

ReRAM: The Next NVM is Here

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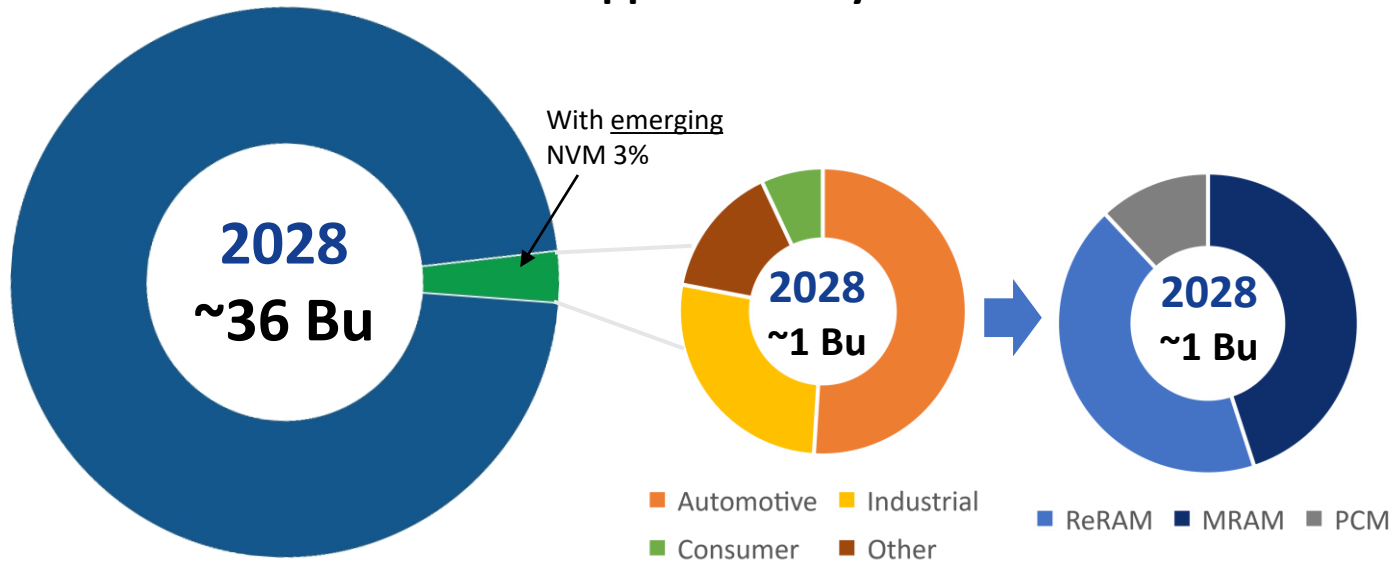
Outline

- Embedded ReRAM market
- Weebit Nano overview
- ReRAM module
- Qualification results
- Summary

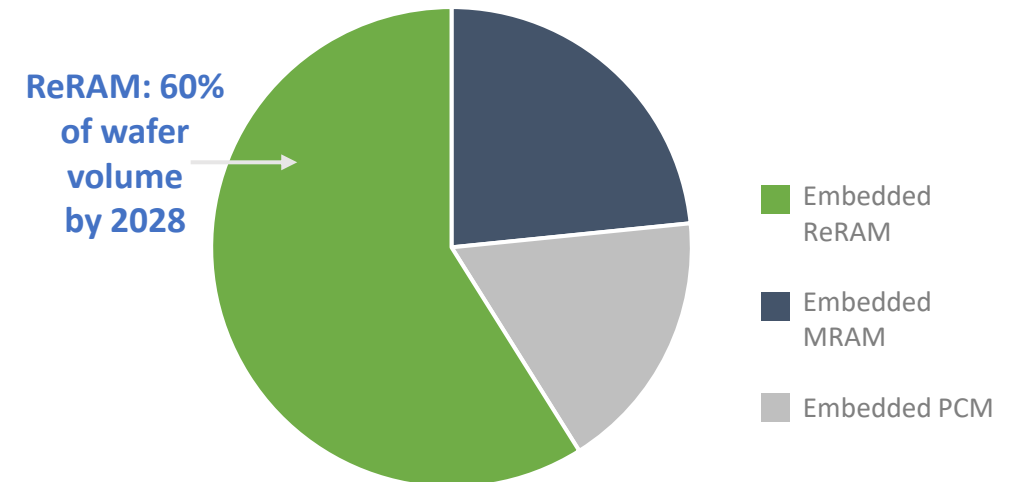
Embedded ReRAM market – Approaching the tipping point

The embedded emerging NVM market is expected to reach \$2.7B by 2028,
with ReRAM expected to represent 37%*

Total MCU shipped units by 2028*



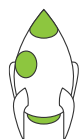
Market Volume in # of Eq. 12" Wafers 2028*



* Source: Emerging Non-Volatile Memory report, Yole Intelligence, 2023

Who is Weebit Nano?

