's distinct position in the quantum computing landscape.

Archer is thinking ahead with its technology. Quantum computing chips are the next generation of semiconductors, embodying far greater power and potential. Quantum technologies broaden beyond computing to include sensing and communications, and together can create an Australian industry [valued](#) at \$2.2 billion. It could create over 8,000 jobs by 2030 and boost the overall economy. Come 2045, the industry could reach \$6 billion in valuation and employ over 19,000 people. It is a gold mine of an industry; however, digging for greatness is not everyone's cup of tea. These advanced semiconductors are being developed by only a handful of companies worldwide, such as IBM and Google, and by Archer in Australia.

Estimated market size (US\$B)



12CQ chip: Archer's bid at transforming quantum computing

Archer is revolutionising the industry with its trademark chip—the 12CQ (pronounced one-two-see-que). The chip is geared towards making the otherwise highly advanced and complex world of quantum computing super simple, practical and highly efficient. It utilises a unique carbon-based architecture that enables qubit processing, which has the potential to completely transform mobile devices.

The Company believes that the 12CQ chip can solve problems that even the most influential tech cannot solve today—and perhaps, ever. It has been designed to store and process qubits, the building blocks of quantum computing.

These qubits have the potential to deliver incredibly fast computations, surpassing even traditional computers and supercomputers. Additionally, the chip could potentially make the otherwise expensive venture of operating advanced computers—costing anywhere [up to \\$10 million](#) in yearly energy costs alone—more accessible.

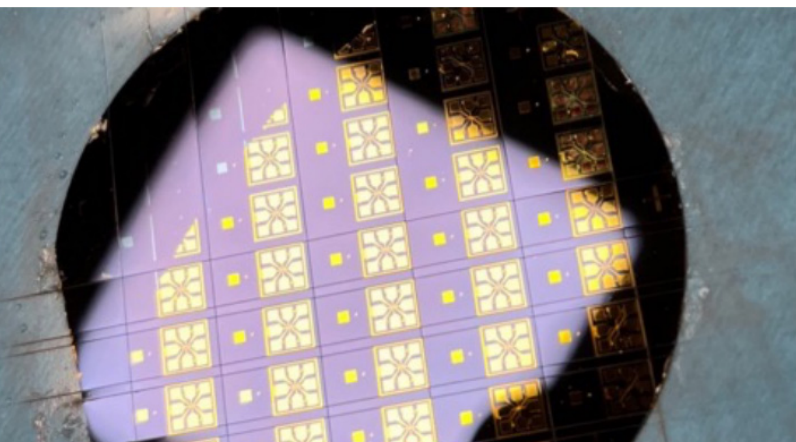


Image: Several small Archer quantum electronic devices are manufactured using UV optical lithography on a standard 2-inch silicon-on-insulator wafer.

In 2023, Archer achieved a significant milestone by improving the functionality of its qubit material at room temperature. Previously, operating the qubit material required a vacuum or inert atmosphere to maintain quantum coherence (keeping the quantum state undisturbed), which limited its practicality. To advance the development of the Company's 12CQ chip, finding a simple and feasible solution to mitigate quantum decoherence, i.e., disturbance caused by air on the qubit material, was crucial.

Archer successfully preserved the qubit material's quantum coherence times and properties at room

temperature, even in the presence of air, while retaining its inherent metallic-like characteristics. This achievement is significant because it means the quantum systems can now stay in their desired states long enough to perform essential tasks in quantum information processing, making a case for efficiency.

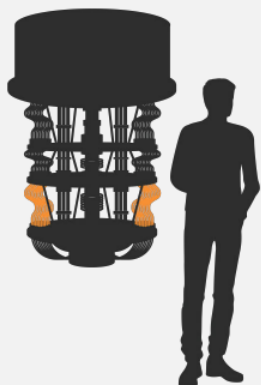
The improvement in qubit functionality built upon the breakthroughs made to incorporate and integrate the qubit material into chip devices that could detect the quantum information at room temperature. Archer developed two devices together with the Swiss Federal Institute of Technology (EPFL), the first was a HEMT device which used typical components found in mobile phones, and the other, remarkably, was able to use CMOS technology - the most widely used technology to manufacture electronic devices. Archer aims to bring quantum computing closer to the average consumer with its 12CQ qubit processor chip, enabling quantum computing at room temperature directly on mobile devices or standard computers. Unlike the current scenario where access to quantum computers is limited to cloud-based services or exorbitant purchases, Archer's technology would allow individuals to own and utilise these devices without the need for room-sized freezers.

