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# Developing nano scale cells for storage class memory

20 October 2016



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# 4DS Memory

**We are** a Silicon Valley memory technology developer listed on the ASX

**We own** 16 US patents with approximately US\$12m invested in development over the past decade

**We make** Interface Switching (non-filamentary) ReRAM for next generation storage class memory

**We enable** higher-density memory to operate cooler, faster and longer

**We have** a strategic partnership with Western Digital subsidiary HGST, a global storage leader

# 4DS has achieved a breakthrough 40nm milestone

- 4DS has achieved working 40nm Interface Switching ReRAM cells for the first time
- This significant milestone was achieved in collaboration with HGST, a subsidiary of Western Digital, the global leader in digital storage
- In the last 2 years, 4DS has consistently improved the scalability of cells from 800nm to 40nm
- 40nm represents a digital memory cell size which is smaller than existing non-volatile memory (NVM) technology, 3D Flash memory
- 40nm is vital for storage class memory – as the cells have no filaments, they are inherently scalable and do not have the same physical limitations as Flash or Filamentary ReRAM
- Patented technology demonstrates potential for 4DS to deliver memory cells which are significantly faster, cheaper and more energy efficient than existing Flash memory

# Why is 40nm significant?

The biggest technical barrier for manufacturers of storage class memory is size

- Memory technology developers are in a race to achieve a resolution of 40nm
- Ability to scale down to 40nm is essential for mass market adoption of storage class memory
- Demonstrating the potential for ongoing scalability is critical for a memory technology to be viable
- 40nm is below the current size of conventional 3D Flash memory of between 45nm to 50nm
- The Flash market is estimated to be around US\$40 billion
- 40nm represents the target cell size needed to prove the value of 4DS' technology to memory makers

# Significantly oversubscribed placement

- A\$4.0 million raised will fund development activities to achieve key technical and strategic milestones
- Significantly oversubscribed, bringing onto the register a number of new, high quality institutions
- Strengthened cash position allows 4DS to focus on demonstrating commercial viability of its technology

A\$4.0 million placement<sup>1</sup>

Tranche 1 - 88.87 million ordinary shares

Tranche 2 - 28.77 million ordinary shares

117.6 million ordinary shares at 3.4 cents

Within existing 15% capacity

Settlement expected 26 October 2016

Subject to shareholder approval at AGM on 30 November 2016

Settlement expected 01 December 2016

1. Completion of placement announced on 20 October 2016.

# Capital structure post placement

ASX Code	4DS
Market capitalisation (fully diluted) <sup>1</sup>	\$32.3 million
Ordinary shares on issue <sup>2</sup>	776.8 million
Performance shares <sup>3</sup>	67.6 million
Unlisted options <sup>4</sup>	106.1 million
Pro forma cash (at 30 June 2016) <sup>5</sup>	\$5.2 million

1. Based on the placement share price of 3.4 cents and including 776.8 million ordinary shares, 67.6 million performance shares and 106.1 million unlisted options.

2. Including 117.6 million placement shares and 113.4 million escrowed shares on issue.

3. Escrowed 12 months and 24 months from relisting with expiry 31/12/18.

4. Including 66.5 million escrowed unlisted options.

5. Includes gross proceeds from the placement.

# Development timeline

<p>Produced 40nm cells, below 3D Flash production geometries</p> <p>16 US patents granted</p> <p>JDA with Western Digital subsidiary HGST renewed to 30 June 2017</p>	<p>Meet endurance performance milestone in early Q4 2016</p> <p>Continue fabrication refinements, characterisation and testing</p> <p>Optimise scalability, endurance, access speed and retention</p>	<p>Expect additional patents to be granted</p> <p>Demonstrate viability of 4DS ReRAM for GB silicon storage</p> <p>Attract a potential IP licensing deal or strategic acquisition</p>
Today	Ongoing	2017 goals



# 4DS Interface Switching ReRAM

## Why is 4DS ReRAM the solution?

- Operates without filaments
  - allows the switching current to scale in line with cell size
- Scales well to smaller geometries
  - well suited for GB silicon storage required for mobile and cloud
- Demonstrates ongoing scalability potential
  - critical to meet the growing demands for storage class memory

## The benefits of 4DS ReRAM

- Higher density / scalability
- Lower power consumption
- Greater endurance and reliability
- Faster access speed and performance
- Simpler manufacturing steps

With **higher density** memory that runs **cooler, faster, longer**, 4DS is well positioned to target the fast growing multi-billion-dollar NVM market

# Joint development agreement with HGST

- HGST is a subsidiary of Western Digital Corporation, the leader in digital storage
- Strategic player in emerging high growth technologies
- Commenced in 2014 and renewed for the 2<sup>nd</sup> time in July 2016
- Goal is to optimise 4DS memory technology for storage class memory
- Collaboration provides access to HGST's expertise
- Accelerates the evolution of 4DS' Interface Switching ReRAM
- Cost effective way to demonstrate commercial viability of 4DS' unique ReRAM technology
- Only known non-filamentary ReRAM technology with a JDA partner