Leading developer of advanced memory technology – Weebit ReRAM – for the global semiconductor industry



Founded: 2015

Israel & France 50 personnel*
(90% engineers/scientists)



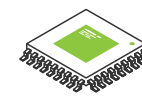
R&D Partner: CEA-Leti

Leveraging years of research
experience in NVM



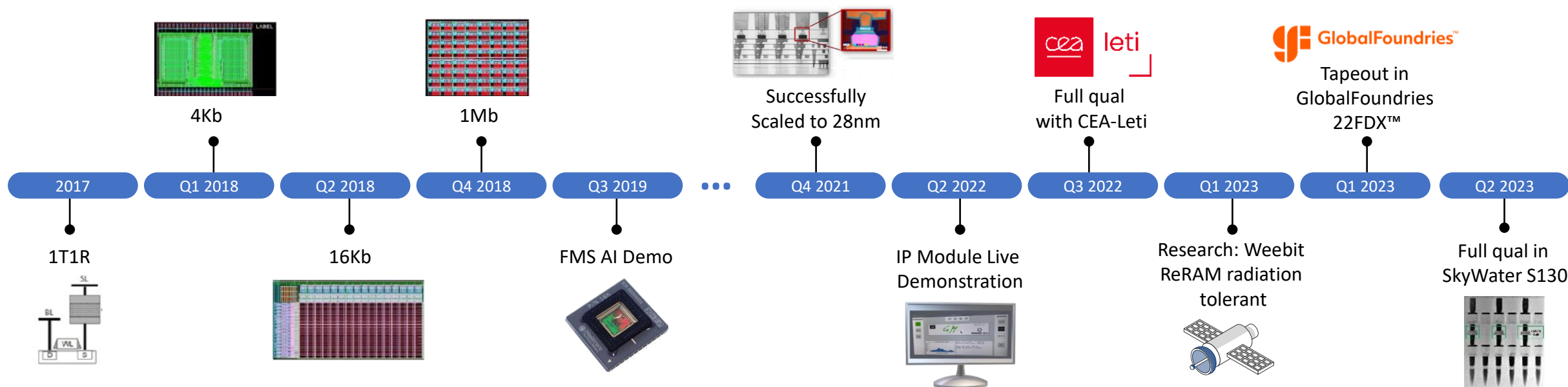
Current Business Model:

IP licensing to semiconductor
companies & fabs



Silicon-Proven Technology

Mbit arrays avail @ 28-130nm
Volume production 2024



*Includes employees and permanent contractors.

Weebit ReRAM module design

Integrating a ReRAM array in a complete module in 130nm technology

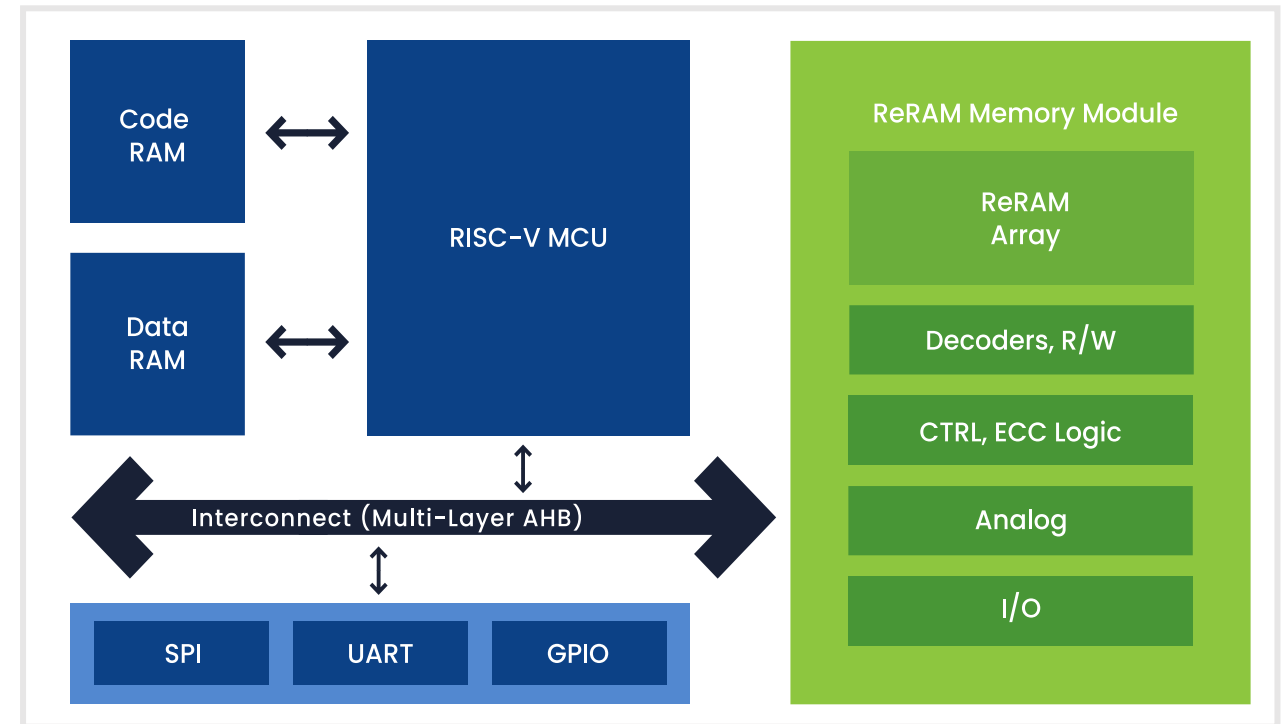
Module includes:

- All analog circuitry
- Smart algorithms (read, set/reset, forming)
- Control logic and data manipulation
- Redundancy, ECC

The ReRAM module is further integrated into a complete subsystem

- Based on a RISC-V processor

Silicon is fully functional and qualified



Embedded ReRAM Demo-Chip

Successfully completed ReRAM module qualification

Major milestone using Weebit's ReRAM memory module produced at SkyWater



Qualified wafers to industry standards

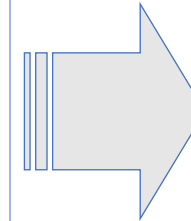


- Endurance
- Industrial robustness



Results driving interest from foundries and customers

- Repeatability
- Uniformity
- Maturity of Weebit's embedded ReRAM



Commercial Traction

Based on results, Weebit ReRAM is **being evaluated by several SkyWater customers**

Weebit is now **qualifying ReRAM** modules at higher temperatures and endurance levels – **for advanced applications**

ReRAM qualification process

- Weebit has now qualified its 2nd ReRAM module
- Qualification process (unlike technology demonstration) requires meeting industry standards (JEDEC, AEC, MIL) to show technology maturity

Stress	Test Item	Reference	Stress Conditions	Test Conditions / Acceptance Criteria	Sample Size	Comments
NVCE	Endurance	JESD22-A117 JEDEC 47	25°C and 85°C V=Vcc max	Datasheet Spec/ 0 Fails	3 Lots/ 77 units	Test all the array bits to 100% Max spec
UCHTDR	Data Retention	JESD22- A117 JESD47	Tstress – 125°C	1000 hrs/ 0 Fail	3 Lots/ 77 units	Readout at 25°C and 85°C
PCHTDR	Post Cycle Data Retention	JESD22- A117	Tstress = 125°C 100% spec	10 hrs/ 0 Fail	3 Lots/ 39 units	Readout at 25°C and 85°C
SMT	SMT Reflow	ESD22 - A113	Tc 260 °C	3 cycles/ 0 fails	3 Lots/ 25 units	Pb-Free Assembly Profile

Qualification results – SkyWater 256Kb, 85°C

Test Description & Conditions	Qual Lot 1	Qual Lot 2	Qual Lot 3	Results
JEDEC NVM Qual tests (85°C):				
NVCE: Cycling endurance @ Room	0/38	0/38	0/38	10K cycles @ 25°C
NVCE: Cycling endurance @ 85°C	0/39	0/39	0/39	10K cycles @ 85°C
UCHTDR: Uncycled data retention ($T_{\text{Bake}}=130^{\circ}\text{C}$, 1000h)*	0/77	0/77	0/77	10 years @ 85°C
PCHTDR: Post-cycle (10k @ 85°C) data retention ($T_{\text{Bake}}=130^{\circ}\text{C}$, 10h)	0/39	0/39	0/39	10 years @ 85°C (RAC)
SMT: Solder Reflow Test ($T_{\text{Peak}}=260^{\circ}\text{C}$)	0/25	0/25	0/25	Passed 3x SMT
Extended Qual tests (85°C):				
UCHTDR: Uncycled data retention ($T_{\text{Bake}}=130^{\circ}\text{C}$, Lot1 2000h, Lot2 1500h, Lot3 1500h)	0/77	0/77	0/77	15-20 years @ 85°C
PCHTDR: Post-cycle (10k* @ 85°C) data retention ($T_{\text{Bake}}=130^{\circ}\text{C}$, 168h)**	0/39	0/39	0/39	>1 year End of life @ 85°C (RAC)

