Weebit Nano (ASX: WBT)
Silicon Oxide ReRAM Technology

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Leti Memory Workshop
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The Emerging Memory

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Weebit-nano Fast Facts

Re-listed on the ASX in August 2016

Targeting embedded, storage and next generations markets

HQ in Israel, R&D in France via Leti

Business and technological Partners: CEA/Leti – France, Rice University - USA

Developing next-gen memory solution based on Silicon Oxide (SiOx) ReRAM

Several US Patents

Our Mission is to Bring to the world a highly manufacturable high performing ReRAM technology

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Israel - Major Center for Breakthroughs in Memory Technologies

2006 - M-Systems The inventor of USB Flash Drive. Acquired by SanDisk for $1.6B (third largest acquisition in Israel's history)

2007 - Saifun a provider of intellectual property (IP) solutions for the NVM market Acquired by Spansion for $368M in 2007

2008 - XIV a manufacturer of high-performance digital storage systems. Acquired by IBM for $350M

2012 - Anobit maker of flash storage technology. Acquired by Apple for nearly $400M and being used in Apple MacBook

2012 - Xtrem IO pioneer in Solid State storage. Acquired by EMC for $430M

2015 - SanDisk Founded by the Israeli Dr. Eli Harari was acquired by WD for $19B.

Weebit Nano Leadership Team

Prof. James Tour

Inventor

Scientist of the Year 2013
R&D magazine

Inducted to the National
Academy of inventors

Feynman prize in
Nano science

David (Dadi) Perlmutter

Chairman

Ex-Intel EVP
IEEE Fellow

Has led intel into
the Data Center

Brought to Market:
Centrino™ mobile technology

Yossi Keret

CEO

Extensive management and
financial experience

Financially led a variety of
international companies

Experience in equity raisings
for public companies

Amir Regev

VP R&D

Two decades in
Semiconductors engineering

45nm NOR Flash Technology
Development at Micron

Was part of Automotive
division at Intel

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Data Going Wild

1.7 Million Instagram Photos

3.3 Million Facebook posts

77,160 hours of video streamed on Netflix

3.1 Million Google Searches

205.6 Million Emails

in **60** seconds

400 Hours of Youtube Videos

51,000+ Iphone applications downloads

370,000 Skype calls

44 Million Whatsapp Messages

422,340 Twitter tweets

Data as of 2016

Storage Capacity Went up to the Cloud

"Insatiable demand for data"

World memory data storage use is growing exponentially

The world is becoming increasingly desperate for a high performance memory device.

Global digital data

2020
40 ZB

2015
7.91 ZB

2012
2.72 ZB

*1 zettabyte = 10^{12} gigabytes

Power Consumption

- In 2014, data centers in the U.S. consumed an estimated 70 billion kWh, representing about 2% of total U.S. electricity consumption

- By 2020 US will need another 17 power plants to meet storage demand*

Data centers are becoming the new polluters

Energy efficiency is not nice to have – it's a MUST!

*Patrick Thibodeau COMPUTERWORLD

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Artificial Intelligence has entered our lives

Man VS. Machine - IBM's Watson Supercomputer Destroys Humans in Jeopardy

From mobile first
to AI first

60%-70% of the IBM
cloud customers are
using Watson AI

Computer (IBM Watson) VS. Human Brain

IBM Watson supercomputer

- 2880 computing cores (90*8*4)
- Volume - 10 refrigerators in size
- Power - 80 kW
- Frequency –> 3.5GHz
- Memory – 16TB RAM (not HDD!)
- 20 tones of air-conditioned cooling capacity

Human Brain

- 10^{11} Neurons 10^{15} Synapses
- Volume - 2 liter
- Power – 10-20 Watt
- Frequency – 4, 8, 40Hz
- Event Driven
- 2 Kg brain weight

Biological brain benefits:

- Massively parallel
- Three-dimensionally organized and extremely compact
- Extremely Power efficient
- Combines storage and computation
- Fault and variation tolerant
- Self-learning and adaptive to changing environments

Biological brain – extremely efficient computing architecture

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Brain-inspired neuromorphic computation aims

Emulate the brain Instead of *simulate* the brain

ReRAM has been identified as a potential
synapse physical and behavioral similarities
Ions migration leads to resistivity modulation

The ability to mimic the biological computation at
the synaptic level will be a big step forward toward
building massively parallel computational systems
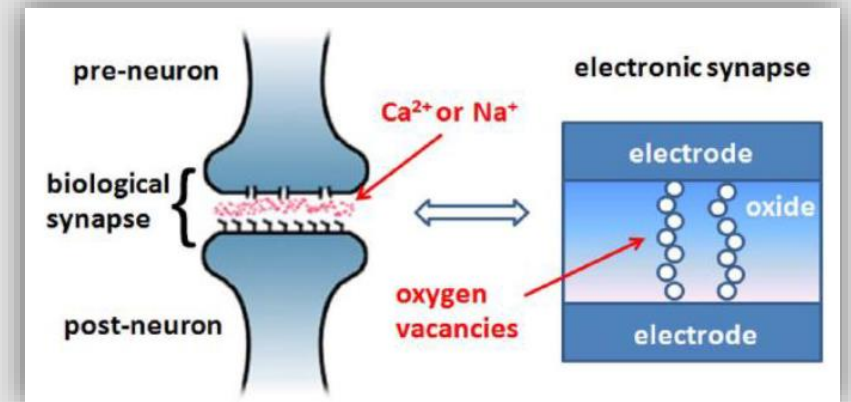
Ions migration leads to resistivity modulation