Archer gaining ground with global patents

The global competitive advantage of Archer's 12CQ qubit chip is reinforced by its patents from multiple countries, including Australia, the US, China, South Korea, Japan, and several European nations. Securing patents in countries like China and South Korea is [not easy](#) since these regions have complex systems in place and require compliance with multiple local regulations. Additionally, the high volume of developers there makes these countries very competitive.

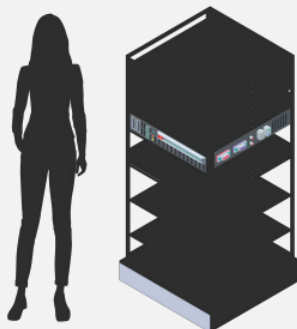
While many companies focus on the applications of quantum computers, Archer sets itself apart by focusing on making it accessible and practical by

Potential solution to push quantum access and use beyond cloud and edge...



Cloud-based

Require ultra-low temperatures and infrastructure to operate.
Accessed via the cloud.
e.g. Superconductor, silicon, topological.



Edge and/or Cloud-based

Operate at room temperature but are difficult to integrate into modern devices. Installed on-site.
e.g. Photonic, ion-traps, diamond.

... to your mobile



Quantum Powered Mobile Devices

QPMs will require practical qubit processors that integrate into modern devices.
e.g. ¹²CQ chip development.

developing its own unique processor hardware. It's a world-first approach. That is why Choucair is unfazed by the presence of tech giants in the quantum computing domain. Moreover, Archer is the first Australian company to partner with the World Economic Forum's Centre for the Fourth Industrial Revolution (C4IR). Archer will use the partnership further to establish the Company as the only ASX-listed company, and one of only a few in the world, developing accessible and practical quantum computing technology.

The quantum computing industry is poised to generate significant end-user value, estimated to range between \$673 billion and \$1.2 trillion when technology maturity is [achieved](#). This value creation is expected to attract investors as quantum hardware develops.

The Australian Government has outlined its Blueprint and Action Plan for Critical Technologies, which includes a national vision and strategy for quantum technology. According to the CSIRO, the advancement of Australian quantum tech could generate \$4 billion in revenue. In the United

States, the National Quantum Initiative Act, signed into law on December 21, 2018, outlines plans to invest over \$250 billion in advanced technologies. The International Roadmap for Devices and Systems also recognises quantum computing as a key technology. These factors contribute to the growing value proposition for investors in the quantum economy.

As of FY23, the Company was well-capitalised, with approximately \$23.3 million in cash and no debt. Archer is a young 'fabless' chipmaker and this is reflected in its balance sheet and its advanced chip design strategy. It spent \$507k on research and development excluding salaries (human capital is valuable in the semiconductor industry) and zero on production and manufacturing since it outsources chip fabrication, retaining 100% of the intellectual property and saving on what would be substantial costs to operate its own foundry. The fabless business model can be successfully and quickly scaled, as it has also been adopted by giants like AMS, NVIDIA, and Qualcomm.

BRAINCHIP HOLDINGS

ASX: BRN | Market Cap \$639.02m

Cybersecurity is the trend du jour, with many companies trying to build new tech without treading into the uncomfortable realm of breaching user privacy. That's where edge AI comes in. As the name suggests, the tech exists at the edge of AI, i.e. on your device.

Departing from the virtual cloud or remote server that processes and breaks down data, edge computing makes devices self-sufficient, allowing them to execute complex algorithms locally on the device. The benefits are multifold. For one, it saves time regarding information processing because the data does not have to travel to a cloud server and back. Secondly, it saves money because users' devices come pre-equipped with an AI algorithm, and developers do not need to maintain a shared remote server.

