



## First revenue is imminent

Weebit Nano (ASX:WBT) has had a bumper year so far. The share price has more than doubled, while WBT's ReRAM technology is being commercialised as we speak. It is commercially available to customers of US semiconductor foundry SkyWater (NASDAQ:SKYT), which should lead to the company's maiden revenues. Meanwhile, WBT has been working with GlobalFoundries, another US foundry, and is in conversations with most of the world's Top 10 foundries and top 10 IDMs. Based on these many conversations, we expect WBT to be able to sign up multiple customers/development partners in the near to medium term.

## ReRAM is on pole position among emerging NVM

In previous research reports, [available here](#), we have talked about how ReRAM is superior to existing Flash technology and other competing, emerging Non Volatile Memory (NVM) technologies jockeying to replace Flash. Electronic devices need a technology that can offer superior performance at increasingly smaller process geometries, while offering minimal incremental costs, which is exactly what WBT's ReRAM offers. The importance of ReRAM has been magnified with TSMC's announcement last year that it is using ReRAM, which has led to (unverified) speculation that it is being used in electronic devices today, including Apple's latest iPhone. There are few viable ReRAM alternatives to TSMC's competitors, such as UMC and GlobalFoundries, but it doesn't seem any of these are an independent offering available for usage by other foundries and IDMs.

## Development roadmap is a 3-stage rocket

Initial applications of WBT's ReRAM technology will be in embedded memory, where SoCs (systems on a chip) require onboard NVM. Embedded ReRAM is currently being commercialised through SkyWater and should expand through licensing agreements with Tier-1 foundries as well. The 2nd stage is discrete (or standalone) ReRAM, i.e. Standalone memory chips. WBT is working on 2 variants; with and without an advanced selector. An advanced selector is required for ReRAM in larger arrays, while smaller capacity ReRAM chips can manage with an existing simple transistor as a selector. We expect discrete ReRAM chips to become available in the next few years, starting with smaller capacity chips first. The 3rd stage is ReRAM applied to neuromorphic processing using for example, Spiking Neural Networks, but this is a longer-term project for the company.

## Valuation of A\$9.56 per share

Our previous valuation for WBT of A\$6.10 has been reached and exceeded. Given the company's progress so far in 2023 and the expected news flow during the remainder of 2023 and into 2024, we believe WBT's valuation gap with a peer like eMemory is likely to narrow in the next 12 months. On that basis, we believe WBT should be valued at A\$9.56 per share, which implies 43% upside from the current share price. See key investment risks on page 16.

Share Price: \$6.66

ASX: WBT

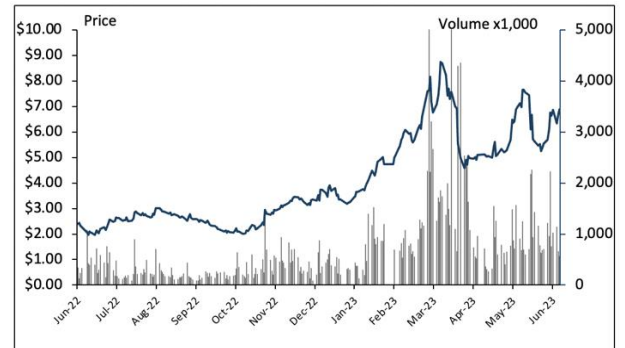
Sector: Technology

19 June 2023

Market Cap. (A\$ m)	1,242.4
# Shares outstanding (m)	186.5
# Share fully diluted (m)	203.8
Market Cap Full. Dil. (A\$m)	1,357.4
Free Float	100%
12-month high/low (A\$)	\$8.75 / \$1.96
Avg. daily volume ('1000)	723
Website	www.weebit-nano.com

Source: Company, Pitt Street Research

## Share price (A\$) and avg. daily volume (k, r.h.s.)



Source: Thomson Reuters, Pitt Street Research

<b>Valuation metrics</b>	
Valuation per share (A\$)	9.56

Source: Pitt Street Research

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Disclosure: Pitt Street Research directors own shares in WBT.



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## A quick refresher on ReRAM

*ReRAM is a Non-Volatile Memory (NVM) technology that enables electronic devices to store large amounts of data in a way that is much faster and more economical than Flash memory.*

**What is ReRAM?** ReRAM (Resistive Random Access Memory) is a Non-Volatile Memory (NVM) technology, similar to today's mainstream Flash memory, that enables electronic devices to store large amounts of data in a way that is much faster, lower power and more economical than Flash memory. See Appendix I for a full outline of how WBT's ReRAM operates.

**Why is ReRAM so much better than Flash?** ReRAM fulfils the same tasks as Flash memory technology, but it is vastly superior to Flash in that it offers a superior performance at a smaller process geometry. In other words, it can process more data and can do so much faster while using less power.

Figure 1: Advantages of Weebit's ReRAM

Metric	Advantages of Weebit's ReRAM
Endurance	Weebit's ReRAM can handle 100k-1m read/write cycles as compared to 1-10k for today's embedded Flash applications, thus performing 10-100x better.
Data Retention	Weebit's ReRAM can store data for 10 years at 125-150°C, superior to other NVM alternatives, which often have a data retention capacity of just 10 years at 85°C.
Power Consumption	Weebit's ReRAM has significantly lower power consumption levels and lower voltage requirements compared to Flash technology and thus enables longer battery life.
Access time	Weebit's ReRAM has a 100x faster program time than Flash.
Environmental tolerance	Weebit's ReRAM can withstand up to 350x more radiation than Flash, is tolerant to electromagnetic interference (unlike Magnetoresistive Random Access Memory, or MRAM) and is thermally very stable (unlike Phase-change memory, or PCM).
Cost	Weebit's ReRAM adds 5-7% to the wafer cost as compared to 10-20% for Flash and 30%, or even 40%, for MRAM.
Manufacturing and Capex	Weebit's ReRAM can be produced using fab-friendly materials and does not require special equipment as compared to other NVMs, which are more complicated and Capex-heavy to manufacture. This is especially true with regards to MRAM, which uses very unconventional materials and tools.
Security	Weebit's ReRAM does not use a floating gate charge (unlike Flash), making it difficult to change its internal state. It can also withstand magnetic attacks (unlike MRAM) and optical attacks. It is more difficult to intrude, read or modify.
Lower carbon footprint	Weebit's ReRAM also has a substantially lower carbon footprint compared to competing technologies as well as better ESG credentials.

