4DS Memory Ltd.

Getting closer to the strategic end game

4DS Memory (ASX:4DS) is developing a next generation data storage technology that, due to its characteristics, can fill the void between DRAM and NAND Flash memory once commercially available. This so-called Storage Class Memory (SCM) is a newly emerging type of computer storage that is neither DRAM nor Flash, but a hybrid form of storage.

To date 4DS has ticked 3 of the 4 technology validation boxes

Of the four main technological development milestones that all new storage technologies need to achieve to become strategically interesting for industry players, 4DS has essentially achieved three, i.e. access speed, cycling endurance and resolution. And we believe number four, data retention, will likely be ticked in the near term, especially since 4DS started developing its technology using higher electrical currents to achieve faster access speeds. This should also improve data retention.

We believe the read (access) speeds for Interface Switching ReRAM 4DS has recently achieved are of particular interest as these are now comparable to DRAM read speeds (~50 nanoseconds). By comparison, Flash memory can achieve read speeds of around 50,000 ns.

DRAM-like speed to have triggered broader industry interest

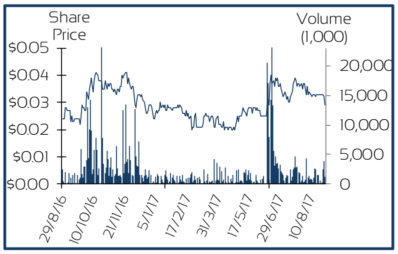
DRAM-like read speeds with near-zero error correction is a ground-breaking achievement for a non-volatile memory technology and will likely have sparked serious industry interest. Apart from 4DS' joint development partner Western Digital (WD), we expect strategic interest from companies such as SK Hynix, Panasonic, SMIC and Samsung, that have all stated ReRAM is their SCM of choice. Additionally, we wouldn't rule out strategic interest from high end consumer electronics companies.

Valuation in takeover scenario at least A$ 0.12 per share

Based on three separate valuation metrics, we believe 4DS is worth at least A$ 0.12 per share. Moreover, depending on circumstances, such as number of interested parties, their strategic priorities, the position of WD, Tech market sentiment etc, a valuation in the range of A$ 0.15 to A$ 0.20 per share may be within the realm of possibilities, in our view.

Management's stated strategy is to seek a strategic buyer for the technology. If executed successfully, we believe the very minimum acquisition price should be A$ 0.12 per share. This implies very substantial upside to the current share price, which is why we reiterate our Buy recommendation and A$ 0.12 price target for 4DS.

4DS Memory Limited	
Number of shares (m)	845.5
Number of shares FD (m)	952.2
Market capitalisation (A$ m)	24.5
Free Float (%)	84%
12 month high/low A$	0,046/0,018
Average daily volume (k)	2,300



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Company report

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. 4DS plans to demonstrate commercial viability in the 2017/2018 timeframe.

BUY

Current price: A$ 0.029

Price target: A$ 0.12

31 August 2017

Interface Switching ReRAM in a nut shell

The best of both worlds: fast and non-volatile storage capacity

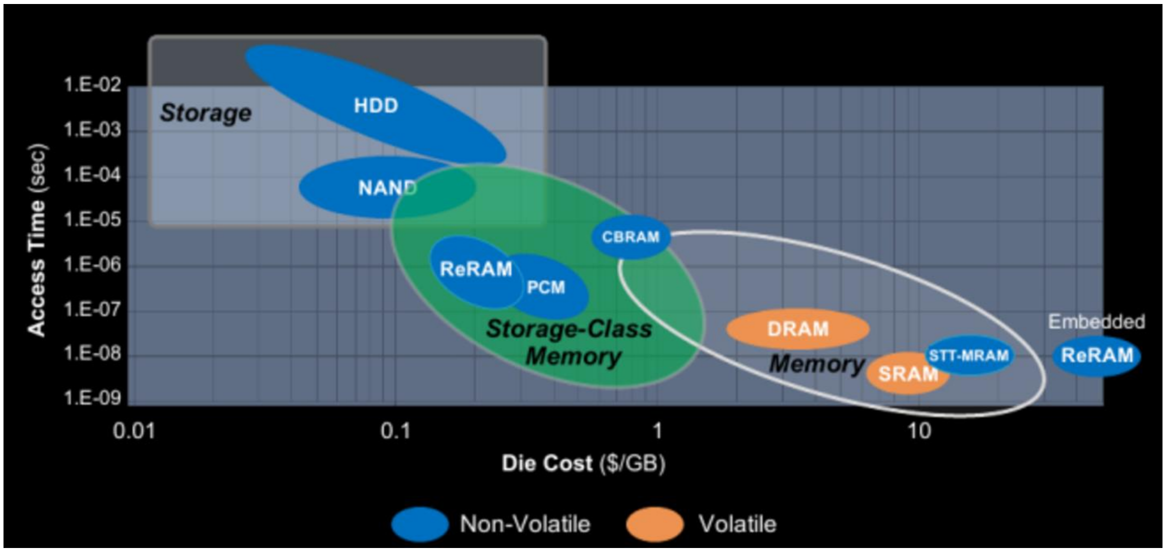
4DS Memory Ltd. (ASX:4DS) is developing a next generation data storage technology that, due to its characteristics, can fill the void in between DRAM and NAND Flash memory (see Figure 1) once commercially available. This so-called Storage Class Memory (SCM) is a newly emerging type of computer storage that is neither DRAM nor Flash, but a hybrid form of storage.

4DS' Interface Switching Resistive RAM (IS ReRAM) is a non-volatile memory, meaning it will retain stored data once that data has been written to the memory cell, even when the power is switched off, similar to NAND Flash. Data stored in DRAM, on the other hand, needs to be refreshed constantly and will be lost when the power is switched off.

However, DRAM read speeds are substantially faster than NAND Flash memory, which provides DRAM with a tremendous speed advantage when compared to NAND Flash. 4DS' technology can achieve read speeds that approach DRAM speeds.

