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THE NEXT NVM IS HERE

How an Embedded Non-Volatile Memory Can Be a Differentiator

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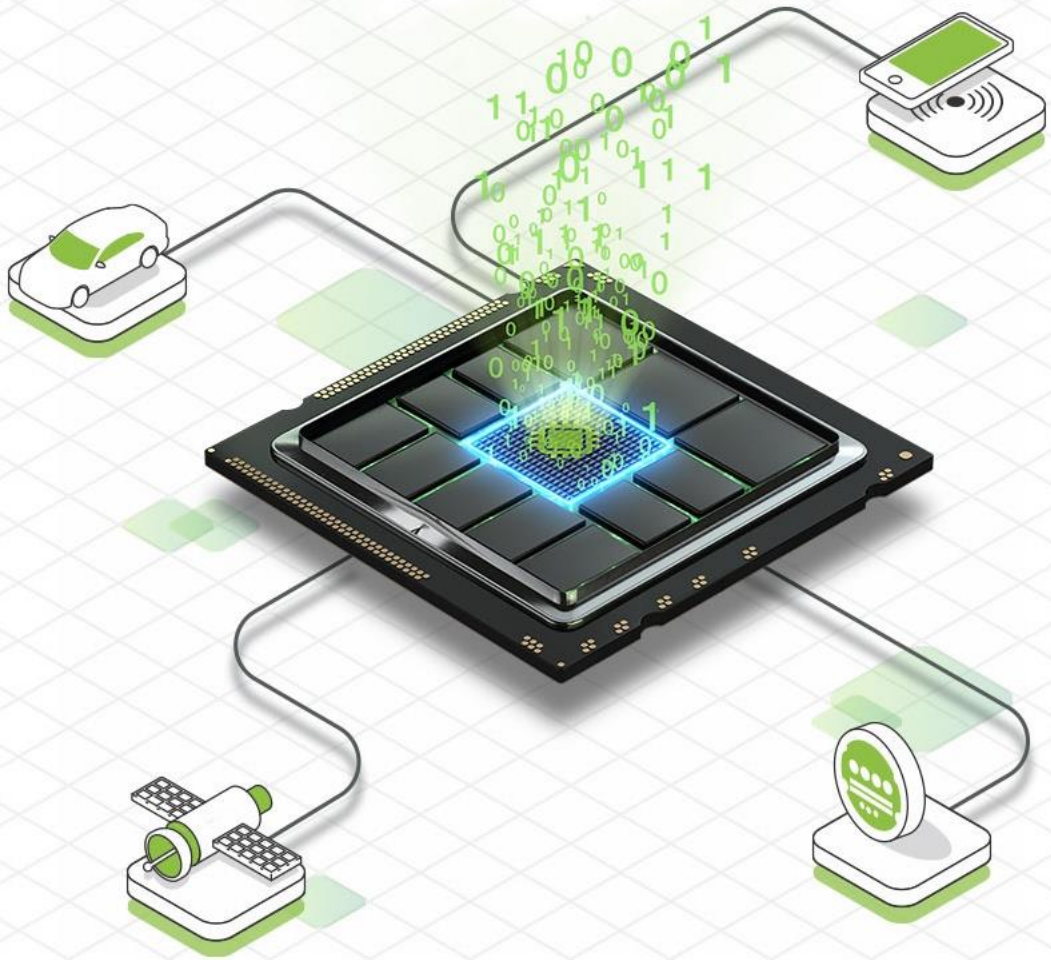
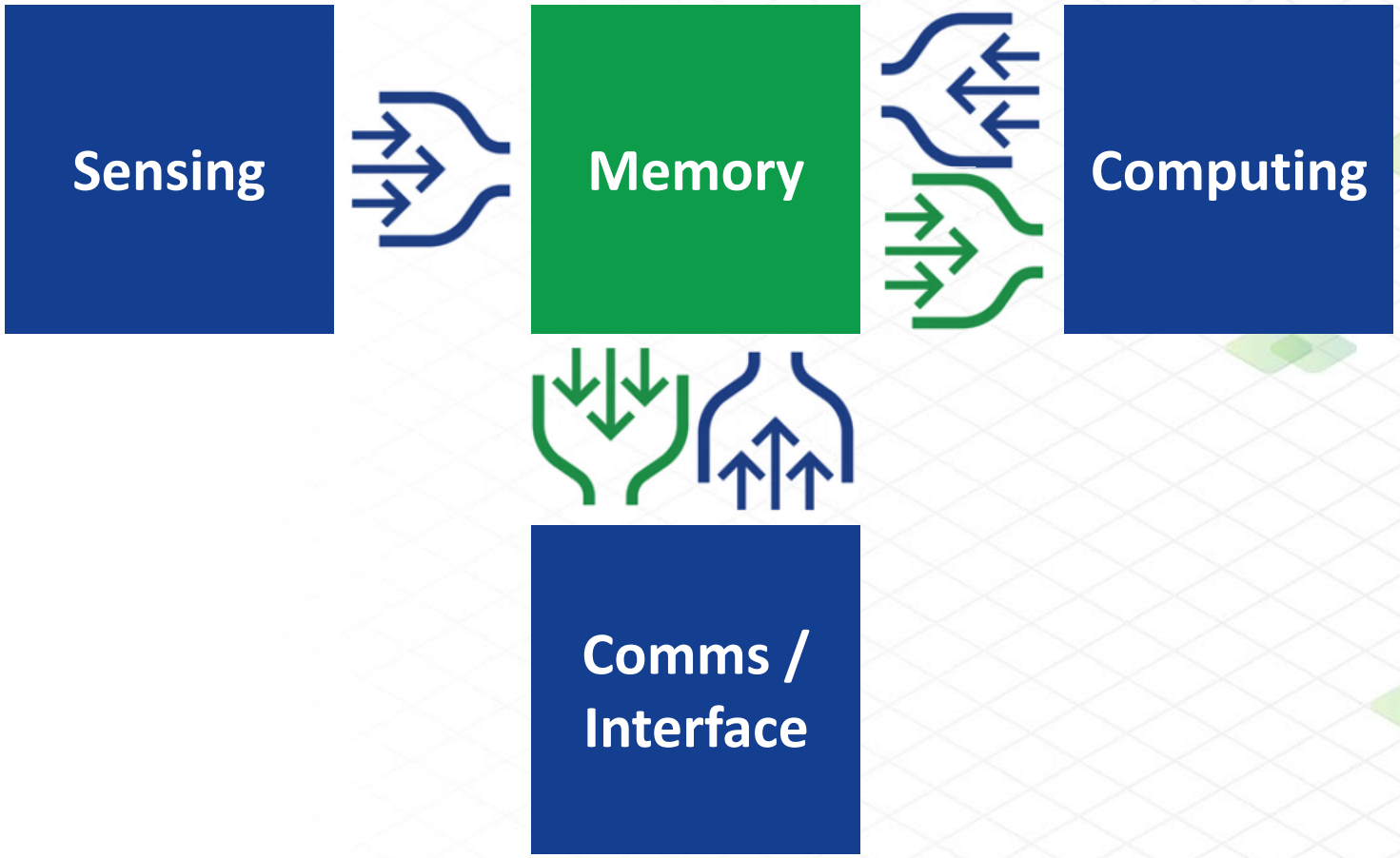
Outline