Sources: ReRAM Advantages, Technology, Company website

While Flash technology has served the NVM market for decades, it is getting closer to its use-by date in the embedded market. It can no longer meet the growing performance needs of modern electronic devices and cannot scale down below 40nm in a technically and economically viable manner. While

ReRAM is not the only alternative to Flash memory, it is the most viable alternative for several reasons as outlined in Figure 1.

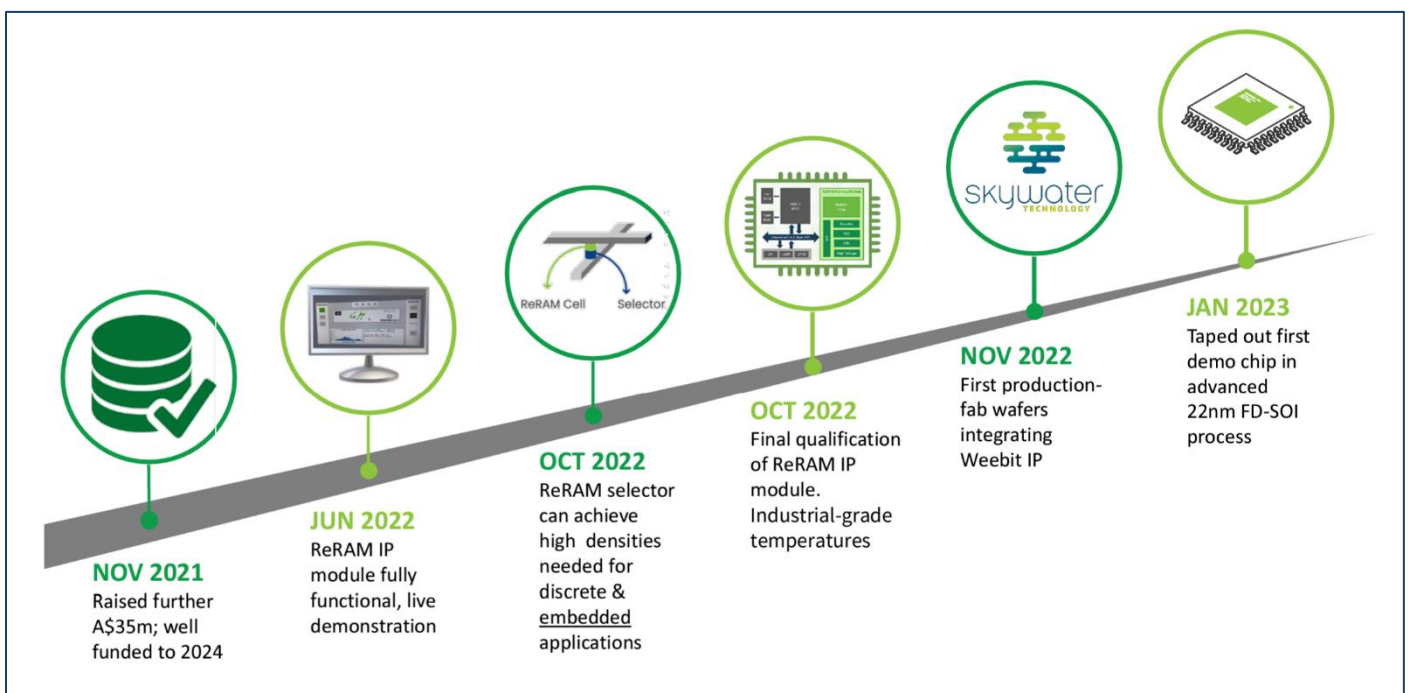
**What are some of the end markets for ReRAM?** We see three key end markets that WBT can access through SkyWater: Medical, Industrial IoT and Aerospace & Defence. As WBT signs on more fabs as partners there are further markets it can penetrate. If its work with GlobalFoundries eventuates in a commercial deal, some potential end markets include MCUs (Microcontroller Units), Automotives, IoT and edge AI.

### Where WBT and its ReRAM technology are at right now

Over the last few years, WBT has developed its ReRAM technology and is about to bring it to market (Figure 2) through its first customer, US-listed semiconductor foundry SkyWater (NASDAQ:SKYT). A foundry is a chip manufacturer that manufactures chips for third party customers.

SkyWater signed a deal in mid-2021 to license WBT's technology for embedded applications, integrate it into customer designs and commercialise it. Over the past 20 months, SkyWater and WBT transferred the technology to the SkyWater foundry, manufactured wafer lots with it and started qualifying the technology proving it can work in the context of SkyWater's chips. The memory module is expected to be fully qualified in the very near future, which means embedded ReRAM can enter production in the latter half of 2023, depending on customer demand and requirements.

Figure 2: WBT's progress since 2017



Source: Company

### Working with SkyWater for the last 2 years

WBT's ReRAM is available in SkyWater's 130nm CMOS (S130) technology process, enabling SkyWater's customers to integrate it in their system-on-a-chip (SoC) designs. WBT's business model (at least while it is exclusively focusing on the embedded memory market) is to license out the technology



and generate revenues through upfront license fees and ongoing royalties based on production volumes.

As time advances, embedded ReRAM will be made available in smaller geometries, i.e. WBT has been working on FDSOI (Fully Depleted Silicon-on-Insulator) applications at 28nm and 22nm for a while, and we expect it will likely scale this technology down below 20nm in the near future. See our research update on [FDSOI from 25 March 2022 here](#).