In other words, the technology 4DS is developing combines the best of both worlds; very fast, non-volatile storage capacity that has applicability in a range of storage scenarios, including data centers, laptops, mobile phones etc, that require GB storage capacity.

FIGURE 1: MEMORY & STORAGE HIERARCHY



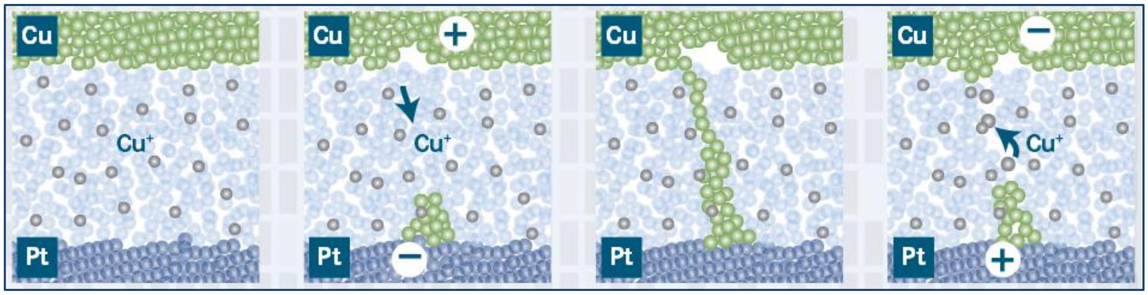
Source: Western Digital, TMT Analytics

Interface switching versus filament

The global semiconductor industry is developing several different ReRAM technologies. One of the key differentiators in ReRAM technology is whether or not a filament is used to create different levels of cell resistivity.

As the name suggests, in filamentary ReRAM a conductive filament, or conductive channel, is created from one electrode to the other by applying a voltage to the top, copper (Cu) electrode. In Figure 2, positively charged copper ions travel through the non-conductive dielectric material towards the bottom electrode made of platinum. The copper ions start to form atoms at the bottom electrode and eventually form a conductive filament connecting the top and bottom electrode. In this state, the cell exhibits a low electric resistance level representing a value of 1. Applying a reversed voltage, the filament is destroyed, changing the material's resistance back to high, representing a value of 0.

FIGURE 2: THE FORMING OF FILAMENT IN RERAM



Source: Forschungszentrum Jülich, TMT Analytics

Interface Switching ReRAM has distinct benefits

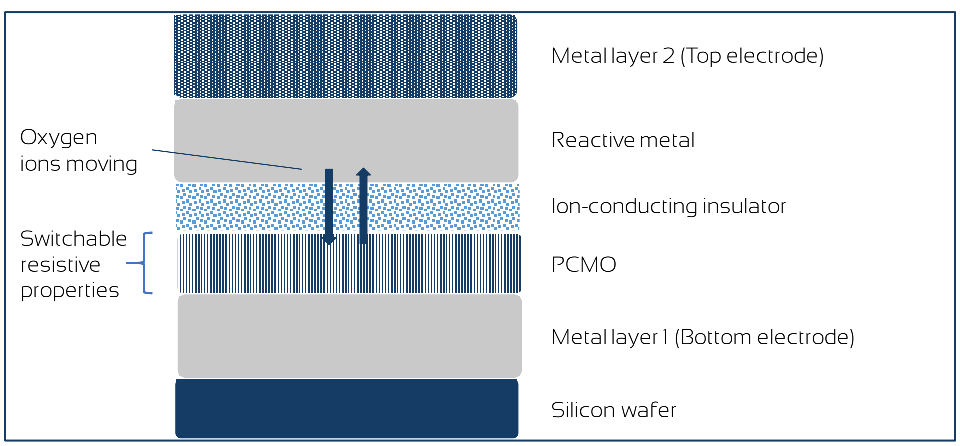
Instead of using materials that stimulate the forming of a filament between two electrodes, 4DS' Interface Switching ReRAM technology manipulates the resistivity of the entire dielectric layer (interface) in the middle (Figure 3). One of the main benefits of this approach is scalability of the memory cell.

Scalability of Interface Switching ReRAM is a big advantage

Interface Switching ReRAM cells, including the surrounding electrical circuitry, can be scaled down in proportion to the electrical currents used to switch the cells. In other words, Interface Switching ReRAM enables lower currents to be used as the memory cells get smaller. Consequently, we expect Interface Switching ReRAM can be scaled substantially below the 40nm resolution (circuitry linewidth) 4DS has already achieved.

Filamentary ReRAM, on the other hand, needs to maintain a minimum size of the electrical circuitry around the cell because this technology typically requires higher electrical currents to switch the memory cells compared to Interface Switching ReRAM. If the circuitry linewidth were to become too narrow, the metal atoms will eventually migrate with the current and the metal wires will fail to carry the necessary current for the cell to operate.

FIGURE 3: DEVICE STRUCTURE OF INTERFACE SWITCHING RERAM



Source: US Patent # 8,378,345 B2, 4DS, TMT Analytics

Cell endurance is substantially higher than Flash memory

Another major advantage of Interface Switching ReRAM is cell endurance. Given that Interface Switching ReRAM does not work on the principle of creating and then destructing a conductive channel between two electrodes, the number of switching cycles of Interface Switching ReRAM is typically substantially higher than for other ReRAM technologies.

For a more detailed description of IS ReRAM, and memory technologies in general, we refer to Appendix A and the research initiation report on 4DS we published on 1 September 2016. The latter is available on our website (www.tmt-analytics.com.au).

4DS aims to sell the technology to a strategic player

Rather than commercialize the technology itself, 4DS' strategy has always been to develop Interface Switching ReRAM to the point where strategic players in the semiconductor or electronics industry will want to acquire the technology outright instead of licensing it from 4DS.