# Our strategy

- Deliver higher density memory that operates with lower power consumption, increased reliability and improved performance
- Develop and own all IP
- Leverage strategic partnership with HGST
- Focus on storage class memory for next generation mobile and cloud
- Demonstrate commercial viability and prove the value of our ReRAM solution
- Create significant shareholder value by continuing to achieve all critical technical milestones

# Summary

- 4DS is developing a next generation Interface Switching ReRAM memory solution which can store more data and can operate cooler, faster and longer compared to traditional storage memory
- Unique, patented IP, wholly owned and developed in-house over the past 10 years
- Development accelerating through strategic partnership with the leader in digital storage
- Low cash burn rate for an emerging memory technology developer
- World-class team of memory specialists, material scientists and test engineers
- Consistently achieved stated milestones
- Board experienced in founding, building and exiting high tech companies
- 4DS is well positioned to target fast growing markets that require storage class memory

**We are addressing the massive memory storage demands of tomorrow**

# Appendix

# Investment proposition

- Penetration of mobile devices, generation of digital content, proliferation of cloud storage, the emergence of the Internet of Things and the growth of connected devices drive the need for memory storage solutions
- NAND Flash (Flash) is a 30 year old non volatile memory (NVM) technology with diminishing ability to reliably scale to meet the exponential growth of data demands
- Industry experts cite resistive random access memory (ReRAM) as the leading emerging memory candidate to overcome the limitations of Flash, creating a multi-billion-dollar emerging NVM market
- 4DS is developing breakthrough ReRAM technology for storage class memory– it enables higher density memory to run cooler, faster and longer than traditional technologies
- With a scalable 40nm cell, 4DS is demonstrating the potential for ongoing scalability, critical for a memory technology to be viable
- Unique, patented IP, wholly owned and developed in-house over the last 10 years
- A strategic partnership with HGST a subsidiary of Western Digital, a world leader in digital storage, is now into its 3rd year
- Experienced management team and industry respected memory specialists

# Board and management team

Global expertise founding and building high-tech companies



**Jim Dorrian**  
Non-Executive  
Chairman

Served as CEO and director of several Silicon Valley companies. M&A and IPO experience gained through founding and managing successful technology exits as a partner at Crosspoint Venture Partners, a venture capital firm for early stage companies.



**Dr Guido Arnout**  
CEO &  
Managing Director

Specific expertise with over 30 years in commercialising electronics technology from concept to product including Power-Escape, CoWare, CrossCheck Technology and Silvar-Lisco.



**Howard Digby**  
Non-Executive  
Director

Former senior roles at IBM, Adobe, Gartner and the Economist Group. Non-Executive Director of Estrella Resources (ASX:ESR) and an advisor to a number of early stage technology companies.



**David McAuliffe**  
Non-Executive  
Director

Experienced company director. Involved in numerous capital raisings and in-licensing of technologies and founder of several companies in Australia, France and the UK, many of which are now publicly listed.



**Michael Van Buskirk**  
Chief Engineering  
Officer

Executive roles with a number of leading memory companies in Silicon Valley including Adesto Technologies Corporation, Innovative Silicon Inc and Spansion Inc.



**Melanie Buffier**  
Corporate Strategy  
& Investor Relations

Investor relations, communications and financial reporting experience gained at some of Australia's leading public companies including Scentre Group, Westfield Retail Trust, and Mirvac Group.



90% of the data in the world today  
was created in the last two years



# Endless demand

Every 24 hours...

**1 million**  
video hours  
are uploaded

**250 billion**  
emails are sent



**700 million**  
tweets are posted

**1.3 billion**  
photos are uploaded

# Silicon storage facts

Apple is the **biggest buyer of Flash** in the world

Microsoft **trialled an underwater data centre** for 90 days to test its cooling benefits

Data centre space will grow to almost **200 million square metres** in 2018

In 2020, demand for silicon storage capacity will outstrip production by **6 zettabytes** (or nearly double the demand of 2013 alone)

Amazon Web Services **adds more server capacity in a day** than Amazon.com had a decade ago

Consumers spend over **US\$2 trillion** on content, devices and services every year

Household digital content is forecast to grow by **150%** in the next 5 years

The world is home to **7.2 billion** mobile devices which are multiplying **five times faster** than we are

# The Looming Storage Crisis

**The world** is facing an impending crisis in memory storage as technology struggles to keep up with demand

**By 2020** demand for storage capacity will reach breaking point as the level of data created, replicated and consumed reaches 50 zettabytes – which is the equivalent of 12,500 billion DVD's<sup>1</sup>

**Flash** memory, the incumbent technology, used in billions of mobile devices, tablets, laptops and data centres cannot scale smaller and cannot forever keep up with these levels of data generation

**Innovation** is needed to meet the future demands for higher density storage that is faster, has greater endurance and is smaller than current technology