*PCHTDR reached more than 3500h bake to show 1st failure points on our 1ST MODULE

** UCHTDR – reached 5000h with no failures, continue to 10,000h on our 1ST MODULE

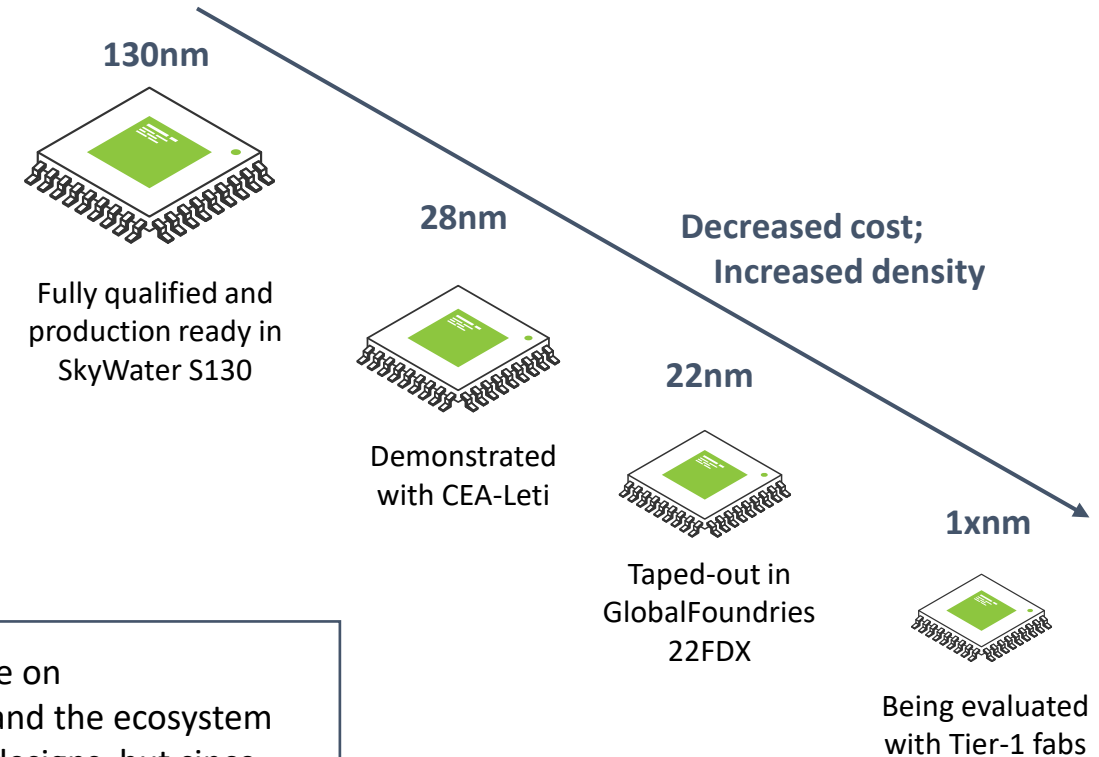
Weebit ReRAM scaling to advanced nodes

Clear opportunities for NVM at 22nm and below

- Existing embedded flash technology is not a viable option
- Serving various applications including IoT, 5G and AI

Recent development: taped-out ReRAM IP module in GlobalFoundries' 22FDX™ FD-SOI (fully depleted silicon on insulator) platform

- Weebit ReRAM + FD-SOI is ideal for low-power embedded devices



"The work Weebit and CEA-Leti are doing to make Weebit ReRAM available on GlobalFoundries' 22FDX is a welcome development as we continue to expand the ecosystem around this platform. Embedded NVM is a key element of our customers' designs, but since embedded flash is difficult to scale below 28nm, many customers are looking to NVM solutions such as embedded ReRAM." – Mike Hogan, Chief Business Officer