However, any potential acquirer will want to see development of the technology's four key performance metrics to the point where the potential acquirer feels confident enough the technology can be further developed for commercial application.

The hoops that every new memory technology needs to jump through

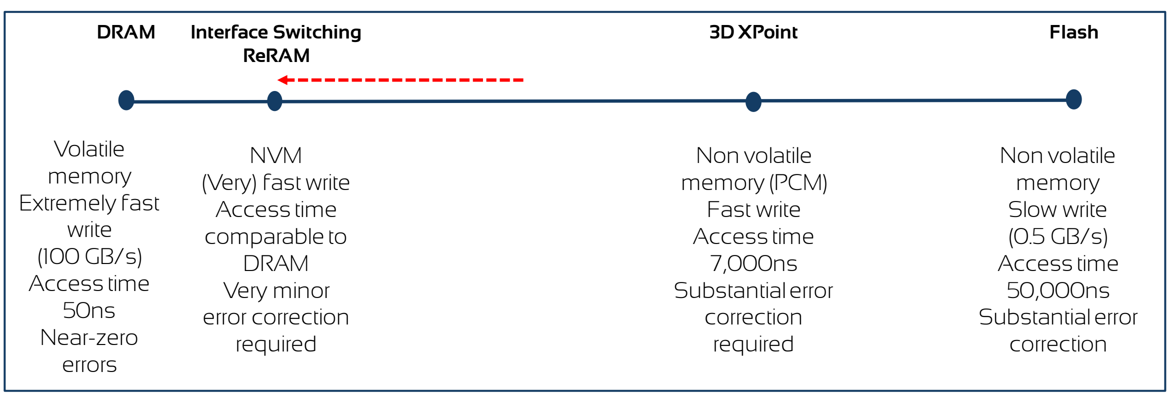
In order to validate a particular storage technology, all memory developers follow a very specific development process. During this multi-year process, memory cells are scaled down towards a certain target resolution and then characterized for cycling endurance, access speed and data retention. The cell architecture and manufacturing process is then further optimized to achieve the targeted goals for these metrics.

Memory device performance is measured on the following key metrics:

Access speed: The speed at which data can be written and read is called access speed. This needs to be sufficiently fast to make the technology suitable for various applications.

Through its development work 4DS has recently achieved read speeds for Interface Switching ReRAM that are comparable to DRAM read speeds of approximately 50 nanoseconds. By comparison, Flash memory can achieve read speeds of around 50,000 nanoseconds. In other words, Flash memory is around 1,000 times slower than Interface Switching ReRAM.

FIGURE 4: ACCESS SPEED BY TECHNOLOGY TYPE



Source: TMT Analytics

Furthermore, Interface Switching ReRAM can be read with near-zero errors, therefore requiring very limited error correction. Certain other emerging storage technologies that can achieve high read speeds require substantial error corrections, which to a considerable extent cancel out the achieved speed gains.

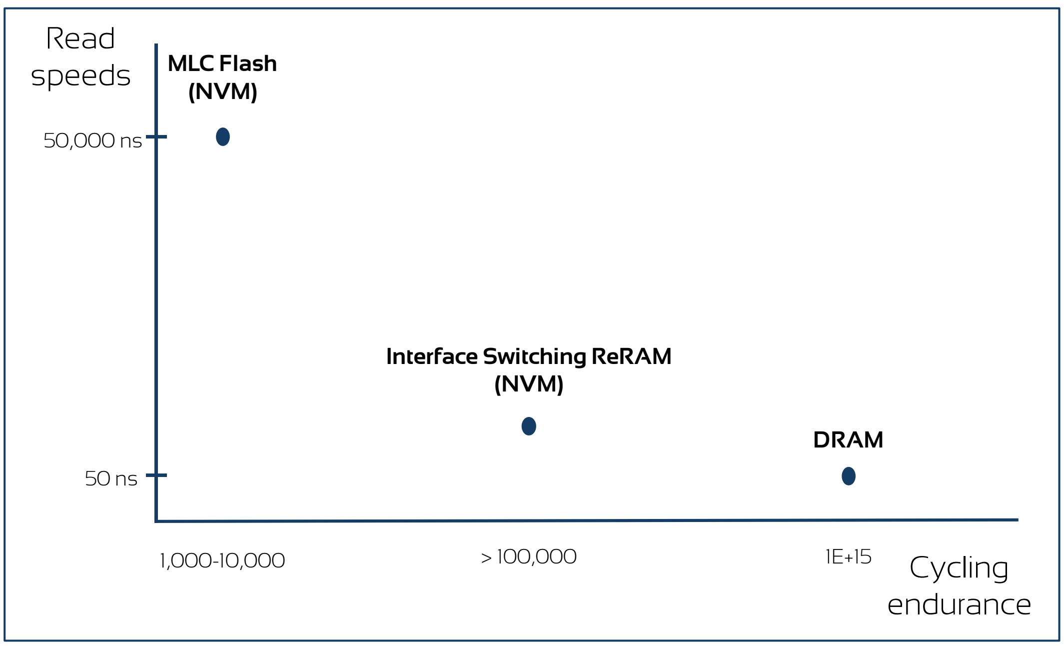
> *DRAM-like read speeds with near-zero error correction is a ground-breaking achievement for a non-volatile memory technology and will likely have sparked serious industry interest.*

Cycling endurance: The number of times a memory cell can be switched from a low resistive state (LRS representing a value of 1) to a high resistive state (HRS representing a value of 0) and back without failure is called cycling endurance.

Today's multi level cell (MLC) Flash memory has a relatively limited number of so-called program-erase cycles (PE cycles), typically between 1,000 and 10,000 cycles, i.e. a relatively low cycling endurance. Single level cells can achieve up to 100,000 PE cycles.

4DS has indicated that Interface Switching ReRAM has achieved cycling endurance for a number of its memory cells well in excess of 100,000. We expect that the technology can be further developed in the next few years to achieve an even longer cycling endurance for end applications that may have such requirements.

