Pitt Street Research

# Weebit Nano Ltd.

## One step closer to opening up the market for standalone ReRAM

**Share Price: A$1.66**

**ASX: WBT**
**Sector: Technology Hardware & Equipment**
**1 July 2021**

On 25 June 2021, Weebit Nano (ASX:WBT) announced it had successfully integrated an Ovonic Threshold Switching (OTS) selector with a oxide ReRAM cell (OxRAM), an industry first. The company has been working on this milestone for several years together with its development partner Leti, which actually developed this selector prior to its collaboration with WBT. The fact that WBT has been able to use Leti's technology, and work with Leti on this integration, has likely shaved many years off the development process.

### Significance of this achievement can't be overstated

While WBT has been working on its embedded ReRAM module for many years and is now close to signing a commercial agreement for this application, the market potential for standalone ReRAM applications is substantially larger, in our view. To illustrate, the Flash memory market, which WBT could potentially address in due course, is expected to exceed US$80BN in size by 2026.

In other words, the selector/ReRAM integration opens up the largest market segment in the global semiconductor industry. With Flash memory slowly, but surely approaching the end of its useful life, we believe the window for ReRAM is opening wider every day.

### Commercial deal for embedded ReRAM soon

In a recent interview we had with CEO Coby Hanoch it was confirmed that a first commercial agreement for embedded ReRAM should be expected within a few months. Potential customers the company is talking to include semiconductor foundries and product companies.

### Valuation of A$4.75 per share

In our previous update on WBT from January 2021, available *here*, we valued the company at $4.75 per share using industry M&A transactions and parallels to ASX-listed peer BrainChip (ASX:BRN).

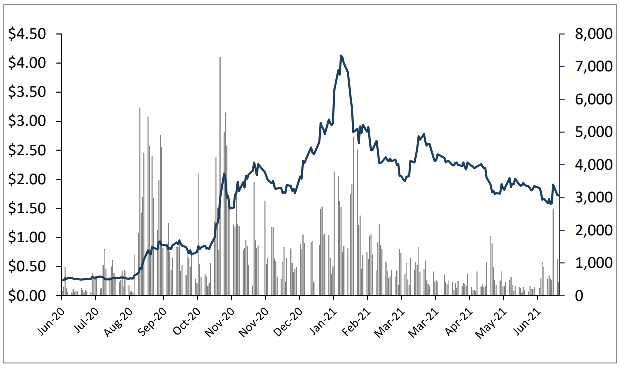
Combined with the likelihood of a commercial deal for the embedded memory module in mid-2021, we reiterate that $4.75 per share valuation.

*Please see page 5 for an overview of key investment risks.*

| | |
|---|---|
| Market Cap. (A$ m) | 203.4 |
| # shares outstanding (m) | 122.6 |
| # share fully diluted | 158.8 |
| Market Cap Ful. Dil. (A$ m) | 263.5 |
| Free Float | 100% |
| 52-week high/low (A$) | $4.27 / $0.26 |
| Average daily volume (x1,000) | 1,247 |
| Website | www.weebit-nano.com |

*Source: Company, Pitt Street Research*

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




*Source: Refinitiv, Pitt Street Research*

| **Valuation metrics** | |
|---|---|
| Valuation per share (A$) | 4.75 |

*Source: Pitt Street Research*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*Disclosure: Pitt Street Research directors own shares in Weebit Nano Ltd.*

## Achievement of crucial technical milestone

Weebit Nano's Resistive RAM (ReRAM) technology is a new form of non-volatile memory. In non-volatile memory the values stored will be retained, even when the power is turned off or lost.

*WBT's SiOx ReRAM technology is applicable to both the embedded and the discrete (stand alone) memory markets*

Non-volatile memory is widely used in electronic systems, e.g. to store pictures and videos on your mobile phone and laptop, to store data on Edge devices in the Internet of Things, 5G equipment, autonomous vehicles as well as storage of all sorts of data in data centers.