## Looking to onboard more foundries and IDMs

Although SkyWater is the only fab that WBT has a formal commercial arrangement with, WBT has told shareholders that it is engaging with the majority of the world's tier-1 foundries and is doing evaluations with some of them. Furthermore, WBT is working informally with GlobalFoundries, another major American semiconductor manufacturer that is a significant worldwide player, particularly in Automotive chip market.

Earlier this year, GlobalFoundries signed a deal with General Motors (GM) to exclusively manufacture chips in America to be used in GM's vehicles. We believe GlobalFoundries could well be the next commercial partner for WBT.

We also take heart from moves by global leader TSMC to use its own ReRAM technology for its customers, one of which is Apple. This has led to speculation that ReRAM is embedded in the new iPhone 14 – something that has not yet been verified. While some investors may not see this as good for WBT because it is a competing technology, we can't imagine TSMC will allow other top-tier foundries to use its specific ReRAM technology.

UMC announced it has ReRAM available, which it qualified with eMemory (which got it from Panasonic). GF has CBRAM (Conductive bridging random access memory) from Adesto, which is still being worked on. But neither seem to be pushing it hard with customers.

We believe WBT's ReRAM is the only other practical alternative on the market right now for semiconductor fabs wanting to incorporate ReRAM technology in their products – at least one that is available in the market. We believe WBT is also likely to attract interest from Integrated Device Manufacturers (IDMs), such as Intel, STMicro, Texas Instruments etc, as well as fabless chip companies, like Qualcomm, Broadcom and NVIDIA.

## Three Non-Volatile Memory markets for ReRAM

WBT is aiming to address three main Non-Volatile markets with its ReRAM technology; embedded memory, discrete memory and neuromorphic processing. In 2022, the total size of the NVM market amounted to ~US\$75bn, while it is expected to grow by nearly 11% CAGR through 2027 (Figure 3).

In CY23, WBT entered the embedded market through SkyWater and this will be its focus in the near term. WBT is looking to move into the discrete market in the next few years, while the neuromorphic processing markets is a longer-term ambition.

*WBT is engaging with the majority of the world's tier-1 foundries and is doing evaluations with some of them.*

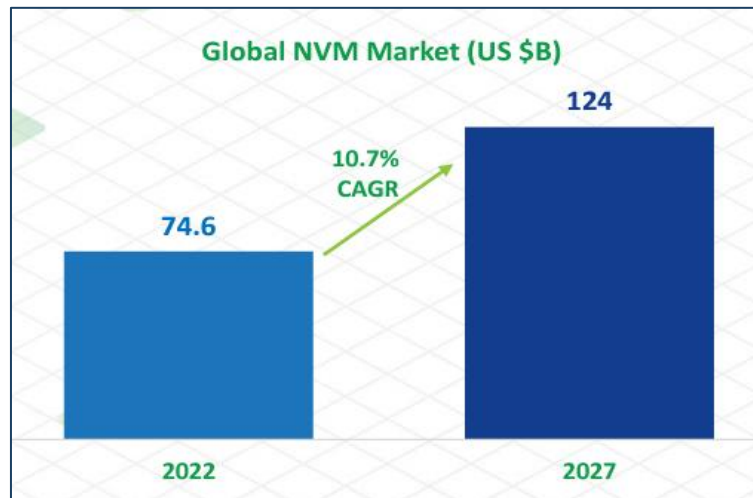
*WBT is viable alternative to TSMC ReRAM*

*WBT is aiming to address three Non-Volatile markets with its ReRAM technology; embedded memory, discrete memory and neuromorphic processing.*





Figure 3: The size of the Global NVM Market



Source: Company

*The Embedded memory market is the first market WBT will enter through its partnership with SkyWater.*

### Embedded NVM is an imminent opportunity

The Embedded memory market is the first market WBT will enter through its partnership with SkyWater. In general terms, embedded memory technology is memory that is embedded in an SoC (System on a Chip) – a chip designed to contain all the elements of a computer system in that one chip rather than having different components. Embedded memory chips can be used in higher-cost applications, such as industrial, medical and automotive applications, as well as in simple, cheaper sensors that require NVM.

The growth of smart connected devices, in popularity and the performance standards they are expected to reach for end-consumers, is increasing the performance requirements of SoCs, which are now required to integrate more capabilities and memory. This has increased the burden on embedded NVMs to pack superior performance at smaller process geometries.

SoCs with embedded Flash scaling to 40nm have been the market standard for years, but the next generation of devices require SoCs with process geometries of 28nm and below. With Flash memory, process geometries of 28nm or lower would lead to leakage of current between adjacent memory cells, which would be too expensive to overcome, rendering the scaling down commercially unviable.

*This is where ReRAM can come in and capitalise on the opportunity, given it can scale down to the required geometries while delivering a superior performance.*

### Embedded ReRAM market size of US\$1bn by 2028

The total embedded NVM market is expected to reach US\$2.7bn by 2028, representing a 133% CAGR over the period 2022 to 2028<sup>1</sup>. In terms of share in 12" equivalent wafer shipments, ReRAM is expected to capture a ~60% wafer share. But given that ReRAM is lower cost than MRAM and PCM, the

*Embedded ReRAM represents an opportunity of US\$1bn by 2028*

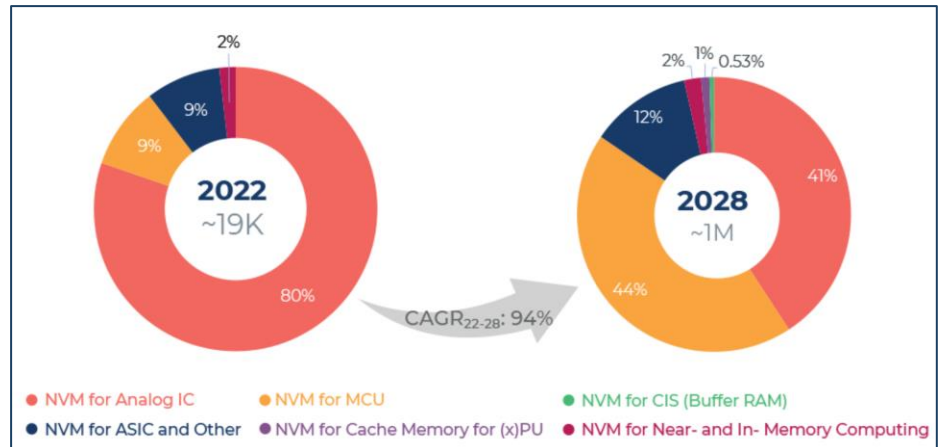
<sup>1</sup> Yole Emerging Non-Volatile Memory 2023



ReRAM revenue share is expected to amount to 37% which would amount to ~\$1bn.