FIGURE 5: CYCLING ENDURANCE AND ACCESS SPEEDS (LOG SCALES)



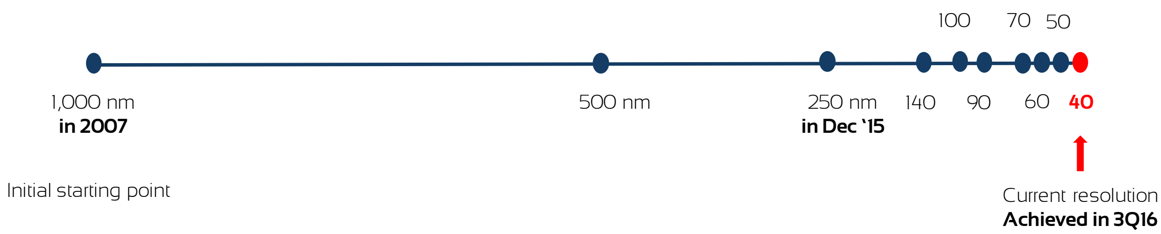
Source: TMT Analytics

Resolution (circuitry linewidth): The linewidth of the electrical circuits of a computer chip is known as resolution. Today's 3D Flash memory is manufactured at a resolution of 40 nanometres (nm) and is therefore the benchmark for any new storage technology. Even though resolutions below 40nm, and even 30nm, are feasible for memory cells, this becomes substantially more expensive given the costs of semiconductor equipment that facilitates these narrower resolutions.

Therefore, current generations of Flash memory are manufactured in stacked layers, i.e. 3D Flash memory. This skyscraper approach obviates the need for resolutions below 40nm, which would be required for single layer cells (SLC).

Consequently, the benchmark for emerging SCM technologies is currently 40nm, which 4DS has already achieved in 2016 (Figure 6). We believe there is no immediate need for 4DS to scale down below 40nm at this stage.

FIGURE 6: EVOLUTION OF 4DS' MEMORY CELL SIZES



Source: Company, TMT Analytics

Data retention is the last major box to tick

Data retention reflects the amount of time a memory cell can stay in a LRS or HRS, and thus represent a value of 1 or 0. Data retention will typically improve with higher electrical currents being used to switch memory cells. However, higher currents may result in memory cells degrading faster. So, a balance between the two needs to be found, again depending on the specific end application.

Furthermore, data retention depends on cell temperature and the number of PE cycles a cell has gone through, i.e. data retention of a specific memory cell will improve at lower temperatures, but will deteriorate with an increasing number of PE cycles.

The higher currents used to achieve DRAM speed should have positive effect on retention

In June 2017, 4DS indicated it had increased the electrical currents used to switch its memory cells in order to achieve DRAM-like access speeds (higher currents lead to better data write results and hence fewer read-out problems).

> *Higher switching currents typically also result in better data retention. In other words, even though 4DS indicated in June that it will need to make further technological progress on data retention, we believe the higher switching currents the company is now applying in IS ReRAM will lead to better data retention compared to late 2016, when the company already mentioned encouraging data retention results.*

While 4DS will obviously still need to confirm and announce data retention results that will be satisfactory for prospective acquirers of the technology, we are quite confident the company will be able to achieve this in the near term, especially given the development team's solid track record of delivering on technical milestones.

Potential application areas now beyond data centers only

4DS has initially been targeting data centers and large-scale storage applications for insertion of Interface Switching ReRAM technology. However, the technical metrics the company has produced over the last twelve months lead us to believe the potential applications for Interface Switching ReRAM are much broader than just data center storage.

Mobile applications and potentially even computer working memory

In our view, Interface Switching ReRAM's very high access speed and cycling endurance would make it a suitable storage application for many mobile devices, such as mobile phones, laptops and tablets. Additionally, depending on eventual commercial price points for Interface Switching ReRAM, we may even see the technology partially replace DRAM, with DRAM and NAND Flash still complementing SCM, as working memory in PC's and laptops, initially at the high end of the product spectrum.

> *This potentially broader application area may not only attract the usual memory players to IS ReRAM technology, but also hardware manufacturers looking for a proprietary edge in storage technology, such as mobile phone and high-end laptop manufacturers.*

Getting closer to the strategic end game

4DS' strategy has always been to develop Interface Switching ReRAM to the point where a semiconductor or electronics manufacturer can acquire or license the technology and develop it further to the point of commercial launch.

With 4DS essentially having achieved three of the four milestones, being endurance, resolution and access speed, we believe the company is getting closer to the strategic end game.

If 4DS can demonstrate satisfying data retention results for Interface Switching ReRAM in the next few months, we believe this will be sufficient to garner interest from multiple third parties, including HGST's parent company Western Digital (NASD:WDC), owner of SanDisk, one of the leading NAND Flash memory manufacturers globally.

Industry interest likely to come from a range of different players

While Western Digital would obviously be in pole position if it were to engage in M&A discussions with 4DS, given its Joint Development Agreement (JDA) with 4DS through HGST, we believe industry interest in Interface Switching ReRAM technology can come from different directions. Especially since recent technological advancements have made the technology more broadly applicable, i.e. beyond data center storage, to mobile applications.

Among the incumbent players, potential interest could come from SK Hynix, Panasonic, SMIC, Western Digital and Samsung given that these companies have all opted for ReRAM as their future technology of choice to address the SCM market, with STMicro undecided as yet. The Micron/Intel alliance have opted for PCM and these companies are therefore less likely acquisition candidates.

Handset manufacturers may show strategic interest

So, in addition to Western Digital and other memory manufacturers, such as Samsung, SK Hynix and Micron, we believe interest could emerge from companies with a strategic interest in SCM. This could include mobile phone manufacturers, such as Apple, Huawei, Xiaomi and (again) Samsung, potentially in conjunction with their manufacturing partners.