- Bottlenecks at the Edge
- Intro to Weebit ReRAM
- The State of Weebit ReRAM Today
- ReRAM: Why Now?
- Where ReRAM Can Provide Differentiation



Bottlenecks at the Edge



Innovative new technologies can overcome memory bottlenecks

- Bandwidth
- Speed
- Power Consumption
- Security

Who Is Weebit Nano?

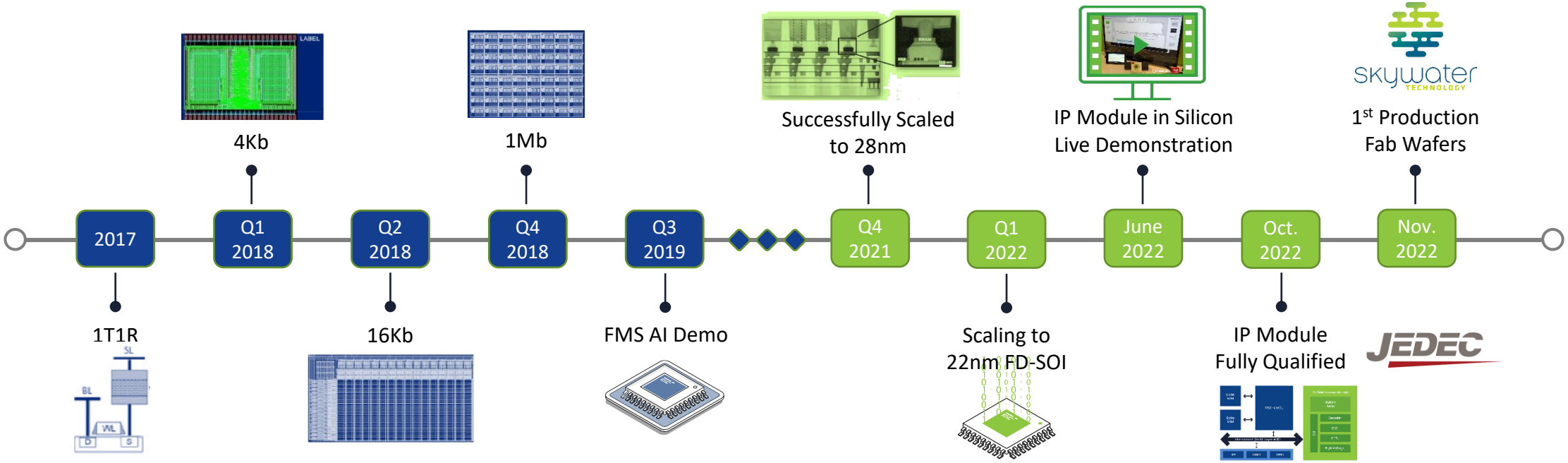
Leading developer of innovative next-generation memory technology: Resistive RAM (ReRAM)

Founded: 2015
Located in Israel & France, ASX:WBT

CEA-Leti: R&D partner
Leveraging years of research experience in NVM & ReRAM

Current business model
IP licensing to semiconductor companies & fabs

Silicon-proven technology
Mbit arrays avail @ 28-130nm
Fully qualified, production-ready