This type of memory is known as standalone non-volatile memory or discrete non-volatile memory (NVM). The NVM market is further segmented by technology and usage, including NAND flash, NOR flash, and in recent years also Storage Class Memory (SCM), which technically sits between DRAM and NAND Flash memory.

Non-volatile memory is also used as an embedded solution, i.e. in combination with complete subsystems as the on-board memory component that can be used by that particular system.

The announcement on 25 June 2021, that sent the share price soaring, is related to the standalone memory application, and targets all NVM domains mentioned above.

## Successful integration of selector with ReRAM cell for use in standalone memory

Selectors are used to address individual cells in a memory array for standalone memory. In embedded memory, where memory cell size is less of an issue, this is done with transistors. Transistors are also used in today's main type of storage technology, NAND Flash Memory, and are the limiting factor in reducing the size of the Flash memory cells.

You see, today's Flash memory chips are essentially memory cell skyscrapers with dozens of layers of memory cells stacked on top of each other. The reason for this is that the memory cells will start to interfere with each other if the resolution goes below 28 nanometers (nm). So, in order to build Flash memory chips with higher storage capacity without making the overall chips larger and more expensive, the memory cells are stacked vertically to form 3D Flash memory. I.e. Flash memory got higher, not wider using the same 28nm resolution.

*NAND Flash memory is reaching its limits for storage class applications*

However, the exponential growth of data, video, audio etc. means storage capacity of individual Flash memory chips needs to increase as well. And Flash memory scaling is not likely to keep up with the increasingly stringent technological requirements of the future. From a control point of view (reading and writing the cells) you simply can't keep stacking layer and layer of Flash memory cells on top of each other.

In other words, Flash memory for large scale storage applications (gigabit chips for data centers, laptops, mobile phones) is reaching the end of life phase. While this may still be 5 years away, or even longer, the industry is looking for successors to Flash memory.

Any future SCM type needs to shrink down to at least 20nm, but preferably a lot lower, if it is to become a viable replacement for Flash. In order to do this, a selector is required.

## What is a selector?

***Addressing an individual ReRAM cell requires a selector other than a transistor***

If you want to write one bit of data in Flash memory, you first need to read an entire block of memory cells, change the specific bit you want to change and then write the full block again. Flash memory needs to be addressed by a transistor to change the value of this one cell. However, with ReRAM individual cells can be addressed (read and written to) without having to read and write an entire block. This is where ReRAM's speed and energy consumption advantages compared to Flash memory come from.

In order to address an individual ReRAM cell, you need a specific selector that is able to address that particular cell. And whatever selector you choose also needs to be scaled to smaller resolutions in the future, in line with scaling of memory cells. And a selector needs to be "stackable", just like 3D NAND Flash memory. Eighteen months ago, WBT and it's development partner Leti decided to use an Ovonic Threshold Switching technology that Leti had already been working on for six years.

***Ovonic threshold switching actually resembles the way ReRAM is switched***

Ovonic threshold switching (OTS) was discovered in the 1960's and is based on the reversible transition between a highly resistive state (OFF state) and a conductive state (ON state) when the voltage applied to the material exceeds a critical threshold value, not unlike ReRAM technology itself.

*For more background on ReRAM technology, please refer to the appendix of this note and to our research library on WBT here, specifically our research initiation report from October 20217.*

OTS is already used in phase-change memories, another type of resistive RAM mostly known to be used by Intel's 3DXpoint, and WBT is now the first company that, together with development partner Leti, has integrated this switching method with an oxide-base ReRAM cell.