China's state-backed push into semiconductors likely to drive interest as well

Furthermore, we would expect several of China's large manufacturers to be interested in Interface Switching ReRAM technology as a future GB storage solution, given a strong, state-backed push to develop a more advanced semiconductor industry.

Under China's economic plan, the country is planning more than US$ 100BN in semiconductor investments, including investments in joint ventures, outright acquisitions and the purchase of foreign semiconductor IP.

Given SMIC's ventures in various SCM technologies in recent years, we would expect SMIC to be one of the key interested players coming out of China.

Several likely strategic scenarios

Scenario 1: HGST (Western Digital) takeover bid

The most straightforward scenario would be a situation in which HGST (Western Digital) makes an outright bid for 4DS, based on the development progress it has seen in the last three years. HGST would need to be convinced that it could take the development process further, to the point where it could manufacture Interface Switching ReRAM at scale within 3 to 4 years. HGST has been able to monitor 4DS' development progress very closely and has firsthand experience in manufacturing Interface Switching ReRAM cells in very small test runs.

Scenario 2: Third-party takeover bid

A second scenario would see a semiconductor or large electronics manufacturer make a takeover bid for 4DS. Earlier we mentioned several companies which we believe might be interested in 4DS' technology, including high-end handset manufacturers and large memory players.

Scenario 3: Technology license deal with HGST or third party

In a third scenario, HGST or a third-party would seek to license Interface Switching ReRAM technology from 4DS, preferably on an exclusive basis. We believe this scenario is the least likely of the three, given that a non-exclusive license would leave the licensee exposed to another industry player licensing the same technology later on, diminishing the value of the license for the first licensee. And an exclusive license agreement would leave the licensee open to a potential change of ownership problem down the line, depending on the agreed license terms.

Could Western Digital frustrate a third-party takeover bid?

4DS' JDA with HGST was renewed for another 12 months on 30 June 2017, providing 4DS continued access to HGST's facilities, know-how and expertise. Without this JDA in place over the last three years, we believe 4DS' development pace would likely have been clearly slower while development costs would have been substantially higher. Therefore, the JDA with HGST has been instrumental in 4DS' progress to date, in our view.

Unclear what rights Western Digital has in case of third-party bid

What is unclear, though, is how the terms of the JDA could affect 4DS' valuation in a potential third-party takeover scenario, i.e. a bid from a company other than Western Digital/HGST in scenario 2.

Under the JDA, 4DS is required to notify HGST of any acquisition or financing proposal the company receives from third parties. Furthermore, under the JDA, HGST has an option to take out a 20-year non-exclusive license on 4DS' technology.

Depending on whether the exact specificities of the JDA will allow it, HGST may choose to exercise its license option in case of a third-party takeover bid or licensing agreement to secure access to the technology and/or to potentially frustrate a takeover bid. This would effectively mean that whoever wants to acquire or license 4DS' Interface Switching ReRAM technology would have to share this technology with Western Digital, which may be a deal breaker for any third party looking to acquire or license the technology.

A drag on valuation?

The exact specificities of the JDA are not in the public domain, which makes it very hard to draw meaningful conclusions on this matter. However, we believe that if HGST has a right to exercise its option when a formal, third-party takeover bid or license deal with 4DS is on the table, this may result in a valuation for 4DS that will likely be substantially lower compared to a situation in which HGST cannot exercise its option while 4DS is negotiating a potential third-party deal.

Although at a very different scale, Western Digital's current battle with joint venture partner Toshiba over the output of their jointly owned multi-billion-dollar Flash memory fab does give an indication of the lengths Western Digital is willing to go to in order to defend its strategic positions.

Outright takeover most likely scenario

We believe 4DS agreeing a license deal(s), even an exclusive one, is the least likely scenario, given the drawbacks for the licensee and the requirement on the part of 4DS to remain committed to further developing Interface Switching ReRAM technology in the next several years.

Regarding a takeover of 4DS, we believe Western Digital is in pole position, but we certainly wouldn't rule out a bid from a third party.

Valuation in the most likely (takeover) scenario

Valuing a pre-revenue company is hard enough as it is, let alone a company that is only expected to start generating revenues three years' from now, and then only theoretically, i.e. 4DS' exit strategy is centered around an acquisition of the entire company by an industry player well before any revenues will be generated.

In order to still get a sense of the potential value of 4DS' technology, we have approached this problem assuming 4DS will license its technology to a third party on commercial terms through 2025. We have subsequently used a DCF model to derive a present value of future free cash flows, which serves as a basis to establish a valuation range for 4DS in a takeover scenario.

DCF in a theoretical licensing scenario

New forecasts from Yole Développement put the size of the Storage Class Memory market at US$ 3.9BN by 2022 (versus earlier forecasts of US$ 4.6BN by 2021). This implies a 106% CAGR when compared to the market size of just US$ 51M in 2016.

Assuming declining industry growth rates after 2022 towards 50% market growth in 2025, we arrive at a market size for SCM of US$ 16.8BN by 2025. For reference, the much more established 3D NAND Flash market is expected to grow by 34% CAGR between 2016 and 2022, from a market size of US$ 5.2BN in 2016. In other words, we believe 50% growth by 2025 in the nascent, but high potential, SCM segment of the memory market is not unrealistic.

We further assume Interface Switching ReRAM can hit the market in 2020 starting with a 1% market share for 4DS' hypothetical licensee, growing to 10% by 2025, resulting in gross revenues for 4DS' licensee of US$ 1.7BN by 2025.

Based on a conservative royalty assumption of 7.5%, 4DS would generate revenues from 2020 onwards, starting at US$ 0.7M and growing to more than US$ 126M by 2025 (SCM market size of US$ 16.8BN * 10% market share for 4DS' licensee * 7.5% royalties to 4DS). We take into account current operating costs of approximately A$ 2.5M (assumed to be growing by 15% through 2025) and a corporate tax rate of 30%.