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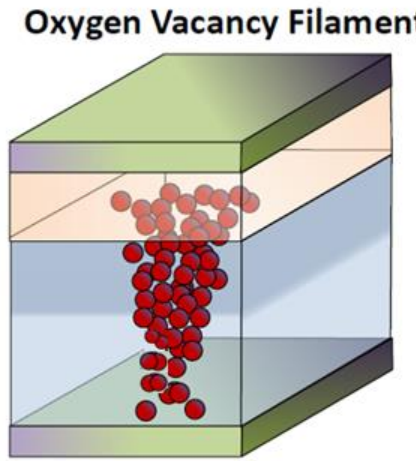
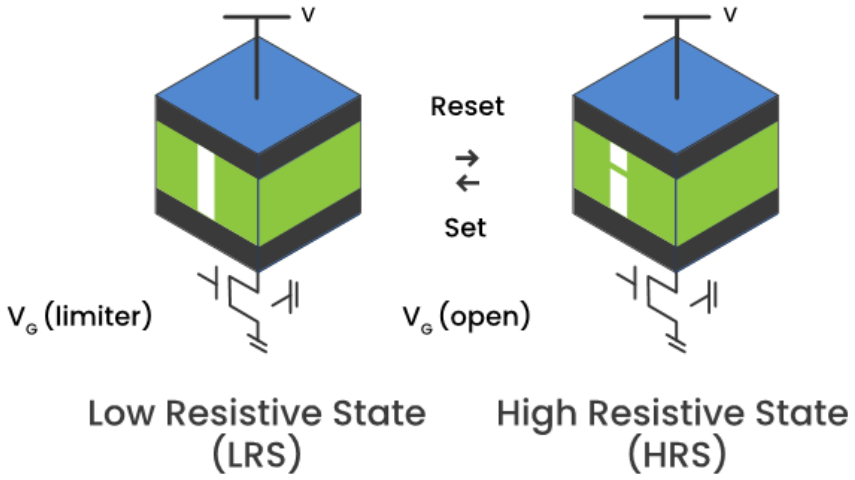
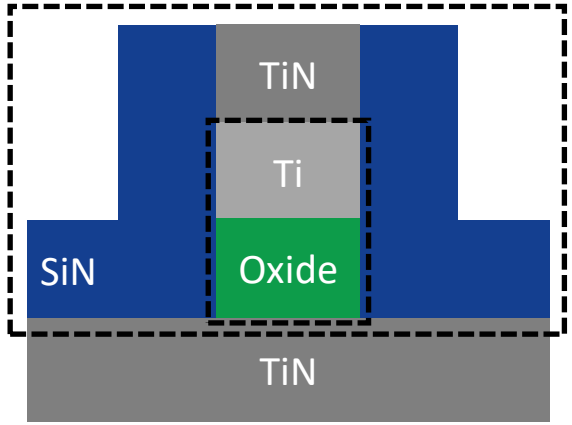
Weebit ReRAM 101

- Weebit's ReRAM is based on oxygen vacancies filament (OxRAM)
  - Depositing a dielectric layer between 2 metal layers at the BEOL
  - By applying different voltage levels, a filament is created ("1") or dissolved ("0")
- Data retained within the stack is resilient to environmental conditions
  - High-temperatures, radiation, EMI
- Most cost-effective NVM technology
  - Only two additional masks
  - Fab-friendly materials, no special handling
  - Using existing tools and equipment
- Power efficient NVM
  - Digital-core-voltage read
  - <2V write voltage
- High performance
  - Fast access time
  - High endurance, long retention



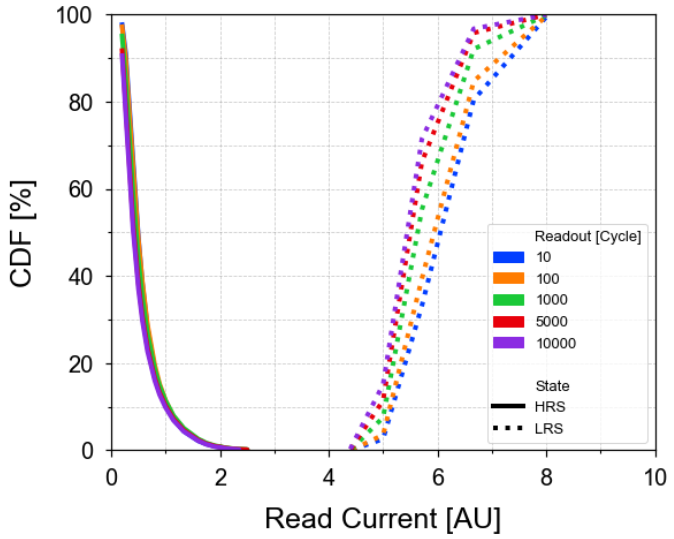




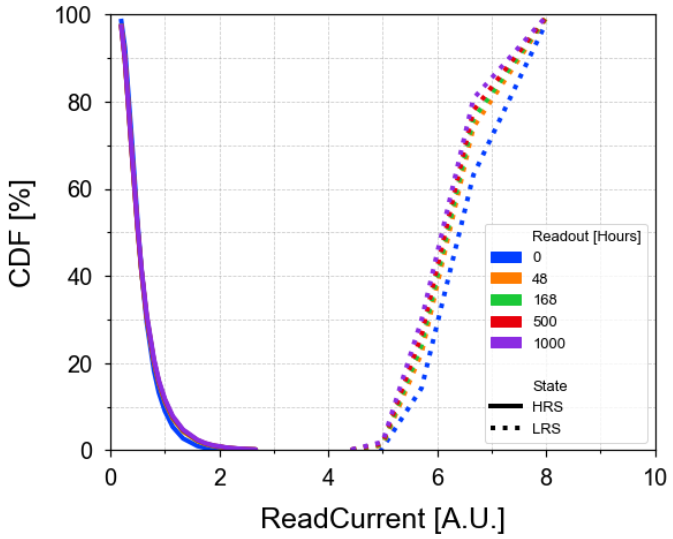
State of Weebit ReRAM Today: Technology is Qualified