It is important to note that the initial US\$2.7bn estimate is mostly based on embedded NVM within MCUs (see Figure 4). It does not account for other target markets, fab transfer fees, non-recurring engineering fees as well as upfront license or use fees.

Figure 4: Embedded emerging NVM volume in 12" equivalent wafers



Source: Yole Intelligence, 2023

### Discrete NVM can displace Flash memory in the medium term

As noted above, discrete memory chips are dedicated, high-capacity memory chips. These chips are used in low-cost, high-density on-device data storage applications, such as mobile phones, PCs, tablets, USB drives and data centres.

NAND Flash has been the dominant discrete memory technology for many years and while the industry has been able to prolong Flash's lifespan by scaling down to 40nm over time, it is gradually losing the battle. Flash memory below 40nm leads to crosstalk between memory cells that will cause them to lose their stored values. Additionally, going significantly lower than 40nm for large scale storage applications is simply uneconomical given the required manufacturing processes and mask costs.

To increase Flash storage capacity, the industry chose to stack memory cells on top of each other, like skyscrapers. But this so-called 3D Flash has got its limits too, although by 2022 the industry managed to stack well over 200 layers of memory cells on top of each other.

*While we may not see 3D Flash hitting a limit in terms of number of layers in the next few years (Samsung reckons 1,000 layers are possible), we believe discrete ReRAM below 20nm just makes a lot more sense from a power consumption, speed and manufacturing costs point of view. Additionally, ReRAM with a selector also allows for 3D stacking with ReRAM.*

In the medium term we believe emerging NVM technologies in the discrete NVM market present a market opportunity of US\$3.3bn by 2026. Approximately 13% of this is expected to be captured by ReRAM technology.

**Discrete ReRAM below 20nm just makes a lot more sense from a power consumption, speed and manufacturing point of view.**

Although WBT is focusing on the embedded NVM segment in the near term, it has made some progress in pursuing the discrete NVM segment by developing a BEOL (back end of the manufacturing line) selector and demonstrated its integration with ReRAM cells. The BEOL selector will be ideal for scaling and achieving high memory densities, i.e. >64Mb, and opening up opportunities in several end-user segments.

### Discrete memory: Low or high density

Although WBT is targeting the entire discrete NVM market, there is a critical distinction that must be made between low and high density applications (Figure 4). Density alludes to the memory capacity of the individual chip.

Although WBT will be going after both low and high-density segments, there are slightly different time frames – pursuing low-density (or memory capacity) applications in the short term and higher density applications in the medium-term. Although the low-density market is lower margin, ReRAM has a unique advantage here because it can easily scale to lower geometries that NOR Flash cannot. Therefore, it can support unique features that would otherwise be impossible such as increased security, low-voltage and high-speed interfaces. Such products can sell for a premium.

### Markets for discrete ReRAM are very diverse

It is still early days for Weebit Nano in the discrete NVM segment, but it aims to enter this market in the medium term.

Figure 5 shows the main discrete NVM technologies that ReRAM can potentially displace, their end use markets (outlined in further detail in the next section of this report) and the timelines for market entry.

Figure 5: Target markets for discrete ReRAM (Size and End-user segments)

Market	Applications	Opportunity	WBT Advantages	Timeline
<b>NVSRAM and EEPROM</b>	IoT, Medical, A&D	US\$2bn (in 2021) 1% CAGR through 2027	Die size Cost	Short-term
<b>NOR Flash</b>	Consumer, automotive & industrial	US\$3.5bn (in 2022) 6% CAGR through 2027	Ultra-low-power operation Ultra-low standby current Die size Cost	Low densities: Short-term Higher densities: Mid-term
<b>NAND Flash</b>	Data storage: On-device or cloud-based	US\$67bn (in 2021) 6% CAGR through 2027	Ultra-low power consumption Endurance	Multi GB dies: Longer-term
<b>Storage Class Memory (SCM)</b>	Emerging market filling gap between DRAM & NAND storage	US\$925m (in 2027) 16% CAGR through 2027	Cost	

Sources: Investor Presentation – March 2023





## Neuromorphic ReRAM is a longer term ambition

WBT's third big market opportunity is neuromorphic computing, but this is a longer-term opportunity for the company. A neuromorphic computing system analyses and processes information by mimicking how a human brain works. In other words, the basic idea behind neuromorphic processing is to use a microchip to leverage neuroscience concepts and knowledge in computing architecture.

In normal applications, memory and processing form two different elements. To process data, it must be sent back and forth between the two units. But the human brain is much more efficient and processes data while collecting and storing it at the same time. Neuromorphic computing (or processing) aims to emulate the efficient processing engine of the human brain in a computer processor.

On-board and real-time processing of data collected by sensors has a very wide range of application areas - essentially any Edge device that has offline and real-time processing requirements with one such example being autonomous vehicles.

So, while currently at an early stage, neuromorphic processing capabilities, once fully developed, will serve many end-user industries. Considered the future of AI, neuromorphic processing has piqued the interest of several established companies, such as Intel and IBM, who are investing in R&D teams and capabilities to gain an edge.

Since conventional computing systems have separate processors and memory units, conventional chip architecture poses substantial challenges when it comes to hardware implementation and deployment of neuromorphic computing. To try and deal with that, several deployment techniques have been proposed, which entail cutting down on memory requirements to fit the hardware, which is actually undesirable. This has brought ReRAM into the picture.