Including the terminal value (3% terminal growth) and discounting back to 2017 at a 15% discount rate, yields an equity value of US$ 130M (A$ 173M at an AUD/USD exchange rate of

0.79) or A$ 0.18 per fully diluted share. Please note this amount assumes full yearly payout of excess cash.

FIGURE 7: DCF VALUE USING VARIOUS DISCOUNTS RATES (A$ M) AND PER FULLY DILUTED SHARE (A$)

15%	173	0.18
16%	148	0.16
17%	128	0.13
18%	111	0.12
19%	98	0.10
20%	86	0.09

Source: TMT Analytics

Figure 7 illustrates various total equity values for 4DS and values per fully diluted 4DS share under different assumptions for the discount rate. These range from A$ 173M and A$ 0.18 per share using a 15% discount rate to A$ 86m and A$ 0.09 per share using a 20% discount rate.

Sensitivity to royalty rate variations

To illustrate sensitivity to variations in the royalty rate, we have included three different assumptions for the royalty rate in Figure 8. As mentioned, we believe 7.5% is quite conservative for a high potential innovative technology, such as IS ReRAM.

However, even assuming a royalty rate of just 5% and applying the highest discount rate of 20% in Figure 8, we can see a theoretical value of A$ 0.05 per share, which is clearly higher than today's share price.

At a 10% royalty rate, which is a fairly common percentage in the semiconductor industry, 4DS' theoretical valuation goes up to A$ 0.13 per share using the highest discount rate.

FIGURE 8: SENSITIVITY TO ROYALTY RATE

Royalty %	5%		7.5%		10%	
Discount rate	Equity value	Per share	Equity value	Per share	Equity value	Per share
15%	107	0.11	173	0.18	239	0.25
16%	91	0.10	148	0.16	205	0.22
17%	78	0.08	128	0.13	178	0.19
18%	67	0.07	111	0.12	155	0.16
19%	59	0.06	98	0.10	137	0.14
20%	51	0.05	86	0.09	121	0.13

Source: TMT Analytics

In our view, the valuation basis for any takeover discussion should start at a royalty assumption of 7.5% at the very least. But even under the most conservative assumptions of 5% royalties and a 20% discount rate, 4DS is substantially at today's share price. undervalued.

VC funding illustrates the prices market is willing to pay for SCM technologies

4DS' stock market listed peer Adesto Technologies (NASDAQ: IOTS) received US$ 66M in Venture Capital (VC) funding up to its IPO in 2015. Adesto's current market cap is US$ 112M (A$ 142M). Adesto is commercializing Conductive Bridging RAM (CBRAM). 4DS' other listed peer, Weebit Nano (ASX:WBT) raised US$ 7.6M (A$ 6M) to date to develop its Filamentary ReRAM technology.

However, VC-funded peers in the SCM space have received substantially more funding in the last eight years as illustrated in Figure 9. While these technologies are at various stages of development, we believe the average funding in the United States for newly emerging SCM technologies of US$ 95M (A$ 120M) illustrate the market is very keen to invest in these types of technologies.

FIGURE 9: VENTURE CAPITAL FUNDING FOR EMERGING SCM COMPANIES

Company	Technology	Funding to-date (US$ M)
Crossbar	ReRAM	81
Everspin	MRAM	81
Crocus Technology	MRAM	98
Spin Transfer	Spin Transfer Torque MRAM	106
Avalanche Technology	Spin Transfer Torque MRAM	107
4DS Memory*	Interface Switching ReRAM	16.7
	excludes HGST's development expenses estimated at >US$ 15M	

Source: TMT Analytics

Moreover, this average funding of A$ 120M is exactly that, funding. While not publicly available, the valuations at which these funding rounds have taken place are likely to have gone up with every new funding round, each fetching a higher valuation than the previous one.

> *In other words, we expect valuations of VC-funded Storage Class Memory companies to be well north of A$ 120M.*

ASX-listed peers split in two valuation groups

As illustrated in Figure 10 the ASX-listed semiconductor peer group is split into two categories; the companies with a market cap around A$ 20M and the more developed companies with a market cap in excess of A$ 100M. In this respect, more developed doesn't necessarily mean generating substantial revenues, but rather technically more developed with solid traction from industry peers and potential customers.

FIGURE 10: ASX-LISTED SEMICONDUCTOR PEER GROUP

Company	Code	Semiconductor sub sector	Share price	Market cap (A$ M)
Weebit Nano	WBT	Filamentary ReRAM	0.018	21.2
Strategic Elements	SOR	Printable memory ink	0.07	17.1
XPED	XPE	IoT communications protocol IP	0.014	17.2
BluGlass	BLG	Semiconductor equipment	0.26	99.5
Brainchip	BRN	Artificial Neural Networks	0.18	152.7
4DS Limited	**4DS**	**Interface Switching ReRAM**	**0.029**	**24.5**

Source: TMT Analytics *Closing prices 30 August 2017*

4DS to move into clearly higher valuation range

At its current market cap, 4DS is in the first bucket, together with other companies mostly in the development phase of their technology. However, with the last development box (data retention) expected to be ticked in the near term, we believe 4DS will be in a very strong position to engage in discussions with industry players regarding a potential acquisition of the company or technology licensing. In turn, we believe this can lead to a substantial rerating of the company towards valuation levels in bucket two, i.e. in excess of A$ 100M.