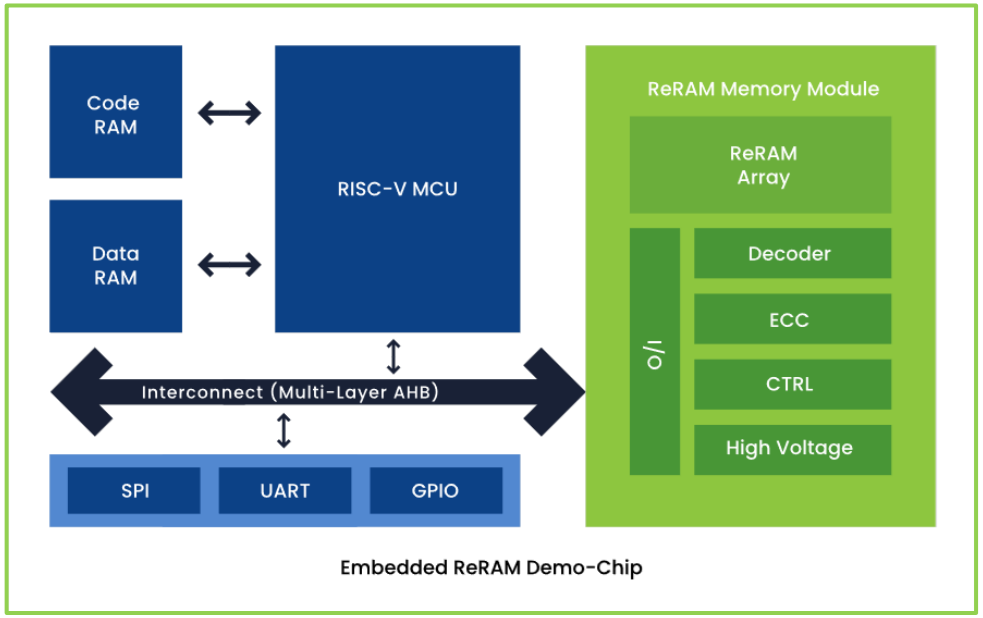
- Weebit's ReRAM successfully passed the JEDEC industry standards for non-volatile memories (NVMs)
  - Confirms the suitability of Weebit's embedded technology for volume production
  - JEDEC standards impose rigorous testing of many silicon dies blindly selected from three independent wafer lots
  - All dies successfully passed the entire set of qualification tests for industrial-grade conditions

Write Endurance (NVCE)



Data Retention (UCHTDR)





Weebit ReRAM Now Available in SkyWater Fab

- **256Kb ReRAM module available for customers' designs**
  - Optimized for SkyWater 130nm node
- **Initial applications**
  - Analog, power management, mixed-signal designs
  - IoT, industrial, automotive
  - Aerospace, defense and military
  - Data logging
  - Heterogenous computing
- **Benefits**
  - Excellent endurance and retention, even at high temperatures
  - Ultra-low power consumption
  - Tolerant to ionizing radiation and electromagnetic interference
  - Inherently secure technology

skywater

Weebit Nano ReRAM Preliminary Key Features

Technology	130nm, SkyWater S130
Mask Adder	2
Supply Voltage	1.8V Read 1.8V+3.3/3.6V Program
Cell Programming Voltage	1.4V – 1.8V Set & Reset
Read Access Time	<20nsec
Operation Temp.	-40°C – 85°C (Can be extended to -55°C – 125/150°C)
Capacity	256 Kbit (Can be customized for 128Kbit – 2Mbit)

https://www.skywatertechnology.com/ip-partner-weebit-nano/

Contact info@weebit-nano.com

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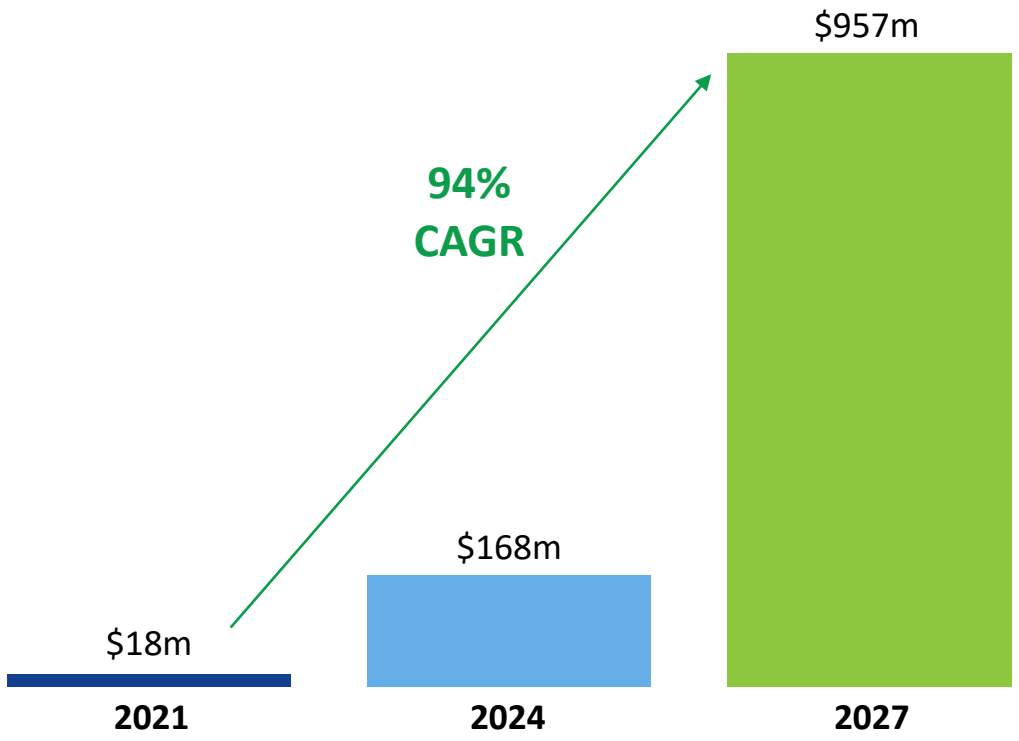
ReRAM: Why Now?