ReRAM could offer the following advantages:

- 1) smaller footprint and non-volatility (compared to SRAM),
- 2) lower voltages and scaling below 28nm (compared to Flash),
- 3) lower cost, lower surface area, multi-level cell (compared to MRAM).

Taking this a step further, WBT's ReRAM can implement synapses similar to human synapses, as demonstrated at the Flash Memory Summit in 2019 using Spiking Neural Network (SNN) algorithms developed by CEA-Leti. The demonstration provided a proof-of-concept, highlighting the potential of WBT's ReRAM, which can be further explored in the long term to address a potential US\$35bn opportunity by 2035.

*Neuromorphic computing could be another use-case for Weebit's ReRAM in the long term*

## ReRAM demand drivers are plentiful

There is a range of end markets where ReRAM can play an important role, but for now we will limit the scope to those markets that SkyWater (WBT's first commercial customer) and GlobalFoundries are active in. WBT is working informally with GlobalFoundries and could potentially be a next customer.

In all cases, WBT's ReRAM offers a number of benefits compared to Flash and competing emerging ReRAM technologies, including security, tolerance to ionising radiation and electromagnetic interference, its ultra-low power



consumption and its excellent endurance and retention – even in harsh temperature conditions.

## SkyWater serves multiple end markets relevant for ReRAM

**Medical (special sensors, implants, consumables, etc)** – This is a broad category that includes ultrasound, CT scanning, MRI, sensors, implants and consumables. All of these applications require speed, precision and the ability to do more with less, while ultra-low power consumption is a key requirement for these battery-operated devices. ReRAM is ideal, not just because of its superior performance, but also because of its high tolerance to radiation and electromagnetic fields – both of which are becoming increasingly important in treating a wide variety of conditions. Examples of conditions treated by electromagnetic fields include nervous disorders, diabetes and spinal cord injuries, while radiation is used in diagnostic radiology (particularly X-rays) and device sterilization procedures.

**Industrial IoT (high-temperature sensors etc)** - IoT devices generally are an enormous opportunity for ReRAM, although the IoT markets SkyWater targets will mostly be industrial. Examples include automation systems and high-temperature sensors. They rely on rapid, reliable data to maximise their efficiency.

**A&D (aerospace and defence)** - Applications used in the Aerospace and Defence industries remain operational for a long time without maintenance in harsh conditions. As a result, NVMs used in these applications must have high endurance and reliability. Weebit's ReRAM beats Flash in terms of endurance and immunity to radiation (mostly relevant in space), while its tolerance to electromagnetic fields is a key advantage vs. Magnetic RAM (MRAM). Therefore, ReRAM is ideal for Aerospace and Defence applications.

## Many opportunities at GF and other foundries

**MCUs (Microcontroller Units)** - MCUs are microcontrollers, an integrated circuit incorporating a processor (CPU), memory and programmable input/output peripherals. They are essentially small miniature computers designed to control a specific function of a larger electronic product, such as a medical device, vending machine or home appliance.

An MCU needs memory to store the program it needs to execute, as well as the data that the device uses for its operation. MCUs employing ReRAM can perform better than those that use other types of memory technology given its superior qualities – particularly its higher memory performance and longer data retention cycle. Importantly, MCUs that are manufactured at 28nm process node and below cannot integrate Flash memory (as discussed, it cannot scale to such nodes), which makes ReRAM the most suitable alternative with a low-cost structure.

Although this end market may not be as prominent as Automotive (given GF's deal with GM), it is a larger opportunity by market size, including all of the categories below (as they employ MCUs to operate). Indeed, IDC Research has estimated that by 2026, there will be 55.7bn connected devices worldwide that will generate 73.1ZB of data annually. By the way, many Automotive chips are actually MCUs, which blurs the distinction between these segments a little.



It is also one where WBT's ReRAM would be taking TSMC head on as the latter is responsible for 70% of global contract manufacturing for MCUs. As we noted above, barring the unlikely event that TSMC allows competing foundries to use its technology, WBT's ReRAM could well be the only viable alternative for TSMC's competitors to use, including GlobalFoundries.

**WBT could benefit from GlobalFoundries' manufacturing agreement with General Motors**

**Automotive** – This could be the biggest opportunity for WBT amongst GlobalFoundries' customers, and many other foundries for that matter. Back in February, GlobalFoundries signed a long-term agreement with General Motors to manufacture for GM's key chip suppliers in the USA. The move was an attempt by GM to simplify its supply chains and to obtain chips that will be better quality and predictability.

Many features of today's motor vehicles require multiple chips that need memory technology to perform various functions, such as storing code and collected data in demanding environmental conditions (Figure 6). Data loss or delays in processing data can be catastrophic.

Weebit's ReRAM can deliver superior performance and better endurance at high temperatures (150°C) compared to Flash and other alternatives. It is much better scalable and less costly to implement, making it a suitable alternative for the Automotive/Industrial market.

Figure 6: Emerging Discrete NVM market – Growth forecast (2020-2026)



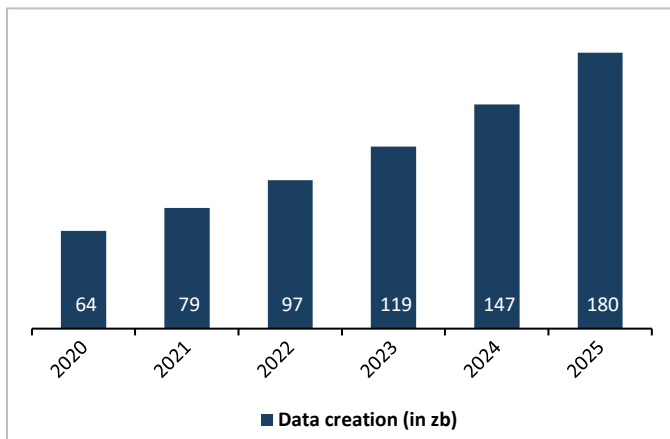
Source: Company

**Internet of Things (IoT)** – IoT devices are sensor-rich and need to store data locally (on the device) for which they require NVMs that can combine high performance with low energy consumption and low costs. This can be achieved by reducing the size of NVMs. Embedded Flash cannot scale below 40nm, which makes it extremely hard to make these devices much smaller and lower power in the long run. ReRAM, on the other hand, offers many benefits over Flash in these respects as it can improve speed, provide better security and has a lot lower power consumption, which extends battery life. The latter is very important for IoT devices as well as Edge devices in general.