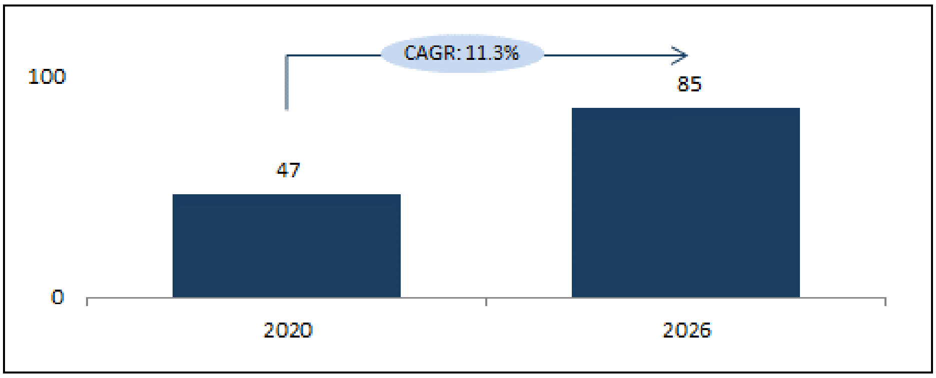
## The importance of this integration can't be overstated

We believe the importance of this successful integration can't be overstated, because it means the company can now move forward and start building discrete memory arrays; initially kilobit arrays and then megabit arrays. But ultimately WBT will need to manufacture gigabit arrays.

***Flash memory market worth USD85BN by 2026***

Gigabit arrays will be required to address the NAND Flash memory market, which is expected to be worth more than USD80BN annually by 2026, according to multiple independent market research firms (Figure 1).

**Figure 1: Global Flash memory market (US$BN)**




*Source: Mordor Intelligence, Pitt Street Research*

As we alluded to earlier, NAND Flash memory really can't scale much further with the 28nm resolution limit already reached. The only way to build larger-

*Flash memory has some life left, but is likely to max out in the not-too-distant future*

capacity NAND Flash memory chips is to keep going vertically. Currently, leading edge Flash memory manufacturers are shipping chips with 128 layers and are working on 176-layer NAND Flash memory chips. There is potential to go to several hundred layers, but where it stops is hard to say. SK Hynix is saying 600 layers is the maximum, while Samsung says it can possibly do 1,000 layers, which will require entirely new cooling systems for the lower layers, incorporating carbon nanotubes, to prevent them from overheating.

***The key take-away is that Flash memory is slowly, but surely approaching the end of its useful life and that the window for ReRAM is opening wider every day.***

We spoke to WBT CEO Coby Hanoch recently. Please see the entire interview through the link below.


## Commercial agreement for embedded memory getting closer

Fow a while now, WBT has indicated that it expects a first commercial agreement for embedded ReRAM around the middle of 2021. In our recent interview with CEO Coby Hanoch he indicated that the company is in advanced discussions with multiple players, including foundries, electronics companies and other potential customers. It appears the company is now very close to signing this first commercial deal.

## Valuation for WBT of $4.75 per share

*Fair value of $4.75 per share*

In our previous update on WBT from January 2021, available *here*, we valued the company at $4.75 per share using semiconductor industry M&A transactions and parallels to ASX-listed peer BrainChip (ASX:BRN).

WBT recently reaffirmed that it expects to be able to sign a commercial deal for the embedded memory module in mid-2021. On that basis, we reiterate our $4.75 per share valuation.

## Key investment risks

- Although WBT is getting closer to commercialisation, the company is still in the development stage of its technology, and hence there is a risk that the potential of WBT's technology may not eventuate.
- Alternative emerging memory technologies are being developed by WBT's competitors. These technologies could potentially be superior in nature and/or could be commercialized sooner than WBT's technology, which would inhibit the company's future growth. However, apart from 4DS Memory (ASX:4DS), we don't see the other ReRAM players (Crossbar and Adesto) as potential competitors. Crossbar seems to have "evaporated" with no significant business activity in the last 18 months, while Adesto was acquired by Dialog for an EV of US$500m (A$758m at the time), specifically for its IP in the Internet of Things (IOT) space. Its ReRAM technology is only used internally and not licensed out at this stage.
- Although WBT now seems adequately funded for the medium term, there remains a risk that the company will need to raise further capital, for instance if its current development programs take longer than currently anticipated, resulting in dilution for existing shareholders.
- There are currently 36m listed, in-the-money, options overhanging the market, which have only been issued recently (July 2020). Therefore, the holders of these options are sitting on a very substantial paper profit and may be inclined to take profits soon. If and when these options are exercised, we believe the 36m newly issued shares will likely be sold soon after exercise.
- COVID-19 is still posing a risk to WBT's research partner Leti in France as new lockdowns may be needed to stem the renewed increase in the rate of infections in France. Additionally, potential inability to travel may pose challenges to WBT's technical and commercial people in its conversation with partners and prospects, which may slow down development and commercialisation.