> *Summarizing the three valuation exercises in Figure 11, we conclude that the starting point for any discussion around the valuation of 4DS' technology in a takeover scenario should conservatively be at least A$ 100M, or A$ 0.12 per share.*
>
> *Moreover, depending on circumstances, such as number of interested parties, their strategic priorities, Western Digital's position, Tech market sentiment etc, a valuation in the range of A$ 0.15 to A$ 0.20 per share could be within the realm of possibilities, in our view.*

FIGURE 11: VALUATION SUMMARY

Metric	A$ M	Per share
DCF value at 7.5% royalties and 18% discount rate	111	0.13
Average VC funding for SCM companies	119.7	0.14
Average peer group market caps (BRN, BLG)	126.1	0.15

Source: TMT Analytics

Reiterate BUY rating and A$ 0.12 price target

Just in the last 12 months, 4DS has made very substantial progress in developing its Interface Switching ReRAM technology. We believe the company is approaching the phase in its lifecycle where interested semiconductor and electronics companies are starting to show concrete interest in the technology.

While any potential acquisition scenario will be prone to a lot of uncertainty due to the many assumptions that need to be made beforehand, we believe we have demonstrated that, at least from a valuation point of view, 4DS' share price will have substantial upside in such a scenario.

> *Management's stated strategy is to seek a strategic buyer for the technology. If they execute successfully, we believe the very minimum acquisition price should be A$ 0.12 per share. This implies very substantial upside to the current share price, which is why we reiterate our Buy recommendation and A$ 0.12 price target for 4DS.*

Appendix A: Interface Switching Resistive Random-Access Memory

As the name partially suggest, Resistive Random-Access Memory (ReRAM) is based on the resistive characteristics of certain materials in order to store data. Specifically, ReRAM uses an electric current to change the resistance level of the materials inside the memory cell, with a low resistance level associated with a value of 1 and a high resistance level associated with the value of 0.

In a ReRAM cell a dielectric, or non-conductive, material is sandwiched between two metals. When a positive or negative voltage is applied to one of the electrodes, the electrical resistance level of the sandwiched material in the middle changes to high or low, depending on the polarity of the voltage (+ or -).

ReRAM has several key advantages over NAND Flash

Because ReRAM doesn't use an electrical charge to store information, as NAND Flash does, but instead uses a low voltage to change a cell's resistance level, ReRAM is much more energy efficient, which is important in many applications, such as storage in data centers and in mobile devices. Also, the switching speed of ReRAM can be 100 nanoseconds or faster, depending on the voltage used, which is substantially faster than NAND Flash, which typically switches at speeds of more than 1 microsecond (1 microsecond = 1,000 nanoseconds).

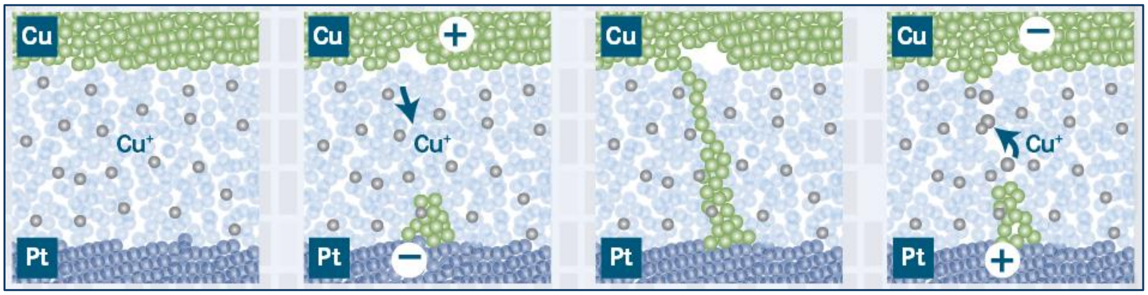
Furthermore, ReRAM has a far superior endurance with the number of P/E cycles potentially orders of magnitude higher compared to today's MLC NAND Flash. Additionally, because the manufacturing process for ReRAM cells is simpler and involves fewer process steps, ReRAM should be cheaper per unit of storage once it's in volume production.

Most importantly though, ReRAM cells can be scaled to much smaller geometries than NAND Flash, which allows for far superior densities and substantially more runway when it comes to taking advantage of future technological developments, especially in lithography.

Different approaches to switching a ReRAM cell: filament and interface switching

There are different ways to alter resistance levels in ReRAM cells. One way is to create a conductive filament, or conductive channel, from one electrode to the other. As illustrated in Figure 12, when a voltage is applied to the top, copper (Cu) electrode, positively charged copper ions travel through the non-conductive dielectric material towards the bottom electrode made of platinum. The copper ions start to form atoms at the bottom electrode and eventually form a conductive filament connecting the top and bottom electrode. In this state the cell exhibits a low electric resistance level representing a value of 1. Applying a reversed voltage, the filament is destroyed, changing the material's resistance back to high, representing a value of 0.

FIGURE 12: THE FORMING OF FILAMENT IN RERAM



Source: Forschungszentrum Jülich, TMT Analytics

Filament-based ReRAM cells have been developed by companies such as Panasonic (in collaboration with Belgian research institute IMEC), Crossbar and Adesto Technologies

(Conductive Bridge RAM, CBRAM) and are commercially available in low volumes for small capacity storage applications in high end applications, such as certain medical devices, wearables and IoT applications. ASX-listed Weebit Nano (WBT) is developing filamentary ReRAM technology using Silicon Oxide (SiOx) as the switching material, i.e. the material in which the filament is formed.

4DS is developing an interface switching ReRAM cell

Another way to manipulate the resistance level of the switching material in a ReRAM cell is based on interface switching. Rather than using materials that stimulate the forming of a filament between the two electrodes when an electrical current is applied, in interface switching memory the resistivity of the entire dielectric layer in the middle is manipulated.