Finally, it makes a case for security. With data not leaving the local device, users' information remains secure. Research [forecasts](#) that the global edge computing market size will reach \$233.7 billion by 2030 and is expected to expand at 37.9% CAGR from 2023 to 2030.

brainchip

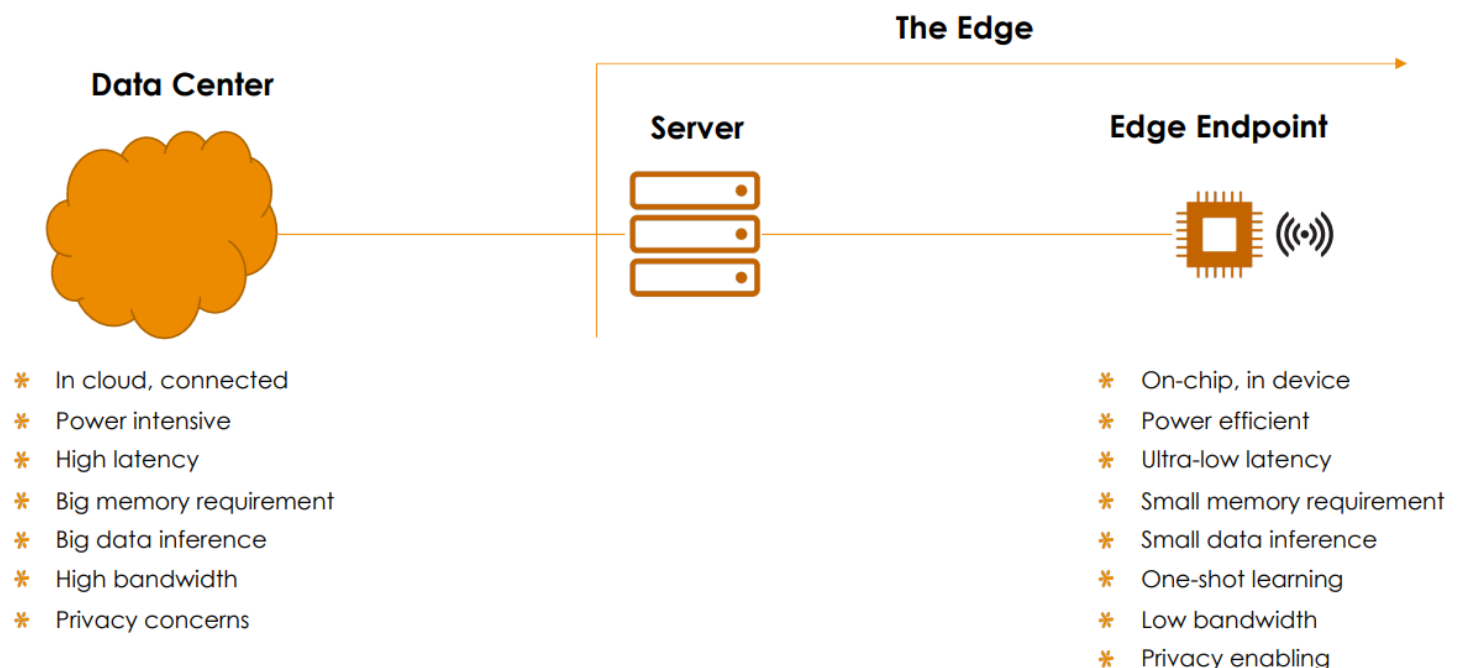
Background

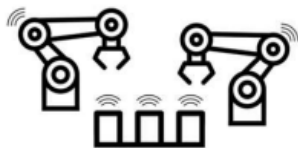
Founded in 2004, Australia-based edge AI on-chip processing company BrainChip (ASX: BRN) is working on this tech. Imagine if all that your brain is capable of—which is a lot—could be recreated with its initial neuromorphic processor, Akida.

It replicates the abilities of the human brain to analyse essential sensor inputs at the point of information acquisition. Keeping machine learning localised on the chip instead of relying on the cloud reduces latency, or time delay, while improving privacy and data security.

As the projected count of edge-enabled IoT devices reaches [7.8 billion by 2030](#), the field faces much competition, demanding BrainChip to up its game.

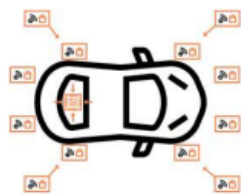
BrainChip enables edge computing to be deployable across real-world applications, such as in AI-enabled cars, consumer electronics, and industrial IoT.