- Power and cost pressures are increasing
  - Advanced nodes are necessary
- Flash scaling complexity & cost are growing
  - Some solutions evolve but are sub-optimal
- Investment in emerging memory tech is increasing
  - Resolving some key challenges in ReRAM (e.g., variability)
- Embedded emerging NVM market expected to reach $2.9B by 2027
  - ReRAM expected market share: 33%

Embedded ReRAM Market Size 2021 - 2027



Source: Yole Emerging Non-Volatile Memory 2022
Note: The embedded emerging NVM market size is evaluated based on assumptions of the average chip area occupied by a given memory technology (Yole)

ReRAM Fits a Broad Range of App Requirements

Based on a back-end-of-line (BEOL) technology, ReRAM nicely scales:

- 130 nm → 65 nm → 28/22 nm → 1X nm
- Bulk CMOS, FD-SOI, FinFET
- Mixed-signal, High-Voltage, Low Leakage, RF CMOS, High-Performance

Mixed-Signal & Power Management

Internet of Things / MCUs

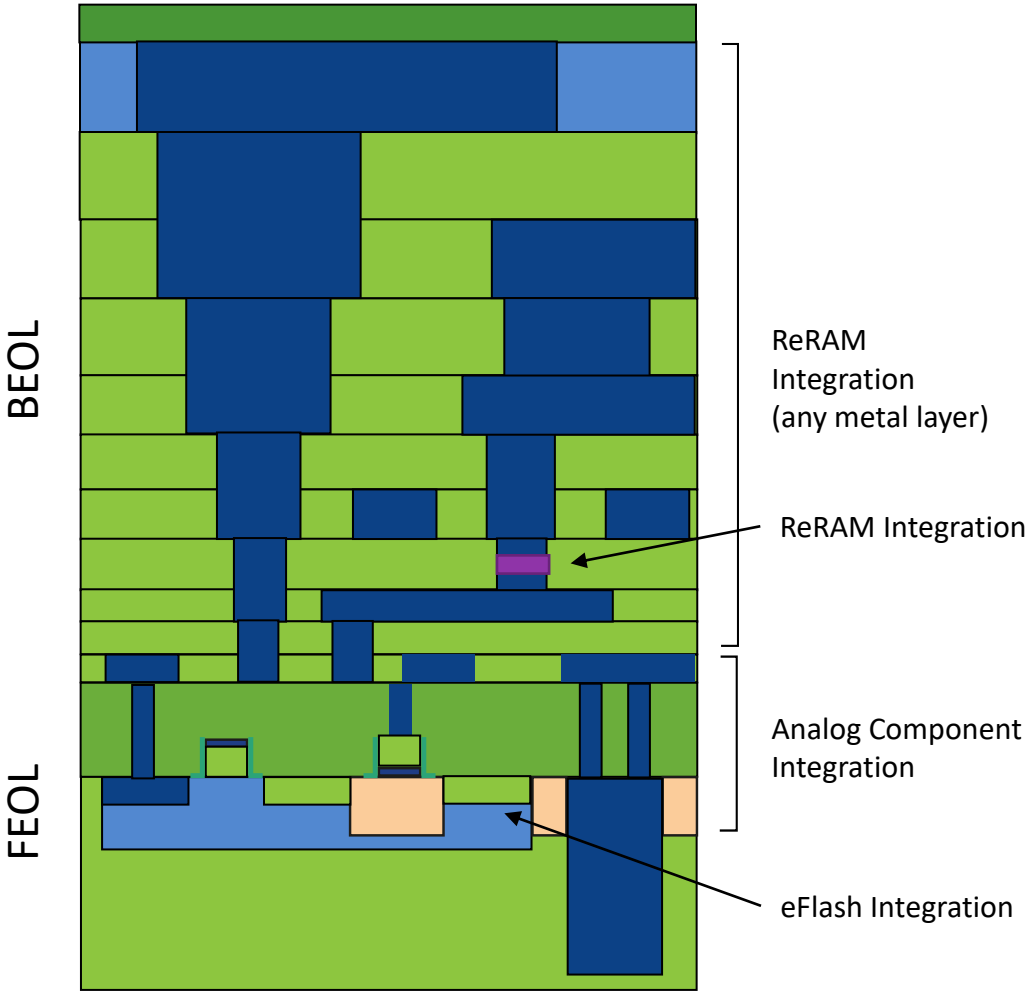
Edge AI Applications

Automotive Applications

Aerospace & Defense

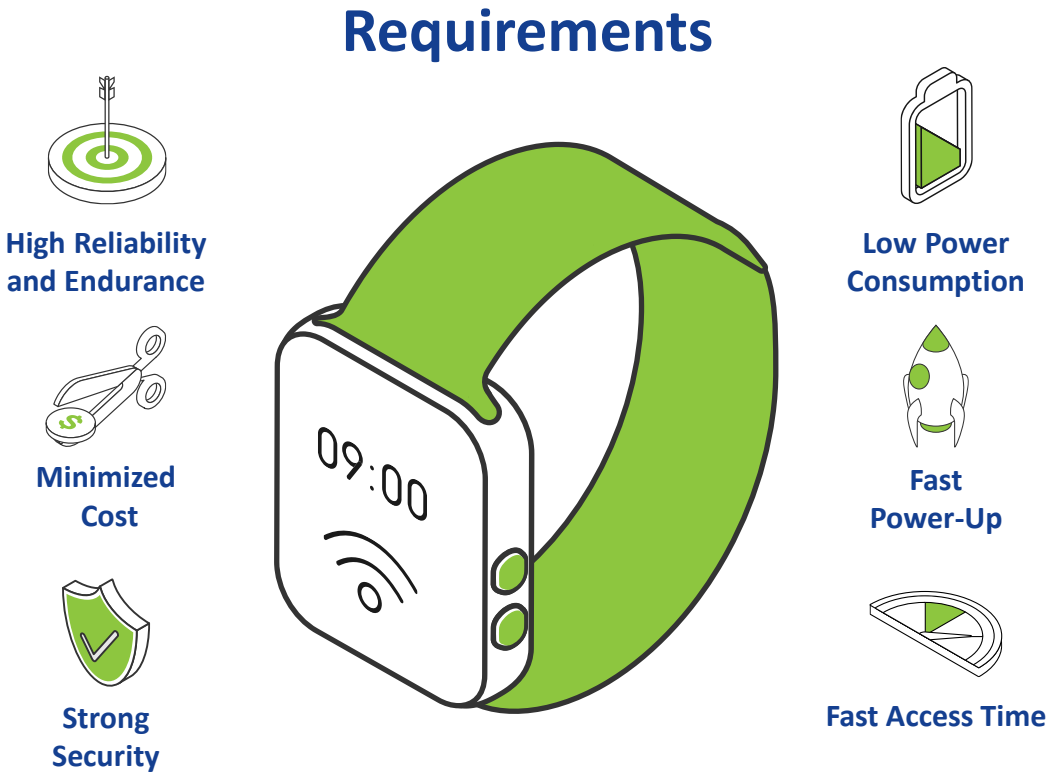
ReRAM – a Differentiator for PMICs

- Growing interest in emerging NVM for mixed-signal & PMIC designs
  - 130nm and below: flash too expensive; difficult to integrate
  - 65nm and below: + MCU integration becomes a reality; MTP cell too large
- Low-density NVM required for:
  - Tables and coefficients, trimming, configuration, MCU firmware
- Weebit ReRAM is:
  - Back End of Line (BEOL) NVM: no interference with FEOL components
  - Reliable at high temperatures
  - Cost-effective, only 2-mask adder



MCU/IoT: A Natural Fit for ReRAM Integration

- Billions of battery-operated edge devices
  - By 2026*: 55.7B connected devices worldwide;
    73.1 ZB of data generated from connected IoT devices
- Name of the game: System Integration
  - Flash not scaling below 28nm
- Embedded ReRAM has significant advantages over external NOR flash
  - **Power:** eliminate external memory interfaces
  - **Speed:** Avoid data fetching from external memory
  - **Cost:** Cut expensive SRAM or external flash
  - **Reliability:** Handles high temps; built for longevity
  - **Endurance:** Enables new use-cases
  - **Secure:** Instantiated on-chip, difficult to hack



