TMT ANALYTICS

DRAM and Flash just had a baby

An industry-first combo of NVM with DRAM-like access speeds and near-zero errors

In a technical update released to the market yesterday, 4DS indicated it has achieved a major technical breakthrough for its Interface Switching ReRAM technology, i.e. read speeds that are approaching speeds seen only in DRAM chips to-date.

Additionally, fluctuations in electrical currents within memory cells, that typically lead to read issues in some other non-volatile memory (NVM) technologies, such as Filamentary ReRAM and PCM, seem to be very limited in the current iteration of 4DS' technology. Consequently, only minor error correction code is required, resulting in very substantial speed gains.

Technical achievements should turn quite a few industry heads

So far, we haven't come across other NVM technologies that combine high read speeds with near-zero read errors, including the much-hyped 3D XPoint. Therefore, we believe this technological update is bound to peek some serious industry interest in 4DS' technology.

From lab to fab

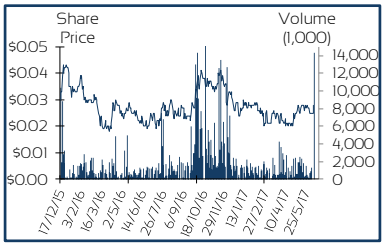
Furthermore, we expect these results will be more than significant enough for HGST, 4DS' joint development partner, to renew their joint development agreement, which is up for renewal at the end of June. The next step for 4DS and HGST will be to go beyond producing basic, proof-of-concept structures and to start transferring the Interface Switching ReRAM design with more elaborate circuitry onto silicon, with the aim to produce a fully functional array of Interface Switching ReRAM cells.

Current market cap nowhere near potential take-out price

Looking at the current market cap of A$ 24.5M, we believe the market grossly undervalues 4DS' technology and market potential. The company has always communicated that it intends to license out or sell its technology to established semiconductor industry participants, rather than build and operate its own fabs. In our view, the current state of 4DS' technology should be a sufficiently solid base to engage in discussions with potential licensees or outright acquirers of the company.

Consequently, following this update the company's valuation should start to reflect the strongly increased probability of a license deal or take-over. Therefore, we reiterate our A$ 0.12 price target and BUY recommendation.

4DS Memory Limited	
Number of shares (m)	845.6
Number of shares FD (m)	947.2
Market capitalisation (A$ m)	24.5
Free Float (%)	85%
12 month high/low A$	0,046/0,018
Average daily volume (k)	1,857



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Flash Note

4DS.ASX

Semiconductors & Semiconductor Equipment

Australia

Risk: High

4DS Memory Limited (4DS.ASX) is a semiconductor development company aiming to provide an enterprise grade storage memory for cloud and data center storage markets. The company is developing a proprietary Interface Switching ReRAM technology leveraging expertise from a strategic partnership with a leading data storage player.

BUY

Current price: A$ 0.029

Price target: A$ 0.12

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Cranking up the currents to improve cell switching results

In the last six months 4DS has been working to improve the read speed of its memory cells. By increasing the electrical currents used to switch an individual memory cell, the read speed has been dramatically increased.

Hard to overstate the importance of near-zero read errors

A current fluctuation study showed no large current fluctuations were observed in 4DS' technology. Consequently, Interface Switching ReRAM will likely only need basic error correction with very limited to no impact on read speed.

It's hard to overstate the importance of near-zero read errors. The ability to read out memory cells with a very limited number of errors alleviates the need to run a lot of error correction code.

Other technologies, such as Phase-change Memory (PCM), used in Intel's and Micron's 3D XPoint memory chips, also achieve high read speeds. However, as a result of a relatively high number of read errors due to random current fluctuations in individual cells, their PCM cells need hardware to correct these errors, which partially cancels out the speed gains achieved during cell reading.