Industrial

**Predictive Maintenance
Manufacturing Management**



Automotive

**In-Cabin Experience
Real-Time Sensing**



Health & Wellness

**Vital signs Prediction
Sensory Augmentation**



Home & Consumer

**Security & Surveillance
Intelligent Home Automation**

Akida IP: Brainchip's Edgy platform

The Akida IP platform can learn directly on the device, allowing for continual enhancement and data-independent customisation, enhancing security and privacy.

The latest version of Akida has Temporal Event Based Neural Nets (TENN) spatial-temporal convolutions. In simple words, the technology studies events and data over time to derive useful patterns. It assists with processing continuous time-based data, such as video analytics, target tracking, audio classification, analysis of MRI and CT scans for vital signs prediction, time series analytics used in forecasting, and predictive maintenance. These capabilities are useful in industrial, automotive, digital health, smart home, and smart city applications.

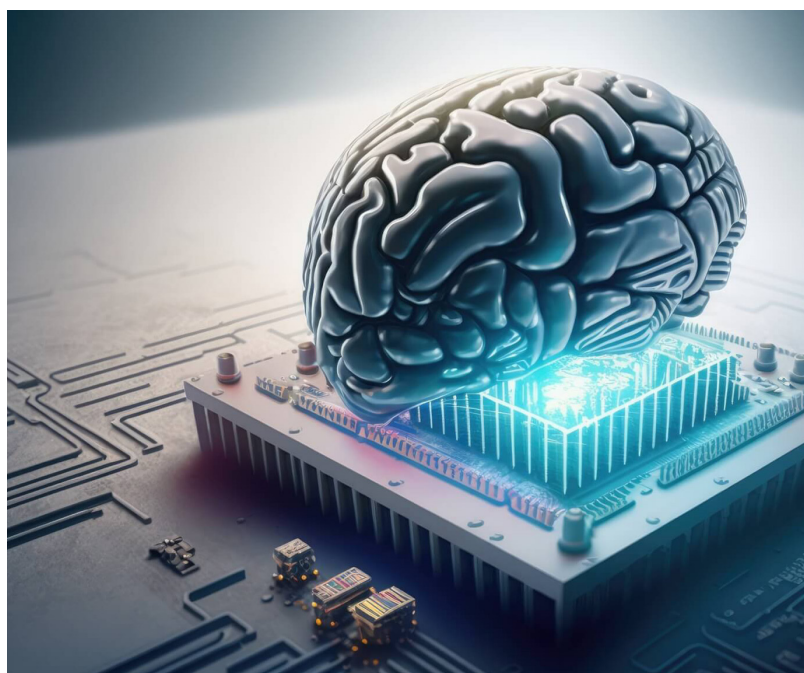
By directly utilising raw data from sensors, the TENNs enable simpler implementations, significantly reducing model size and operations while maintaining high accuracy.

Akida's new version has a boost for Vision Transformers (ViT). These are helpful neural networks for tasks like understanding images, recognising objects, and dividing pictures into parts (semantic segmentation). Plus, Akida's hardware support allows it to skip unnecessary steps, and it can independently execute complex networks like RESNET-50 entirely within the neural processor without requiring the help of the central processing unit (CPU), thus easing the load on the computer.

The devices are small in size and consume only microwatts of power. The scalability extends to high-definition vision solutions delivered through valuable battery-operated or fan-less devices, facilitating a wide range of applications, including surveillance systems, factory management, and augmented reality, with exceptional efficiency.

Entering a competitive space

While Brainchip has its research ready, it is still working on turning a profit from its platform as it attempts to get shareholders on board. In May 2023, the Company received a strike for its remuneration report, and in FY23, its cash in-flow of \$3.14 million paled in comparison to its outflow of \$23.7 million. Additionally, edge AI has a lot of prominent, well-established players, such as Nvidia's AI tech, that pose a stiff competition to BrainChip.