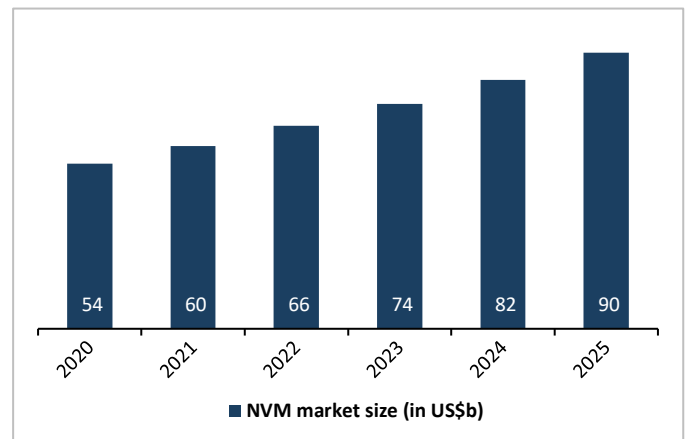
These devices are likely to drive the proliferation of data and generate 180zb of data each year by 2025 (Figure 7). Gathering, storing and processing the data generated by these devices is expected to drive the demand for NVM (non-volatile memory), which is at the heart of data storage and processing functions, to US\$90bn by 2025 (Figure 8).

Figure 7: Forecast for global annual data created (2020-2025)



Source: Investor Presentation - April 2022, Investors, Company website

Figure 8: NVM market - Growth forecast (2020-2025)



Source: Investor Presentation - April 2022, Investors, Company website

**edge AI** – Edge AI applications are required to store weights for artificial neural networks, which need a storage capacity of anywhere between 10 – 100 MB. SRAM and DRAM are volatile, costly and typically require an additional off-chip memory module. Embedded Flash is non-volatile, but scalability issues mandate the use of external memory. ReRAM, however, meets the performance requirements Edge devices, is ~4x smaller than SRAM, is non-volatile and can scale to smaller process geometries, making it ideal for use in Edge AI applications. While ReRAM technology with the storage capacity needs of Edge AI applications has not been developed yet, WBT may further develop this application of ReRAM and potentially enter this segment in a few years’ time.

## Geopolitics are another key driver

Geopolitics is a key driver of demand too as Western countries push to invest locally in semiconductors in order to start reducing their exposure to Taiwanese manufacturing especially. During COVID it became clear that semiconductor supply chains were too reliant on TSMC in particular. On top of that, Taiwan may become a hotspot as China tries to increase its influence (or dominance) over the island.

As a result of these two developments, both the United States and the EU have passed their versions of a Chips Act to boost new fab construction and advanced R&D.

Additionally, many governments have earmarked tens of billions of dollars in new investments towards new semiconductor fabs. The US has committed US\$54bn, the EU \$43bn, India \$10bn and even Singapore is spending \$5bn on one new fab.

South Korea has even earmarked US\$450bn to turn the country into a semiconductor manufacturing powerhouse in the next decade. Similarly, Japan aims to triple its domestic semiconductor manufacturing and has

**Governments are heavily subsidising domestic semiconductor manufacturing**



*New chip designs open up a big commercialisation window for ReRAM*

handed out US\$7bn in subsidies so far to a range of semiconductor companies.

In parallel (and not unrelated), many semiconductor companies have announced substantial capital investments, from the largest such as TSMC and Micron, down to players such as SkyWater – which is building a US\$1.8bn fab in Indiana.

Many of these new investment funds will likely be allocated to leading edge equipment, which implies chip design will likely move to the next level too. In turn, this opens up a major commercialisation window for emerging NVM such as ReRAM.

## Valuation for WBT of A\$9.56 per share

When it comes to valuing WBT versus a peer group, there aren't many listed companies similar to Weebit Nano. However, one that comes fairly close is eMemory (TWO:3529).

Traded on the Taiwan Stock Exchange, eMemory is a 22-year old company focussed on various embedded NVMs, including ReRAM, used in a range of applications. The company is working with a number of foundries, IDMs and fabless chip companies around the world that use eMemory's IP library to design highly secure applications for code storage, anti-cloning, parameter and ID setting, encryption key storage and signal tuning.

With an estimated A\$153m in FY23 revenues (through December) from IP licencing (~33% and royalties ~66%), eMemory is obviously a lot further in its journey than Weebit Nano. However, we believe eMemory is a great example of what WBT's journey may look like, specifically because, like eMemory, WBT aims to complement its future customers' IP libraries with proprietary IP in a highly lucrative revenue model. eMemory's EBITDA margins vary between 60% and 64% with a Return on Equity of 58.2% in FY22.

## Two important differences

One key difference with eMemory is that WBT is 100% focussed on ReRAM, while ReRAM is a specialty/niche product for eMemory. It's main IP centers around OTP (one-time programmable memory), MTP (multi-time programmable memory) and PUF (Physical Unclonable Functions).

Another difference is that WBT aims to sell its discrete ReRAM chips for mass storage applications directly to customers in a fabless model. This is still several years away, but it's different from the licensing model that WBT is using for its embedded ReRAM products and that eMemory is using for its main products.

In the fabless model for discrete ReRAM, we expect WBT's revenues to be substantially larger than would be the case in a licensing model, even though EBITDA margins are typically lower than in a licensing model.

## eMemory is valued at A\$7.8bn

On a fully diluted basis, WBT is currently valued at A\$1.36bn, or ~17% of eMemory's valuation of A\$7.8bn.