Please refer to [www.pittstreetresearch.com](www.pittstreetresearch.com) for our initiating coverage report on WBT, including more elaborate risk assessments.

## Appendix I – SiOx ReRAM technology

### 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 SiOx ReRAM, which, in terms of performance metrics, sits right between Flash and DRAM.

### How does it work?

Generally, in case of NAND Flash memory, the values of 1 and 0 are attributed on the basis of the trapped electrical charge present in the memory cell's floating gate. However, in 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 2). 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.

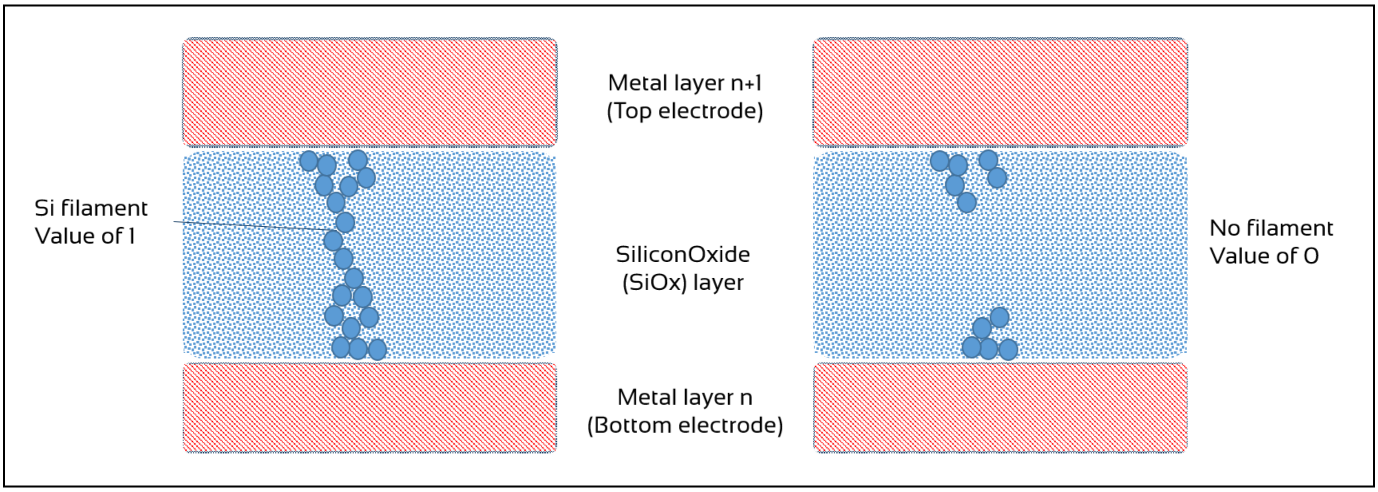
i) Through interface switching, which changes the resistivity of the entire layer between the electrodes or

ii) By creating a filament that connects the two electrodes.

WBT uses the latter.

The technology WBT is developing is based on the forming of 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 SiOx layer.