1. Source: International Data Corporation.

# 2D Flash versus 3D Flash

Flash currently dominates the silicon storage market

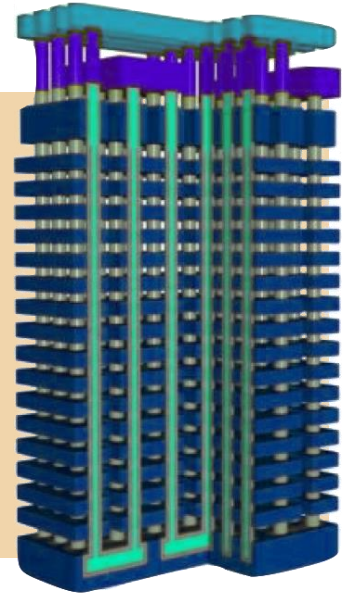
## 2D Flash

- 16nm to 20nm cell size
- Limits are # of electrons



## 3D Flash

- 45nm to 50nm cell size
- Limits are structural



# Flash cannot scale forever

- It's time for a memory innovation for GB silicon storage
- What is ReRAM?
  - resistive random access memory
  - non volatile: retains data when power is switched off
  - changes in material resistance works as the storage mechanism
- Scalability and low currents are essential for GB silicon storage

# ReRAM landscape

Company	Exchange : Code	Market Cap	Type	Target Market
Crossbar	Private	n/a <sup>1</sup>	Filamentary ReRAM	Internet of Things, wearables, SSDs
Weebit Nano	ASX : WBT	A\$35.2 million <sup>2</sup>	Filamentary ReRAM	Internet of Things, wearables
Adesto Technologies	NASDAQ : IOTS	US\$33.6 million <sup>2</sup>	Filamentary ReRAM	Internet of Things
Strategic Elements	ASX : SOR	A\$30.9 million <sup>2</sup>	Nano cube ReRAM	Printable memory
4DS Memory	ASX : 4DS	A\$32.3 million <sup>3</sup>	Non-filamentary ReRAM	Storage class memory- mobile, cloud

## Recent transactions

Acquirer	Transaction	Date	Value	Technology	Market
Western Digital	Acquired startup Virident	2013	US\$685 million	Flash controllers	Cloud
Western Digital	Acquired sTec	2013	US\$340 million	Solid state drives	Cloud
Seagate	Acquired LSI	2014	US\$540 million	Flash controllers	Mobile
Cypress	Merger with Spansion	2015	US\$5 billion	Flash memory	Flash systems
Western Digital	Acquired Sandisk	2016	US\$19 billion	Flash memory	Cloud

1. Raised US\$85 million to date.
2. Fully diluted and based on last close at 19 October 2016.
3. Fully diluted and based on placement price of 3.4 cents.

# Two approaches to ReRAM

The 4DS memory cell uses no filament to switch therefore no scaling issues

	Filamentary ReRAM	4DS Interface Switching (Non-Filamentary) ReRAM
Switching currents	High and don't scale with cell size	Low and <b>scale with cell size</b>
On-off current ratios	Must be high due to widely fluctuating currents	Can be low due to much <b>more stable currents</b>
Scalability	Limited by wire current densities due to constant switching currents	Lower current allows <b>smaller cells</b> not limited by wire current densities
Cycling endurance	Constant filament formation and destruction results in eventual cell breakdown	Does not rely on a destruction mechanism thereby <b>increasing reliability</b>
Data retention	High switching currents needed for long data retention	Low switching currents <b>help data retention</b>
Market sweet spot	Low density: IoT devices, small embedded memories	<b>High density:</b> GB silicon storage for mobile and cloud

# Why is 4DS ReRAM better placed?

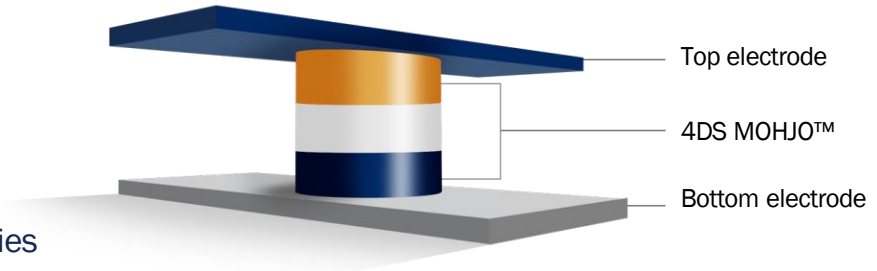
**4DS ReRAM technology is non-filamentary therefore has no filamentary scaling issues**

4DS MOHJO™

- Metal Oxide Hetero Junction – patented cell structure and operation
- Oxygen exchange across hetero-junction
- A voltage pulse reversibly changes resistance
- Reversing voltage polarity switches resistance
- Non-filamentary switching mechanism

4DS patented ReRAM

- Inherently scales well beyond mainstream memories
- Ideal candidate to replace Flash as dominant future non volatile memory





# Corporate directory

## **4DS Memory Limited**

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