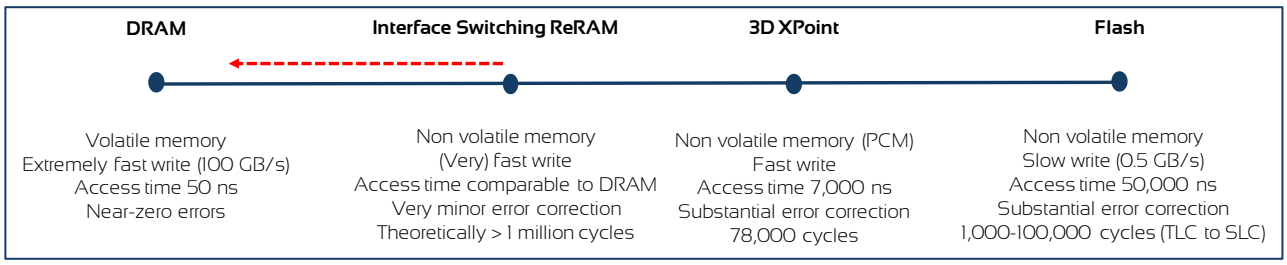
Ticking all the boxes of a potential SCM solution

Prior to yesterday's announcement regarding high read access speeds with very limited error correction, 4DS already achieved several key milestones, including 40 nanometer (nm) resolutions and cycling endurance in excess of 100,000 read/read cycles. Given that currents have been increased to speed up cell reading, we expect data retention will also have improved.

A major step closer to fulfilling the promise of Storage Class Memory (SCM)

As the company announced, its technology is moving closer to DRAM where speed and error levels are concerned (Figure 1). At the same time, the company's goal is to enable Interface Switching ReRAM to be manufactured in GB capacity. In other words, 4DS seems to have taken a big step on its path to fulfilling the SCM promise of high capacity and high speeds, in our view.

FIGURE 1: INTERFACE SWITCHING RERAM SPEEDS MOVING CLOSER TO DRAM



Source: TMT Analytics

Technological achievement may position Interface Switching ReRAM as premium storage solution

To date, 4DS has mostly positioned Interface Switching ReRAM as a next-generation solution in the SCM space, specifically for data centers etc, where Gigabyte (GB) and Terabyte (TB) storage requirements demand high capacity solutions with low energy consumption.

However, based on the technical results 4DS has now achieved, we believe Interface Switching ReRAM can potentially also be positioned as premium storage solution for applications, such as high-end laptops and mobile phones etc. Therefore, once Interface Switching ReRAM becomes commercially available, the combined characteristics of very high read speeds, low energy consumption and high cycling endurance could likely command a pricing premium in the market for mobile applications, similar to the premium SSD still commands in laptops today.

A key element in achieving commercially applicable SCM cells will be the scalability of 4DS' technology. The current resolution is 40 nm, which will likely be sufficient for the first generation of commercial Interface Switching ReRAM modules. However, we would expect further scaling towards 30 nm over time and potentially stacking of Interface Switching ReRAM in 3D structures, similar to how the life of NAND is currently being extended by the industry, in order to bring down price points of Interface Switching ReRAM.

4DS is substantially mispriced by the market

At a market cap of A$ 24.5M, we believe 4DS' market potential is substantially underestimated. Currently, Phase-Change Memory (PCM) and Resistive RAM (ReRAM) as well as higher cost Spin Transfer Torque RAM (STT-RAM), are the three key contending technologies in the SCM race, with all three likely to have a place in the future SCM market.

The SCM market is projected to amount to nearly US$ 5BN by 2021 according to Yole Développement and is expected to increasingly replace Flash memory and encroach on DRAM at the same time. In other words, SCM is not only targeting the US$ 30BN Flash memory market, but may also take share from the US$ 55BN DRAM market over time, depending on performance and price per bit.

While mass adoption of SCM will take several more years, depending on scaling and price points, all players in this market are vying for position. With many companies active in this space and only a few seemingly having made a final choice of technology (e.g. Intel/Micron's choice for PCM), we believe the list of 4DS' potential suitors is quite long and may include Integrated Device Manufacturers (IDM's) as well as foundries, such as Renesas, Infineon, Texas Instruments, MicroChip, Cypress, Panasonic, SMIC, SK Hynix, TSMC, Samsung and Western Digital (SanDisk/HGST) as well as several emerging Chinese companies.

Furthermore, we wouldn't rule out interest coming out of left field, e.g. Apple given its history of IP-based acquisitions and its current interest in Toshiba's Flash memory unit.