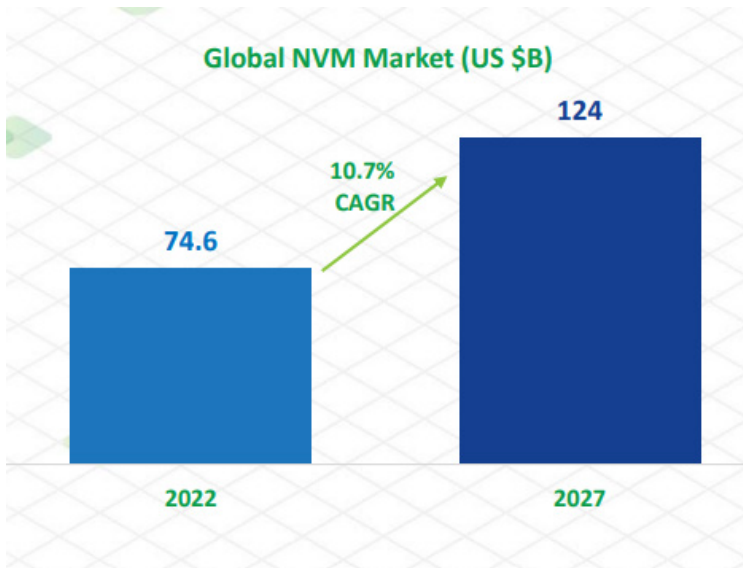


WEEBIT NANO

ASX: WBT | Market Cap \$954.17m



If you have used flash and hard drives, you know the underlying anxiety of keeping these devices safe and hoping they don't crash, taking all your storage along with them. In cases like those, technologies like ReRAM offer significant memory storage without needing electricity, featuring better writing speeds and being developed by Weebit Nano (ASX: WBT).



Background

Israel-based semiconductor memory tech company Weebit Nano (ASX: WBT)—founded in 2015—is developing its ReRAM technology solutions for a range of new electronic products such as Internet of Things (IoT) devices, smartphones, robotics, autonomous vehicles, 5G communications and artificial intelligence.

In simple terms, semiconductor memory technologies store electronic data as binary information (either '1' or '0') within a memory cell. These memory cells are grouped into "Words" units, each with a specific memory address for identification. These addresses are crucial in performing "Read" and "Write" operations. During a Write operation, data is stored in a Word,

whereas a Read operation retrieves data from the Word based on its designated address.

Memory technologies such as DRAM, SRAM, and flash utilise electrical charges to store data. Each technology employs its unique method: DRAM utilises tiny capacitors to store each bit of memory, SRAM employs bi-stable latching circuitry, and flash memory stores the charge on a floating gate.

However, all three technologies (DRAM, SRAM, and Flash) encounter difficulties when scaling to the most advanced process technologies. The size of these memory cells has reached its limits, as they have become super small.

Additionally, memory techs that rely on storing data as a charge are generally less resilient to radiation, which poses challenges in utilising them across various applications, including medical, industrial, aerospace, and others.

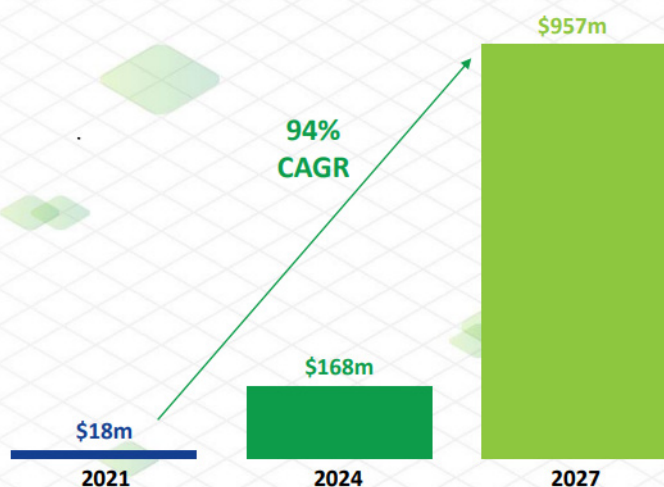
ReRAM: Less power-hungry memory storage

Weebit's ReRAM technology offers advantages over flash memory solutions through energy efficiency. On the production end, it uses fab-friendly, i.e. fabrication factory-friendly materials.

This technology can be integrated into current flows and processes without requiring specialised equipment or significant investments. It requires less power than traditional memory solutions and can work at higher temperatures, thus helping companies, especially in the automobile and industrial settings.

Weebit Nano and SkyWater Technology have jointly confirmed that Weebit's Resistive Random-Access Memory (ReRAM) intellectual property (IP) has undergone qualification for industrial temperatures.