As mentioned earlier, eMemory's main focus is not ReRAM and the company is expected to grow its revenues by 16.1% CAGR from 2017 through 2024 (using its reported numbers and S&P Capital IQ estimates for FY23 and FY24). However, as illustrated by the most recent market estimates from Yole,

*WBT is 100% focused on ReRAM and aims to sell discrete ReRAM chips in a fabless model*





embedded NVM is expected to grow by 133% CAGR from 2022 through 2028, i.e. substantially faster than eMemory's top line growth.

So, even though eMemory is a well-established company, while WBT is just starting on its commercialisation journey, we believe the valuation gap between the two companies may be too large and could narrow substantially on the back of WBT's upcoming news flow, especially around its commercialisation, which is in full swing.

## WBT share price catalysts

We believe there are several potential catalysts that could drive WBT's share price higher in the next 12 months:

- First commercial customers for the WBT/SkyWater S130 process, which incorporates WBT's embedded ReRAM in SkyWater's 130nm SOC designs.
- Additional commercial agreements and/or collaborations with large foundries. The company has mentioned on several occasions that it is in discussions with most of the top-10 global foundries and expects to sign another tier-1 foundry around the middle of 2023.
- In addition to foundries, we expect IDMs and fabless chip companies may very well be interested in WBT's ReRAM technology as well. Any news in this regard would add very substantial market potential for WBT that hasn't been talked about very much to date.
- Wider availability of embedded ReRAM in SkyWater processes, e.g. 90nm. This would expand the commercial potential for WBT at SkyWater.
- Positive progress reports on WBT's discrete ReRAM development, initially for lower densities (smaller capacities), i.e. below 64MB.
- Potential M&A discussions involving the acquisition of WBT or part of its IP. The semiconductor industry is highly acquisitive when it comes to expanding IP portfolios. In other words, while talk of a potential acquisition of WBT is speculative at this point, it is not at all beyond the realm of possibilities, in our view.

## Conclusion: New valuation of A\$9.56 per share

Our previous target price for WBT of A\$6.10 has been reached and exceeded. Given the company's progress so far in 2023 and the expected news flow during the remainder of 2023 and into 2024, we believe WBT's valuation gap with a company like eMemory is likely to narrow in the next 12 months.

We believe WBT's valuation should be able to move up to 25% of eMemory's valuation, from 17% currently, if and when the company announces additional commercial deals and positive technical progress on its discrete ReRAM development. At that 25%, WBT should be valued at A\$9.56 per share, which implies 43% upside from the current share price.



## Key investment risks

- **Competition risk:** Alternative emerging memory technologies are being developed by WBT's competitors. These technologies could potentially be superior in nature and/or could be commercialised sooner than WBT's technology, which would inhibit the company's future growth.
- **Funding risk:** Although WBT now seems adequately funded for the medium term, the company may need to raise further capital in the medium to longer-term. That may be required, for instance, if development programs and technology transfers/qualifications take longer than currently anticipated or multiple growth opportunities arise, resulting in dilution for existing shareholders.
- **Macroeconomic and geopolitical risks:** The semiconductor industry is one of the most vulnerable industries to macroeconomic and geopolitical risks – in particular, downturns in the global economy and tensions between China and the West. The prices of semiconductor stocks can fluctuate substantially in response to mere media reports of deteriorating conditions.
- **Operational risks:** WBT's success is assumed on its ability to successfully produce and market the ReRAM technology. A failure in either regard for whatever reasons, such as supply chain issues or departure of key personnel, may lead to a deterioration in investor sentiment towards WBT.



## Appendix I – ReRAM technology...how does it work

### ReRAM technology: The right balance between Flash memory and DRAM

ReRAM is a fast, cost-effective and energy-efficient non-volatile memory (NVM) technology. It can be considered a hybrid memory technology, as it is non-volatile like Flash memory and nearly as fast as DRAM, which is volatile, i.e., a DRAM cell will lose the value (1 or 0) that is stored if the power is switched off. WBT is developing a ReRAM technology, which, in terms of performance metrics, sits right between Flash and DRAM.

#### How does it work?

Generally, in the case of NAND Flash memory, the values of 1 and 0 are attributed based on the trapped electrical charge present in the memory cell's floating gate. However, in the case of a ReRAM cell, the values (1 and 0) are attributed based on the resistance level of the cell material sandwiched between the two electrodes (Figure 1). A value of 1 is attributed to a state of low resistivity, while a value of 0 is attributed to a state of high resistivity.

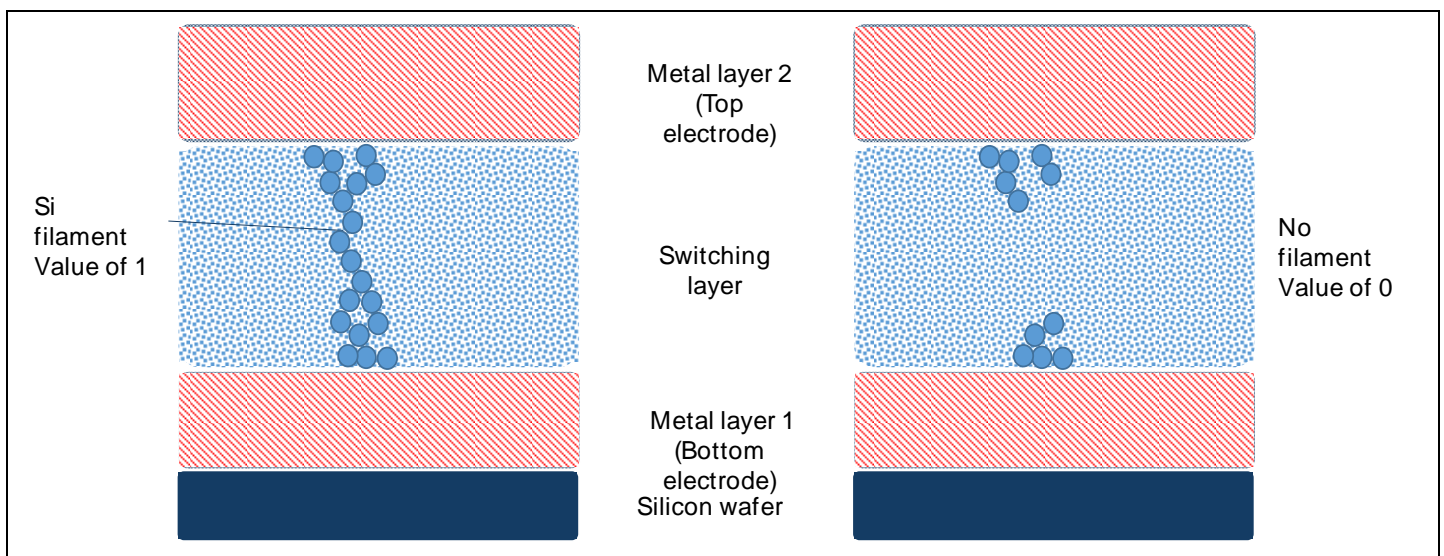
There are two ways of changing the resistance level of a ReRAM cell.