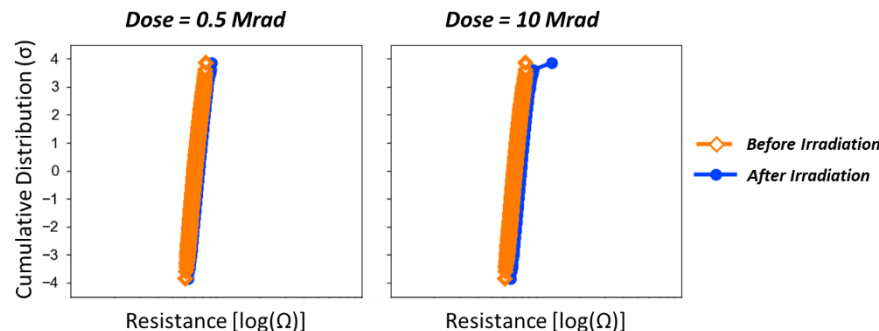
ReRAM is inherently radiation tolerant

ReRAM cell stores data within dielectric stack in back-end-of-line (BEOL) process, so various types of radiation do not affect it

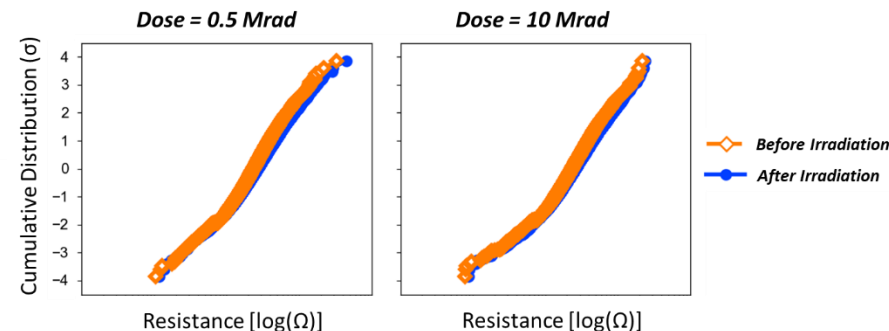
- Does not use charge trap like flash
- Radiation mostly affects front-end-of-line (FEOL) – CMOS
- Access circuitry must be hardened using standard methods

Weebit is partnering with University of Florida's Nino Research Group to test ReRAM structures under radiation

- Initial study irradiated pre-cycled 130nm 16Kb 1T1R arrays in 0.5Mrad-10Mrad in UF training reactor



Low Resistance State (LRS) distribution before and after different radiation doses



High Resistance State (HRS) distribution before and after various radiation doses

Note: The scale of these two diagrams is not the same.

Results confirm that Weebit ReRAM preserves data and can be fully reprogrammed after high doses of irradiation



New whitepaper available

<https://tinyurl.com/dbk2nmwv>

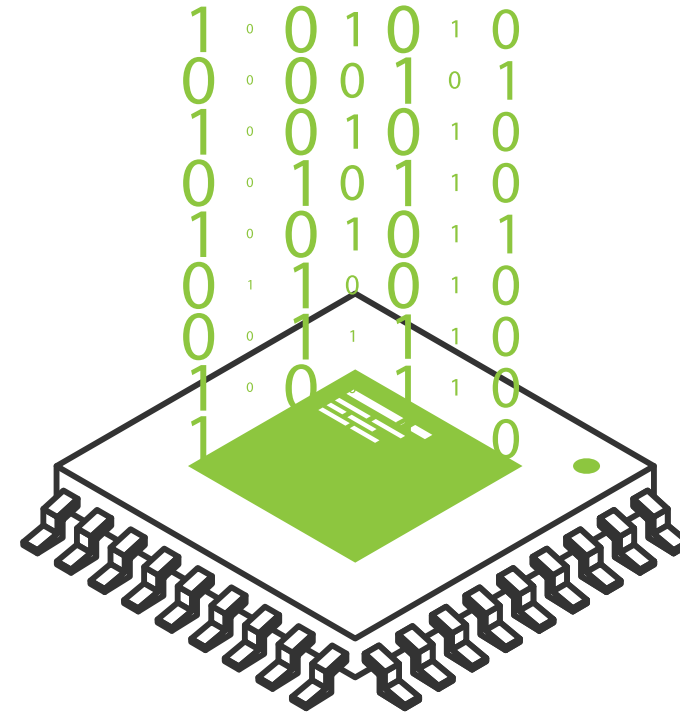
Conclusions

Weebit ReRAM was ported successfully to a commercial foundry (SkyWater)

- Is fully functional within one year, and qualified

Weebit has functional ReRAM modules fully qualified in SkyWater at 85°C and 125°C

Weebit continue developing and scaling ReRAM technology towards 22FDX™ FD-SOI and beyond





Thank You!



www.weebit-nano.com