Embedded ReRAM Market Size 2021 - 2027



This qualification was achieved by utilising SkyWater's 130nm CMOS (S130) process, including third-party processing. The qualification process involved using demonstration chips produced by SkyWater, which integrated Weebit's ReRAM IP. These chips were subjected to rigorous testing based on JEDEC industry standards for non-volatile memories, including testing numerous silicon dies randomly selected from three wafer lots.

Assessing the viability

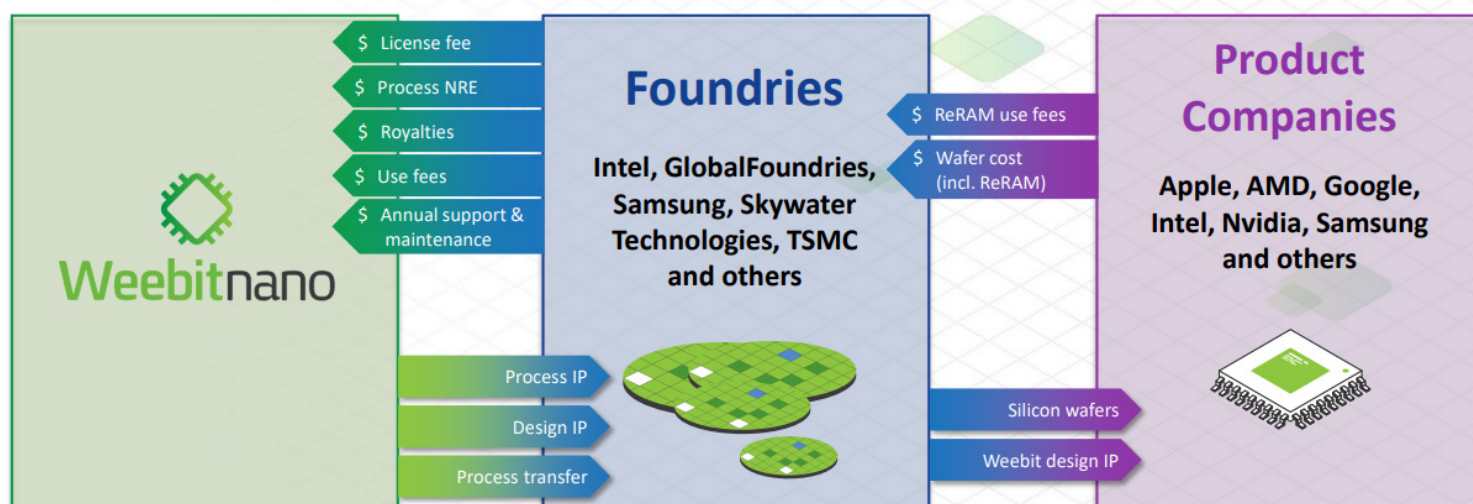
Typically, the data retention time of a memory device refers to how long stored data remains intact under specified temperature conditions.

While most non-volatile memory devices can retain data for approximately ten years at temperatures of 850 degrees Celsius or 1050 degrees Celsius, they struggle to maintain such retention levels at higher temperatures.

In contrast, Weebit's ReRAM technology is reliable even at elevated temperatures, with data retention capabilities of up to ten years at 1500 degrees Celsius or an impressive 20 years at 1250 degrees Celsius.

Weebit is currently in the discussions and technical assessments phase with foundries and integrated device manufacturers (IDMs). It aims to secure a licensing agreement with a Tier-1 foundry or IDM.

It is also working towards scaling its embedded ReRAM technology below the 22nm threshold. Its ultra-low power capabilities are not yet applicable to the automotive or defence industries, and the tool is still in the early stages of development. In FY23, the Company had no customer receipts, spent \$11.6 million on research and development and had \$88 million in cash, owing to the proceeds from issuing its equity securities.



4DS MEMORY

ASX: 4DS | Market Cap \$48.98m

The second semiconductor memory tech on the list, 4DS Memory (ASX: 4DS), offers interface switching ReRAM. At the outset, seeing as the memory market size is expected to be US\$44 billion (\$65.8 billion) by 2032, it's no wonder multiple companies are trying to fight it out for the top spot.