** Source: IDC Research 2021*

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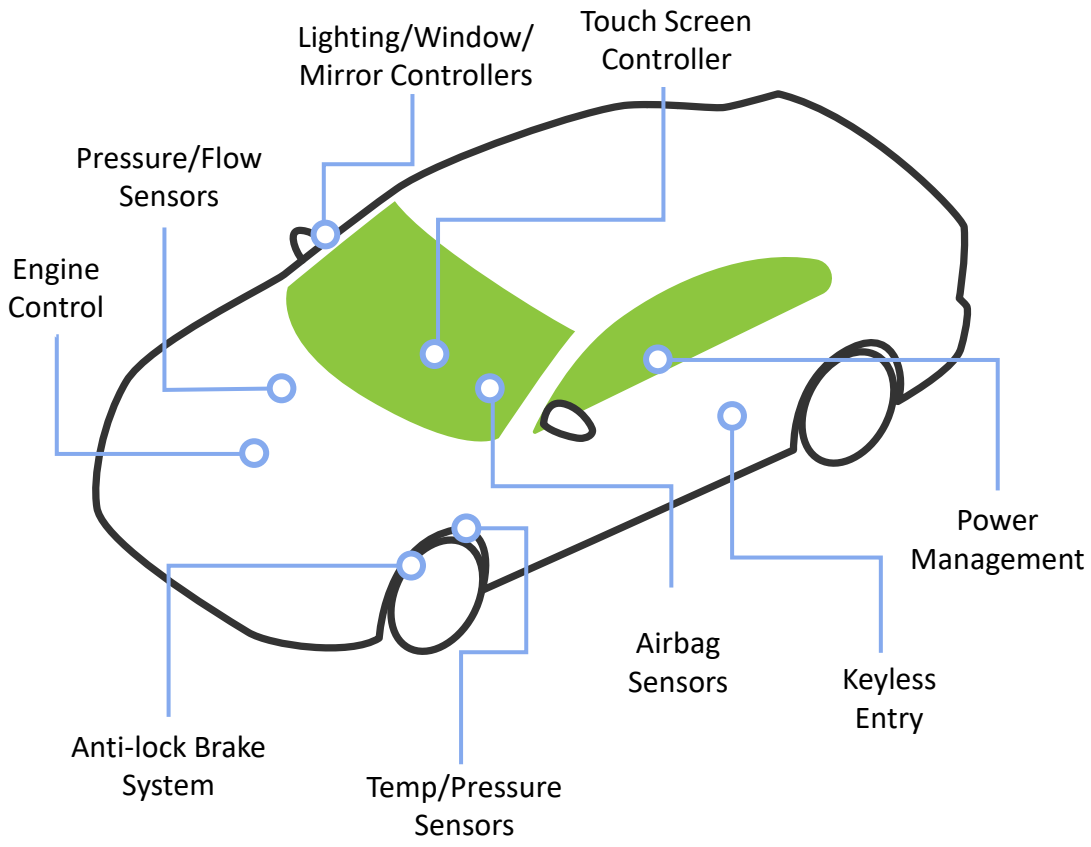
New NVM Technologies Enable Automotive Differentiation

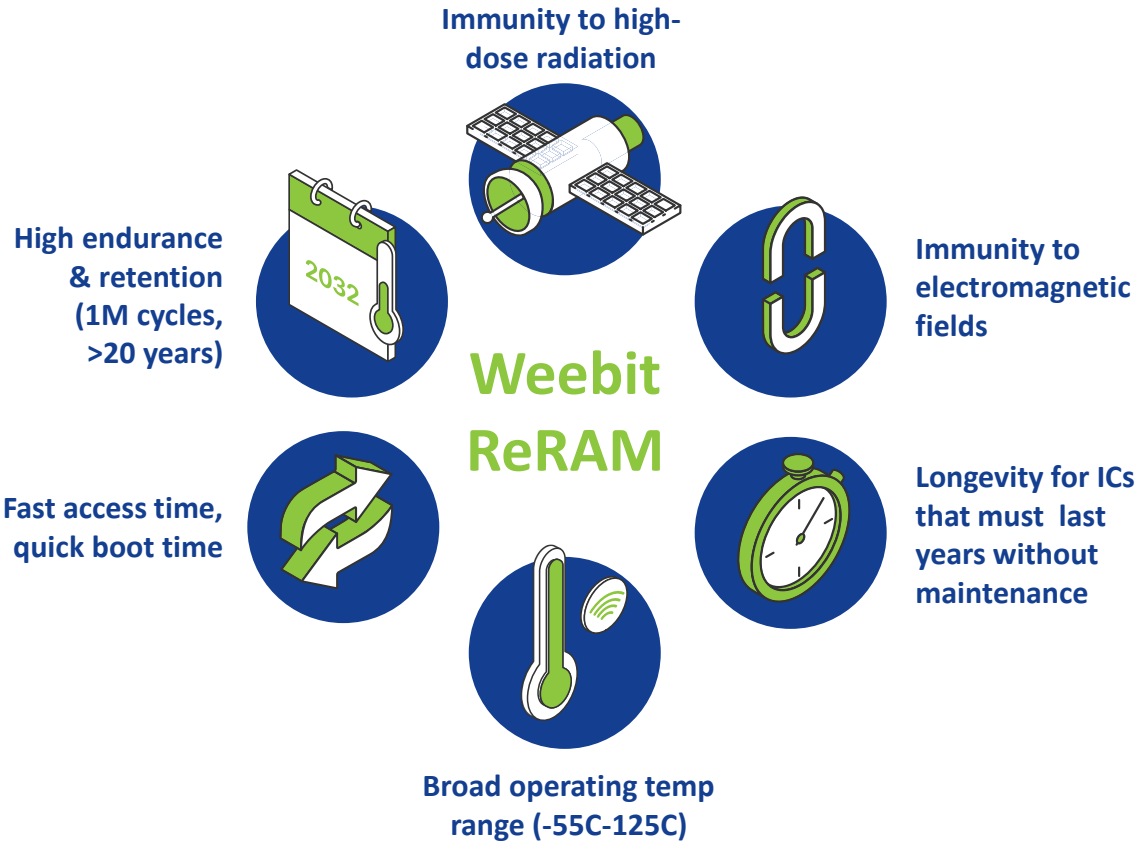
- Automotive ICs have unique requirements
  - Design for safety, security and longevity
  - Reliable at extreme temperatures, EMI, vibration, humidity, etc.
  - Support fast boot, instant response, frequent OTA updates
  - Advanced process nodes are adopted quickly
- Growing needs for emerging NVM
  - Needed for code storage, trimming, data logging
- Weebit ReRAM
  - High-temp reliability, immunity to EMI, endurance, fast switching speed, longevity, secure
  - Can effectively scale to the most advanced process nodes