In other words, it's clearly a sellers' market for whoever can come up with a viable SCM technology. In our view, with this technological breakthrough 4DS has taken a major step in this direction.

So what could 4DS potentially be worth?

In order to answer this question, we have done a simple exercise in which we assume 4DS licenses out its technology to its current joint development partner Western Digital. Under the development agreement, Western Digital has the option to license 4DS' technology on a non-exclusive basis.

Typical technology royalties in the semiconductor industry range from 5% to 15% of the licensee's revenue generated by this technology. We have assumed royalty payments of 7.5% in a non-exclusive licensing deal. We have not taken into account any upfront payments, such as a license fee or non-recurring engineering costs.

Based on industry numbers from Yole Développement through 2021 (US$ 5BN SCM market size) and assuming declining industry growth rates towards a conservative 30% market growth in 2025, we arrive at a market size for SCM of US$ 32BN by 2025.

We have further assumed Interface Switching ReRAM can hit the market in 2020 starting with a 1% market share for the licensee, growing to 10% by 2025, resulting in gross revenues for 4DS' licensee of US$ 3.2BN by 2025.

Based on the 7.5% royalties, 4DS would generate revenues from 2020 onwards, starting at US$ 2M and growing to nearly US$ 240M by 2025 (SCM market size of US$ 32BN * 10% market share for 4DS' licensee * 7.5% royalties to 4DS). Taking into account current operating costs of approximately A$ 2.5M (growing by 10% through 2025) and discounting back to 2017 at a rich 15% discount rate, yields a value US$ 189M (A$ 252M at an AUD/USD exchange rate of 0.75), or A$ 0.30 per share. Please note this amount does not include a terminal value to capture revenues beyond 2025.

Many assumptions to make, but undervaluation should be very clear

Of course, this valuation is purely theoretical at this stage and there are many variables at play here, such as the royalty rate, the discount rate, market growth and market share of 4DS' potential licensee etc, that impact the company's value in a licensing scenario. Furthermore, we would expect any potential licensee would want an exclusive license to the technology, driving up the royalty percentage.

However, what should be clear from the above is the very substantial gap between 4DS' current A$ 24.5M market cap and the company's potential value in a licensing scenario, which we believe has become substantially more probable following the technical achievement the company just reported.

Take-over more likely than a license agreement

The exercise above should also serve to provide a guide in valuing the company in a potential take-over scenario. A take-over is more likely than a license agreement, in our view, as semiconductor manufacturers will not be keen on sharing the technology through a non-exclusive license agreement, while an exclusive license agreement would be a de facto acquisition, or should be, in terms of valuation.

4DS to re-rate due to expected industry interest in Interface Switching ReRAM

Based on 4DS' latest announcement, we expect the company to now be in a position where it can start discussions with industry participants in this space, including Western Digital, to commercialize Interface Switching ReRAM technology.

Our current price target of A$ 0.12 is based on 4DS approaching the average market cap of ASX-listed semiconductor companies, such as BrainChip (ASX:BRN) and BluGlass (ASX:BLG), that are still in the development phase with their respective core technologies, but that have achieved substantial traction in the market, e.g. through evaluation agreements (Figure 2). However, as illustrated in our valuation exercise above, we believe 4DS' value could be substantially higher than that in case of a potential licensing or take-over scenario.

Based on the valuation upside, we reiterate our BUY recommendation for 4DS.

FIGURE 2: PEER GROUP VALUATION ASX-LISTED SEMICONDUCTOR COMPANIES

Company	Code	Semiconductor sub sector	Share price	Market cap (A$ M)
Weebit Nano	WBT	Filamentary ReRAM	0.019	22.3
Strategic Elements	SOR	Printable memory ink	0.063	15.4
XPED	XPE	IoT communications protocol IP	0.024	27.7
BluGlass	BLG	Semiconductor equipment	0.265	101.4
Brainchip	BRN	Artificial Neural Networks	0.16	135.7
4DS Limited	**4DS**	**Interface Switching ReRAM**	**0.029**	**24.5**

Source: TMT Analytics

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