ReRAM, or Resistive Random Access Memory, can read and write data faster than other memory technologies (think flash drives, hard drives and SD cards). Its speed means that devices using ReRAM, say your smartphone, can perform tasks more quickly, like opening apps or loading files faster. Plus, it is compact, meaning that it can be used for super small devices, and it is strong, indicating that it won't get damaged quickly or undergo mechanical failures. Its promise against established memory devices is a wide-ranging one.

Background

Established in 2007, 4DS Memory is specifically making progress in the standalone ReRAM memory market out of its research facility in Silicon Valley. 4DS Memory aims to reimagine the landscape of high-density and cost-effective

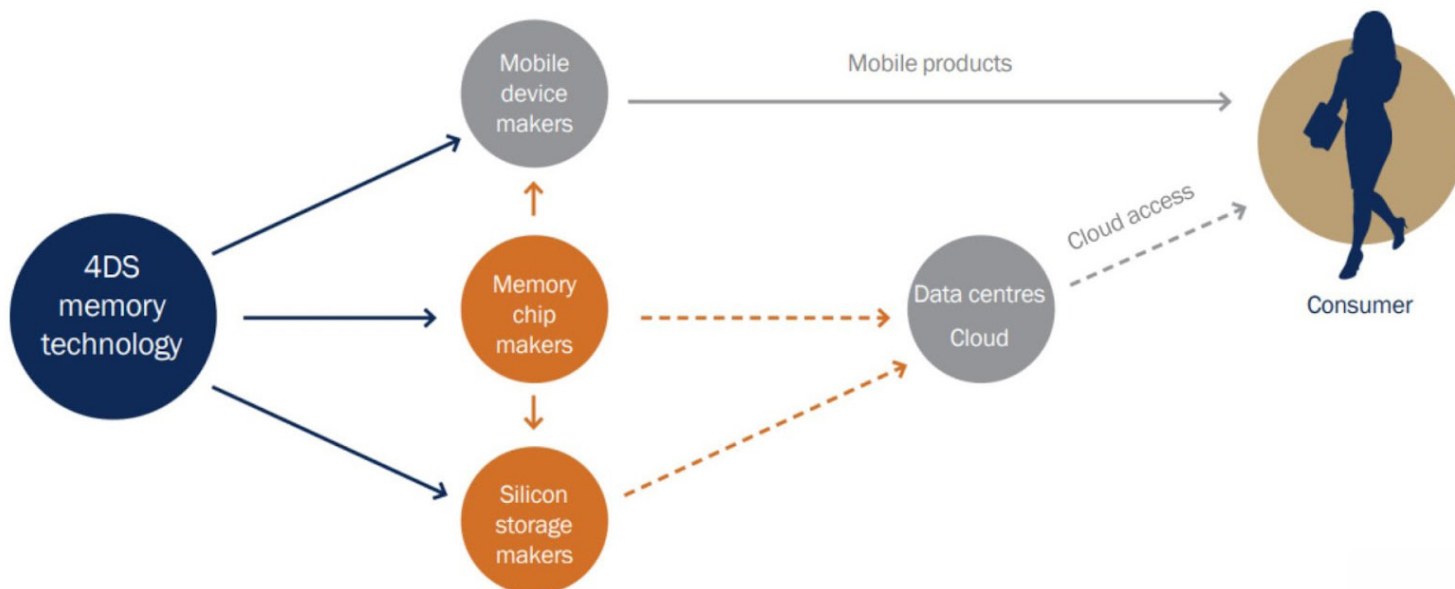
memories. The Company has 32 and 1 pending patents, but they are all based in the USA and have been developed in-house to create high-density Storage Class Memory.

Interface Switching ReRAM: memory solutions with greater storage capacity

In 2014, 4DS Memory entered into a joint development agreement with HGST (Hitachi Global Storage Technologies). This collaboration has been instrumental in producing cells necessary for high-density and cost-effective memories. By working closely with HGST, 4DS Memory gained insights into the future requirements of electronic systems, enabling it to develop solutions that meet the evolving demands of the market.

In 2017, 4DS Memory established a read speed comparable to Dynamic Random-Access Memory (DRAM) without needing speed-crippling error correction. This positioned 4DS Memory's ReRAM technology as an alternative to traditional memory solutions. Then, in late 2017, 4DS Memory formed a collaboration agreement with imec, an independent semiconductor development institute.