**Figure 2: Cell switching by forming and breaking a silicon filament in a SiOx switching layer**




*Source: Pitt Street Research*

$SiO_x$ has typically been used as an insulating component in semiconductor manufacturing. However, by applying a certain voltage to one of the electrodes, a switchable conductive pathway of silicon nanowires (filament) can be formed within the SiOx layer (Figure 2). 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 SiOx layer, leaving the silicon atoms to cluster and form a conductive silicon pathway to the other electrode. The filament is ~5 nanometer (nm) to 7nm in diameter.

WBT uses SiOx in its ReRAM cells, a material that is well understood by the semiconductor industry and has been used in chip manufacturing for decades. We believe that the industry's familiarity with SiOx is a key factor in driving the adoption of WBT's technology among both semiconductor design houses and foundries.

### SiOx ReRAM's technical parameters validate its commercial use

***The endurance and retention levels demonstrated by WBT's technology open up many commercial opportunities***

The key parameters for any non-volatile memory are retention and endurance. As demonstrated in the tests conducted by WBT's research partner Leti in May 2019, the company's ReRAM technology is at the forefront of the ReRAM market. The tests demonstrated data retention of over 10 years at 130–150°C, and endurance of a million cycles. Notably, these endurance levels are significantly higher than today's state-of-the-art Flash memory technologies.

Moreover, the retention levels that were achieved at these high temperatures have broadened the scope of potential commercial applications wherein WBT's technology can be used, including the most notable addressable market of electric vehicles.

Additionally, prospective customer XTX has independently verified and validated WBT's technology as well, providing sufficient validation of the technology, in our view.

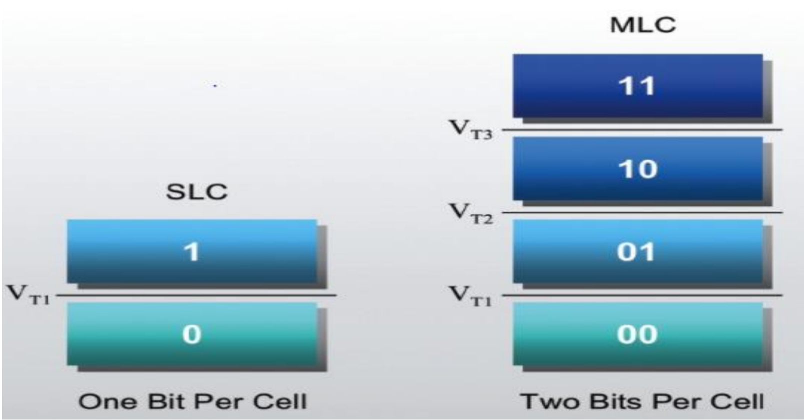
## Appendix II – MLC technology

### MLC technology: Putting more data in the same cell is another way to increase density

Traditionally, memory cells had two possible states, 1 and 0, and therefore could contain 1 bit of data. These cells are termed as single-level cells (SLC). However, now MLCs are available wherein the stored charge can be a variety of values and 2 bits of data can be stored in a single cell (Figure 3). MLC technology thus allows more data per unit of area to be packed onto a chip compared to SLC.

Typically, the cycling endurance and reliability required in end-user applications determine the appropriate storage technology to be used. SLCs have lower power consumption and therefore a longer lifespan compared to MLC (~100,000 cycles for SLC versus ~10,000 for MLC). Owing to higher reliability and faster speeds, SLC can be found in high-end storage applications, including data center storage. However, MLCs are less expensive to manufacture per unit of storage and this makes MLC Flash the most commonly used Flash, especially in consumer electronics such as mobile phones, cameras and tablets.

**Figure 3: Relative voltage levels for SLC and MLC**




*Source: Pitt Street Research*

## Appendix III – Analyst Certification

Marc Kennis, lead analyst on this report, has been covering the Semiconductor sector as an analyst since 1997.

- Marc obtained an MSc in Economics from Tilburg University, Netherlands, in 1996 and a post graduate degree in investment analysis in 2001.
- Since 1996, he has worked for a variety of brokers and banks in the Netherlands, including ING and Rabobank, where his main 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 equities 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.

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