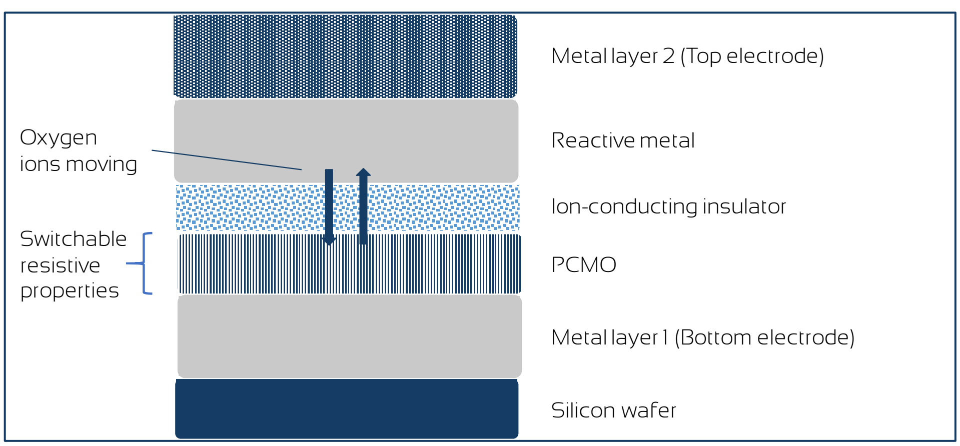
Work that MOHJO!

The heart of 4DS' technology consists of a Metal Oxide Hetero Junction Operation (MOHJO). In semiconductor manufacturing, a hetero junction simply refers to the interface between any two solid-state materials. As illustrated in Figure 13, a material called Praseodymium Calcium Manganese Oxide (PCMO) is deposited onto the bottom electrode made of an inert metal. PCMO, which is a so-called Perovskite material, has certain properties making it highly suitable for this specific type of application. An ion-conducting insulator and a reactive metal, that can partially oxidize, are subsequently deposited onto the PCMO layer, followed by the top electrode, which is also an inert metal.

When a positive voltage is applied to the top electrode, oxygen ions move from the top of the PCMO layer, across the ion conducting insulator to the reactive metal. This substantially increases the resistance level of the PCMO layer to which the value of 0 is attributed. Alternatively, when a negative voltage is applied to the top electrode, oxygen ions move in the opposite direction to the top of the PCMO layer, which becomes conductive again. A value of 1 is attributed to this state of the PCMO layer.

In this memory cell architecture the PCMO layer is effectively the cell switch, meaning that if the correct electric voltage is applied, it will switch from a low resistive state (LRS) to a high resistive state (HRS) or vice versa. By attributing a value of 1 to a LRS and 0 to a HRS, for example, the device can be used to store binary information, i.e. zero or one, similar to other forms of RAM.

FIGURE 13: DEVICE STRUCTURE OF INTERFACE SWITCHING RERAM



Source: US Patent # 8,378,345 B2, 4DS, TMT Analytics

Filamentary versus Interface Switching solutions

One of the key challenges for the filamentary approach to ReRAM is the scaling problem. Memory cells will continue to become ever smaller on the back of technological advancements in semiconductor manufacturing over time. However, the electrical currents required to read and write filamentary ReRAM cells, i.e. to change the resistivity level, will stay roughly the same because switching current is not related to the size of the cell or to the materials used.

However, there is a maximum current that can be applied to any given semiconductor circuit. This so-called current density limit (maximum electrical current per square nanometer) essentially dictates how narrow the lines in a chip can become. If the same amount of electrical current needs to travel through a thinner wire, this higher current density will likely lead to metal migration in the wire and eventually in wire breakdown.

More importantly, every memory cell needs an access device to select the proper cell to write to or read from and the access device needs to be a certain size to carry the filament switching current. The actual size that determines the memory density is the largest of (1) the memory cell size, (2) the minimum wire width to carry the current, and (3) the minimum transistor size needed to control the current.

Appendix B: Board of Directors

James Dorrian (Non-Executive Chairman): Mr. Dorrian is a former partner at Crosspoint Venture Partners, a Silicon Valley based early stage venture capital firm. He has served as both CEO and Board Member of several Silicon Valley companies and has in depth experience in M&A and IPOs. Prior to this, Mr. Dorrian was the Founder and CEO of Arbor Software and has held management roles with a number of multinational IT companies. He is a founding member of the OLAP standards council, an industry consortium for On-Line Analytical Processing. Mr. Dorrian received a Bachelor of Arts from Indiana University in Economics and Communications.

Dr. Guido Arnout (Managing Director and Chief Executive Officer): Dr. Arnout has helped guide multiple Silicon Valley companies through commercialization or sale. He was the founding President & CEO of PowerEscape, which introduced the first tools for the development of low-power software executing on multicore devices. He was also founding President & CEO of CoWare, which pioneered system level design tools for hardware-software co-design and the time-based licensing business model. Dr. Arnout co-founded the Open SystemC Initiative (OSCI), an industry consortium to standardize a language for system level design, and as its President submitted the SystemC language to IEEE. He served as VP of Engineering and later senior VP of marketing of CrossCheck Technology. He co-founded and later became VP of Engineering of Silvar-Lisco, the first commercial EDA (electronic design automation) company. Dr. Arnout received his PhD in electrical engineering from the University of Leuven in Belgium.

David McAuliffe (Executive Director): McAuliffe is an experienced board director and entrepreneur who has had over twenty years' experience, mostly in the international biotechnology field. During that time, he was involved in numerous capital raisings and inlicensing of technologies. He is a founder of several companies in Australia, France and the United Kingdom, many of which have become public companies. Mr. McAuliffe has an Honours degree in Law and a Bachelor of Pharmacy degree.

Howard Digby (Non-Executive Director): Mr. Digby started his career at IBM and has spent over 25 years managing technology related businesses across the Asia Pacific region, including 12 years being based in Hong Kong. Before returning to Perth, he was with The Economist Group as regional managing director. Prior to this he held senior management roles at Adobe and Gartner where his clients included major semiconductor players including Samsung, Hynix and TSMC. Mr. Digby is a Non-Executive Director of Estrella Resources (ASX: ESR) and is currently an advisor to geospatial imagery company Spookfish (ASX: SFI). Mr. Digby has a Bachelor of Engineering (Mech, Hons) from The University of WA.

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