The objective was to develop a production-compatible process and demonstrate that 4DS technology is a viable candidate for Storage Class Memory (SCM). This partnership was





+ DRAM is super-fast, has exceptional endurance but is expensive and volatile



+ NAND Flash is slow, has limited endurance but is cheap and non-volatile

A new innovation is required and the industry refers to it as **Storage Class Memory** - over time this is predicted to have a market size as large as DRAM and NAND Flash

Counting on collaboration
Through strategic collaborations with industry leaders like HGST and imec and the development of groundbreaking technology, 4DS Memory is poised to revolutionise the memory landscape.

As data processing and storage requirements continue to surge, 4DS Memory's Interface Switching ReRAM technology presents a solution combining DRAM's performance with the non-volatility of NAND Flash, addressing the needs of future electronic systems.

extended until mid-2023, showcasing both parties' confidence and value in working together.

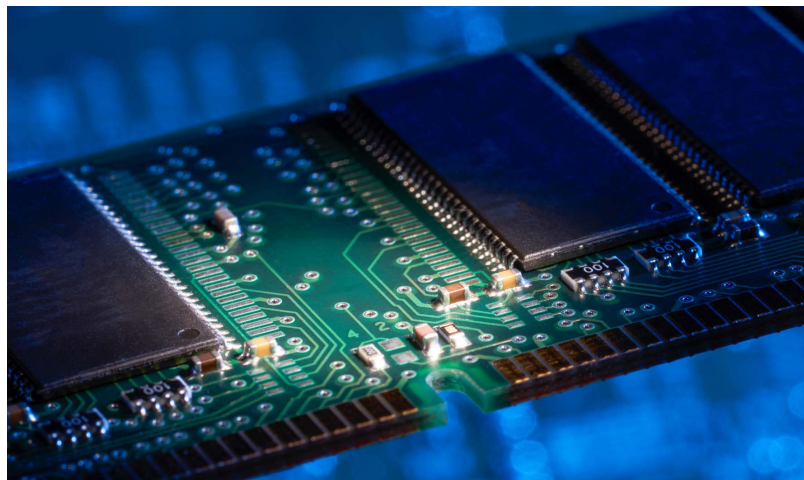
Leveraging imec's infrastructure, which includes a 300mm semiconductor pilot line and an extensive network of experts and industry players, to fast-track the development of 4DS's high-density Gigabit memories.

4DS Memory owns some USA patents that protect its Interface Switching ReRAM technology. This portfolio safeguards its intellectual property and strengthens its position in the market. The value of these patents will increase significantly if the manufacture and analysis of the Fourth Platform Lot in 2023 prove successful.

The high-density high-volume memory segment is dominated by DRAM and NAND Flash, with market sizes of approximately \$95 billion and \$56 billion, respectively. However, as data processing and storage needs continue to skyrocket for mobile devices and cloud data centres, the industry requires a new non-volatile memory solution that offers attributes closer to DRAM than NAND Flash. 4DS Memory's Interface Switching ReRAM technology aims to bridge this gap.

The journey to building 4DS memory tech hasn't been simple. In October 2022, the way the material was made caused damage to the structure of a layer called 4DS PCMO (the layer responsible for storing and retaining data). This damage made it harder to program the memory cells than the circuitry could handle. Previously, similar cells had been programmed successfully, so the Company shifted its focus to improving the etching process to avoid damage to the 4DS PCMO layer.

In FY23, the Company had cash equivalents of \$5.6 million, following \$4.7 million cash outflow on operating activities including \$3.4 million research and development expenses.



Disclaimer

The content published in this report is solely for general information purposes and is not to be construed as financial advice. Should you seek financial advice you should consult with an appropriately qualified person. Opinions expressed in this report are subject to change without notice and The Sentiment who produced this content is under no obligation to keep the information current. The Sentiment, affiliated companies & associates may have a conflict of interest with companies discussed in the report due to commercial arrangements, for example they may be shareholders in the company, be engaged by them to assist in investor communications or receive commission/brokerage for funds raised.

Contact:

The Sentiment
Level 2, 353 Flinders Lane, Melb VIC 3000
editor@thesentiment.com.au