Why neuromorphic computing

Conventional computing:

- Already facing scaling challenge (Moore's law)
- Excessive power consumption – 4-6 orders of magnitude than the brain
- Physical separation between CPU and memory – Von Neuman bottleneck

Neuromorphic computing:

- Mimic neuro-bio architecture of nervous system
- highly energy efficient - Asynchronous event driven algorithms
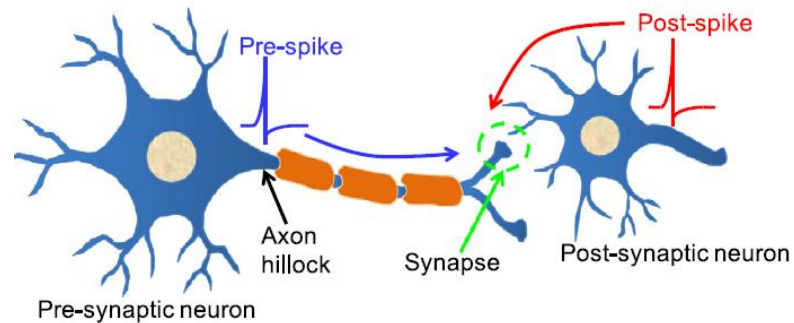- Localization of the memory and processing units synapse and neurons

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Basic Concept – From Neurons to learning

o 10^{11} neurons and, 10^{15} synapses - Each neuron connected through 1000–10,000 synapses

o Hebb's Law (1949) - 'Neurons that fire together, wire together'
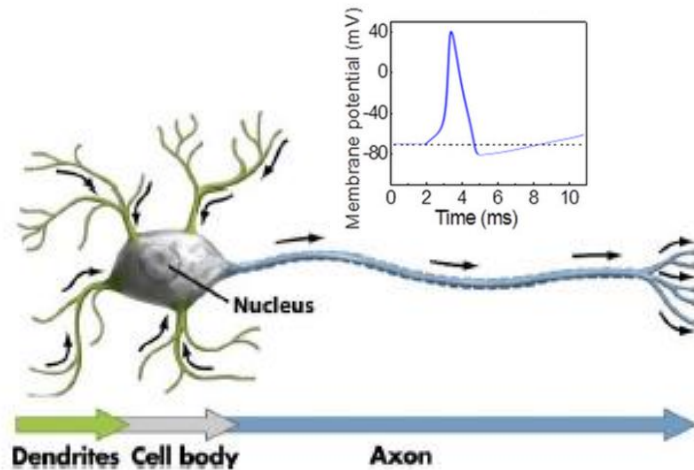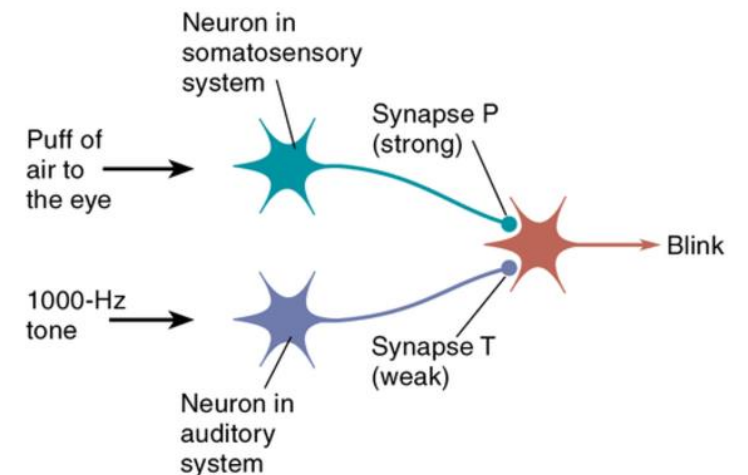
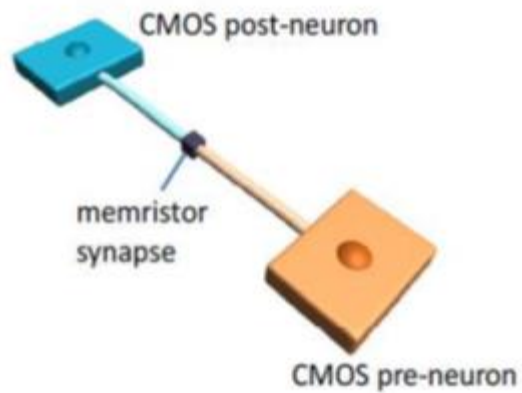**Basic Neuron**   **Pre-Post Neuron Synapse**   **Hebbian Learning Plasticity**
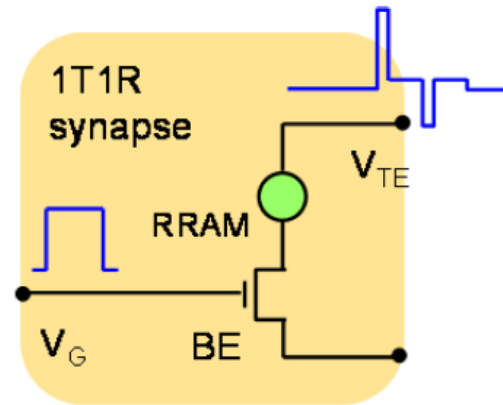
Basic Concept – From ReRAM to learning