- Through interface switching, which changes the resistivity of the entire layer between the electrodes or
- By creating a filament that connects the two electrodes.

WBT uses the latter.

The technology WBT is developing is based on forming a conductive channel between the two metal electrodes of a ReRAM cell. These electrodes are typically made of metals, such as titanium, tungsten, aluminium or copper. The conductive channel is formed inside a non-conductive layer.

Figure 9: Cell switching by forming and breaking a filament in the switching layer



Source: Pitt Street Research

By applying a certain voltage to one of the electrodes, a switchable filament made of oxygen vacancies can be formed within the switching layer (Figure 9). In this high-conductivity, low resistance state, the cell value is 1. By subsequently applying a reverse voltage to the electrode, the filament can be



broken down again, effectively switching the memory cell back to the original state of 0.

The actual filament is formed as the applied electrical voltage strips away some of the oxygen atoms in the switching layer, leaving the dielectric atoms to cluster and create a conductive pathway to the other electrode. The filament is ~5nm to 7nm in diameter.

## Appendix II – Glossary

**Access time:** It refers to how long it takes to read data or write data to a memory cell.

**BEOL:** It refers to Back-End-Of-Line. It is the second portion of IC fabrication in which interconnecting layers are formed which connect transistors on the wafer.

**CMOS:** It refers to 'Complementary Metal-Oxide Semiconductor', a popular semiconductor technology used to manufacture most chips in the semiconductor industry.

**Data retention:** It refers to the amount of time the data stored in memory will retain its value without any power supply.

**Discrete/Stand-alone NVM:** It refers to a chip which contains only memory.

**DMEA:** It refers to Defence Microelectronics Activity, a provider of microelectronics to all branches of the U.S. government.

**DRAM:** It refers to Dynamic Random Access Memory, a type of volatile memory which is used in computer processors as the main memory

**Embedded NVM:** It refers to memory that is embedded on an SoC.

**Endurance:** It refers to the number of times a block of memory can be programmed and erased before the memory wears out and becomes unreliable.

**Fabless:** It refers to companies which design chips for customers.

**FEOL:** It refers to Front-End-Of-Line. It is the first portion of IC fabrication in which individual components are constructed and patterned inside the wafer substrate.

**Fabs/Foundries:** It refers to companies which manufacture chips for customers.

**IC:** It refers to Integrated Circuit, a set of semiconductor components connected on a single semiconductor wafer.

**IDM:** It refers to a company which designs and manufactures its own brand of chips.

**MPU:** It refers to a Micro Processing Unit, a device that implements the core elements of a computer system on a single integrated circuit, or as a few integrated circuits operating as a cohesive unit, designed for the processing of digital data.

**OEM:** It refers to Original Equipment Manufacturer, a company which produces equipment and parts which are sold by another company to their customers under their own brand name.

**Scaling geometry:** It refers to achieving a reduction in the size of a chip (measured in nanometres/nm) in the fab manufacturing process.

**Neurons:** It refers to fundamental units of the brain which carry information throughout the body.



**nm:** It refers to nanometre. It equals one billionth of a metre, or a millionth of a millimetre.

**NVM:** It refers to non-volatile memory, a type of memory which retains data even when the power supply is disconnected.

**NRE:** It refers to non-recurring engineering costs, a one-time cost which is incurred in the R&D and design phase of a product.

**Rad-hard:** It refers to radiation hardened, a term used to describe devices which can tolerate substantial amounts of radiation.

**SNN:** It refers to Spiking Neural Networks. They are artificial neural networks which mimics the brain's neural networks.

**SoC:** It refers to System-on-a-Chip, a chip which integrates a computer system on it.

**SRAM:** It refers to Static Random Access Memory, a type of volatile memory which is used to store local data and machine code.

**Synapses:** These refer to structures in the human body which facilitate communication between two neurons.

**Wafer:** It refers to a thin slice of semiconductor material.

**zb:** It refers to Zettabyte, a unit for measuring computing memory. It equals  $10^{21}$  bytes. For reference, an mb equals  $10^6$  bytes.

## Appendix III – Analyst certification

Marc Kennis has been an equities analyst since 1996.

- Marc obtained an MSc in Economics from Tilburg University, Netherlands, in 1996 and a postgraduate degree in investment analysis in 2001.
- Since 1996, he has worked for various brokers and banks in the Netherlands, including ING and Rabobank, where his focus has been on the technology sector, including the semiconductor sector.
- After moving to Sydney in 2014, he worked for several Sydney-based brokers before setting up TMT Analytics Pty Ltd, an issuer-sponsored equity research firm.
- In July 2016, with Stuart Roberts, Marc co-founded Pitt Street Research Pty Ltd, which provides issuer-sponsored research on ASX-listed companies across the entire market, including technology companies.

Nick Sundich is an equities research analyst at Pitt Street Research.

- Nick obtained a Bachelor of Commerce/Bachelor of Arts from the University of Sydney in 2018. He has also completed the CFA Investment Foundations program.
- He joined Pitt Street Research in January 2022. Previously he worked for over three years as a financial journalist at Stockhead.
- While at university, he worked for a handful of corporate advisory firms.



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