A DISRUPTIVE TECHNOLOGY FOR STORAGE CLASS MEMORY
DISCLAIMER

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MEMORY / STORAGE OPPORTUNITY SPACE

- Super low power or super fast
- Limited or massive amounts of data
- Retrieve data locally or from the cloud
- Retain results locally or stream into the cloud
- Must not fail in high temperature environment or when moving (automotive)
- Price-sensitive applications (consumer devices)
## 3 DISTINCT MEMORY / STORAGE CLASSES

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Internet-of-things</th>
<th>Embedded on SOC</th>
<th>High density / High volume</th>
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# 4DS FOCUSED ON HIGH DENSITY / HIGH VOLUME

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### CURRENT HIGH DENSITY / HIGH VOLUME LEADERS

<table>
<thead>
<tr>
<th>Use</th>
<th>Leader</th>
<th>Yearly volume (in gigabytes)</th>
<th>2017 revenue* (by chip makers)</th>
<th>$ per gigabyte</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Memory</td>
<td>DRAM</td>
<td>11.5 billion</td>
<td>US$ 72.1 billion</td>
<td>US$ 6.27</td>
</tr>
<tr>
<td>Silicon Storage</td>
<td>NAND Flash</td>
<td>175.7 billion</td>
<td>US$ 53.7 billion</td>
<td>US$ 0.30</td>
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*2017 Source Gartner*
# HIGH DENSITY / HIGH VOLUME MEMORY / STORAGE

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<th>Feature</th>
<th>DRAM System Memory</th>
<th>NAND Flash Silicon Storage</th>
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<td>Highest 100 times more than HDD</td>
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<td>Cycling Endurance</td>
<td>Highest $10^{12}$ times higher than SSD</td>
<td>Lowest $10^3$</td>
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<tr>
<td>Data Retention</td>
<td>Lowest 0.1 sec</td>
<td>Medium $10^9$ times longer than DRAM</td>
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<td>Random Access Read Speed</td>
<td>Fastest</td>
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<tr>
<td>Bit Capacity</td>
<td>Lowest (2D only)</td>
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### “UNIVERSAL MEMORY” MAY NEVER EXIST

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VAST SPACE BETWEEN DRAM MEMORY & NAND FLASH STORAGE

- **DRAM**
  - Endurance: $\times 10^{12}$
  - Retention: $<100$ ns
  - 9 orders of magnitude

- **NAND Flash**
  - Endurance: $\times 10^{13}$
  - Retention: 10 years
  - 9 orders of magnitude

9 orders of magnitude
STORAGE CLASS MEMORY (SCM)

- **DRAM**: $10^{12}$ endurance, <100ns retention
- **NAND Flash**: $10^3$ endurance, 10 years retention

9 orders of magnitude

Storage Class Memory
4DS AIMING FOR SPACE CLOSE TO DRAM – BIGGEST OPPORTUNITY

Direct Access Read Speed

≈ 50ns

1 to 10µs

<100ns

9 orders of magnitude

10 years

Retention

DRAM

Storage Class Memory

NAND Flash
STORAGE CLASS MEMORY REQUIREMENTS

- Based on well understood physics (like DRAM and NAND Flash)
- Scalable technology over many generations (like DRAM and NAND Flash)
- Tunable technology in the vast space between DRAM and NAND Flash
- Capable of speed as close as possible to DRAM
- Capable of cost/retention as close as possible to NAND Flash
- Current priority is DRAM-like read speed over NAND Flash-like retention
- General consensus is that Storage Class Memory must be area-based ReRAM (non filamentary)
# STORAGE CLASS MEMORY REQUIREMENTS

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## HIGH DENSITY / HIGH VOLUME SWEET SPOTS

<table>
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<tr>
<th>Memories</th>
<th>Systems Memory</th>
<th>Silicon Storage</th>
<th>Storage Class Memory (close to DRAM read speed)</th>
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<tbody>
<tr>
<td>DRAM</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>NAND Flash</td>
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<td>✔</td>
<td></td>
</tr>
<tr>
<td>MRAM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filamentary ReRAM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase Change ReRAM</td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Interface Switching ReRAM</td>
<td></td>
<td></td>
<td>4DS</td>
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</table>
STORAGE CLASS MEMORY: A DISRUPTIVE TECHNOLOGY

Opportunity to offer:

- Faster systems
- Consuming less power
- Capable of processing more data
- In a more cost-effective way

Critical for the fastest growing segments: Cloud and Mobile
ABOUT 4DS

+ Founded in 2008
+ Publicly traded on Australian Stock Exchange (ASX Code: 4DS)
  + 964 million shares on issue / 122 million unlisted options / Market Cap fully diluted at A$0.11.5 = US$90 mil*
+ All technology developed in-house
  + All R&D in Silicon Valley
  + 20 US patents granted + several pending
+ JDA with HGST (subsidiary of Western Digital – US$ 20 billion Market Cap) since July 2014
  + Gives us insight into what is really important in a data-centric world

* As of 23rd August 2018
COLLABORATION AGREEMENT

- Jointly develop a transferrable production ready process
  - For state-of-the-art high volume / high density production tools
- Apply this process on imec’s proven megabit memory platform
  - To fabricate a megabit 4DS Interface Switching chip
  - On same wafer size used for high volume production (300mm)
WHY IMEC?

- #1 independent semiconductor research & development institute
  - Collaborates with the who’s who of electronic products & systems
  - Collaborates with the who’s who of high volume / high density memories
  - Has excellent track record in transfer of semiconductor process from “lab” to “fab”
  - Uses same tools as industry for high volume production of high density memories
  - Uses same wafer size (300mm = 12”) as industry uses for volume production
- Long track record in research & development of emerging memories
  - Has a proven megabit memory platform
  - Has used this platform to explore a wide range of emerging memories
CURRENT STATUS

- Scales to geometries needed for high-density and 3D: 40nm
- Endurance yield > 97%
- Read speed comparable to DRAM: *an area-based ReRAM first*
- No need for speed-crippling error correction: *a ReRAM first*
- Endurance between DRAM and NAND Flash
- Retention between DRAM and NAND Flash
- imec wafers from production equipment due late September 2018
BOARD AND MANAGEMENT

Global expertise founding and building high-tech companies.

JIM DORRIAN
Non-Executive Chairman
- Served as CEO of several Silicon Valley companies
- Extensive M&A experience
- Partner at VC firm Crosspoint Venture Partners

Last transaction was the sale of Bill Me Later – a company Jim founded and sold to PayPal for US$1 billion

Dr GUIDO ARNOUT
CEO & Managing Director
- 30+ years in commercialising electronics technology
- Successes include, Power-Escape, CoWare, CrossCheck Technology and Silvar-Liso

HOWARD DIGBY
Non-Executive Director
- Former senior roles at IBM, Adobe, Gartner and the Economist Group
- Non-Executive Director Elsight Ltd and Chairman of Omni Market Ltd
- Advisor to a number of early stage technology companies

Dr SESHUBABU DESU
Chief Technology Officer
- Expert in thin films, semiconductor processing and non-volatile memories
- Professor, Dean and Head of Electrical Engineering at various universities

DAVID McAULIFFE
Executive Director
- Experienced company director
- Involved in numerous capital raisings and in-licensing of technologies
- Founder of several companies in Australia, France and the UK, many of which are now ASX listed

MICHAEL VAN BUSKIRK
Chief Engineering Officer
- Executive roles with a number of leading memory companies in Silicon Valley
- These include, Adesto Technologies Corporation, Innovative Silicon Inc and Spansion Inc.
THANK YOU