- STDP events - Spike Time Dependent Plasticity
- SRDP - Spike-Rate Dependent Plasticity
- LIF – Leaky Integrate and Fire - Integration of Spikes
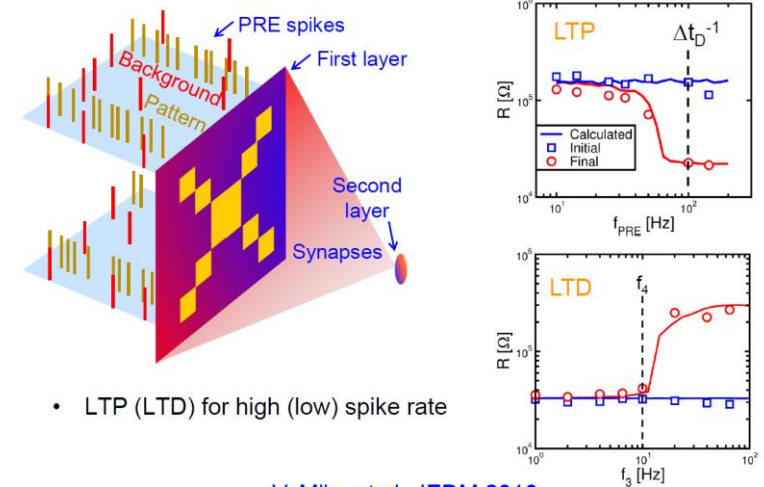
Basic Memristive Synapse   **SRDP concept**   **Online unsupervised learning**

S. Ambrogio, et al., Nanotechnology 24 (2013)

V. Milo, et al., IEDM 2016

ReRAM Technology for Tomorrow

Mimic the brain as accurately as possible

- Incredible ReRAM resembles to Neurons biological synapse
- Physical similarities leads to functional similarities
- Highly energy efficient

Which make it an enabler to Brain Inspired Artificial Intelligence systems using ReRAM
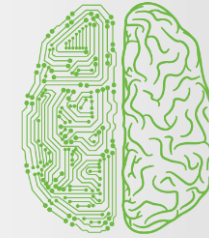
Brain inspired computing systems

Object recognition
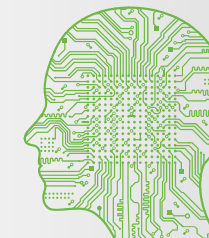
Machine learning

ReRAM is the solution for tomorrow's needs Achieving artificial intelligence capabilities

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ReRAM Technology Development Today

ReRAM designed for the Next-Gen memory:

Energy Efficiency
Ultra-low Power in pJ range

Speed
Fast programming 100-1000 faster than Flash

Integration
Bringing the memory closer to the processor

Low Cost
Manufacturability - minimum added process steps and cost

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Market Requirement for NVM

- Total Amount of Storage requirement is Growing, Doubling every 2 years
- Total Number of Connected Devices is Growing - 50B expected by 2020

Storage – Standalone Memory

- Insatiable demand for data
- Storage Class Memory
- Next Gen SSD

3D architectures + Multi Bit capabilities

Devices – Highly Integrated Memory

- IoT and Embedded
- Neuromorphic Systems
- Novel Computing architectures

CMOS integration with minimal added masks

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Manufacturability

Weebit nano SiOx ReRAM – manufacturability oriented:

Silicon Oxide – Weebit nano Next-Gen memory solution:

o **Fab Friendly** – ½ Century Process and Manufacturing experience

o **Compatibility** – well integrates with existing proven processes

o **High Bandgap** – Large memory window

Silicon Oxide – manufacturable anywhere:

✓ **Any Fab** – no need for specialized foundry

✓ **Any Tool** – no need for special tool

✓ **Any process** – no need for special process

Silicon Oxide- shortest time to market

🟥 ReRAM Not Used in Semiconductor Fabs   🟩 Used in Semiconductor Fabs

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Summary

ReRAM technology Addressing exponentially growing memory market

New opportunities emerging in cognitive Artificial Intelligence systems

Weebit Partnership with Leti - a world leading research institute

Energy efficiency is the key in every aspect of devices and cloud

Manufacturability is a key issue in adopting new technology

Silicon Oxide- shortest time to market

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Silicon Oxide - Shortest Time to Market

Thank You!

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