Some Places Where NVM is Found in a Car



Aerospace & Defense: Demanding Apps Need New NVM

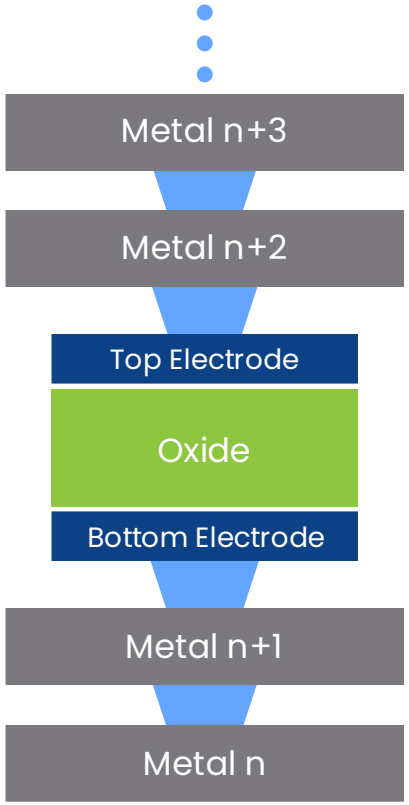
- **Growing interest in emerging NVM for aerospace and defense ICs**
  - Flash can't withstand radiation
  - Flash isn't easily scalable into advanced nodes
  - Limited endurance and energy efficiency
  - Other emerging technologies sensitive to temperature and EMI
- Low density NVM required for:
  - MCU firmware, logging, configuration



ReRAM for Secured Applications

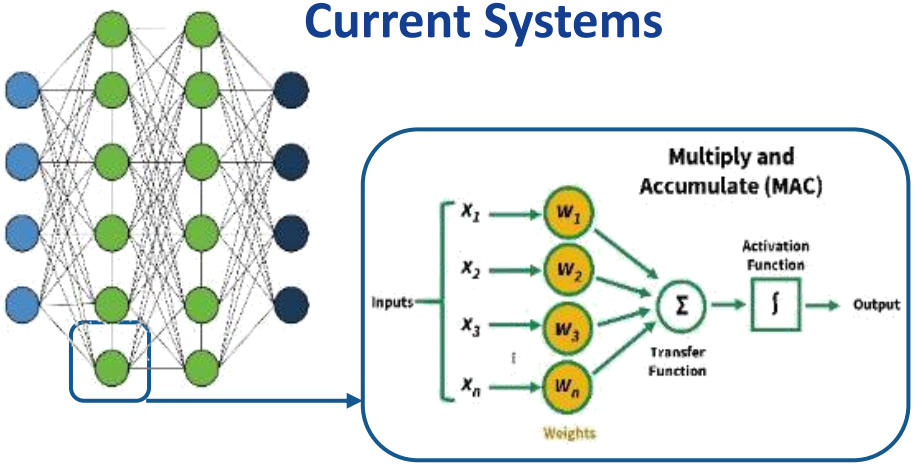
- In today's connected world, security is #1 threat
  - Smartcards, mobile payments
  - IoT devices, automotive, other connected systems
- ReRAM is more secure than other embedded NVMs
  - Keeps memory content including data, logs, and code safe from hacking
  - Much more difficult to intrude, read or modify
- ReRAM is also ideal for HW security mechanisms
  - Physical unclonable functions (PUFs)
  - True random number generators (TRNGs)

Weebit ReRAM



ReRAM to Drive Innovation for Edge AI and Future Neuromorphic Compute

Current Systems



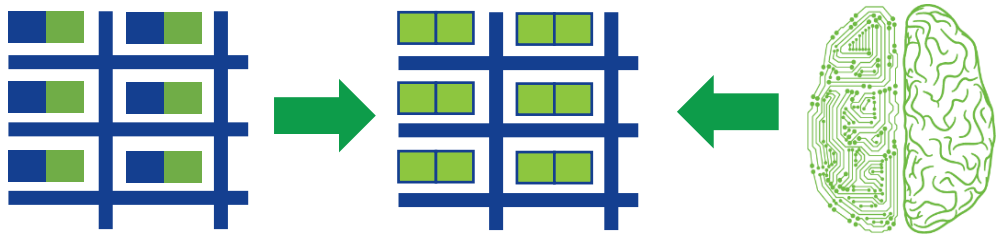
Requirements

- High capacities (10MB-100MB), >SRAM
- Non-volatile behavior for synaptic weight storage
- Short latency / high bandwidth

Near Memory Compute

- ReRAM brings NVM closer to compute

Brain Inspired Systems



Near Memory Compute (NVM)
ReRAM replaces expensive/power hungry SRAM

Analog In-Memory Compute (ReRAM)
ReRAM does storage and compute in the same place

Future systems will mimic the behavior of the human brain for fast real-time processing on massive amounts of data

Orders of magnitude improved energy efficiency

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The Evolution of ReRAM: The Next NVM is Here

1960s – 2010s

- ReRAM spent decades in research and development until the industry recognized the limitations of flash

2015 – 2016

- Weebit founded
- Partnering with Leti to drive development of innovative NVM based on 10+ years of research

2017 – 2018

- Weebit's first demonstrations of small ReRAM arrays
- Focus on fab-friendly and easy-to-integrate technology

2019 – 2021

- Weebit's technology matures
- IP productization
- First commercial deal
- Starting to scale technology to smaller process nodes

2022 – onwards

- Customers requesting ReRAM **now**
- Weebit ReRAM is industry-qualified, ready for production
- Multiple fabs considering Weebit ReRAM
- Weebit & Leti continue to innovate

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Thank You!

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