



**Adesto**

# RRAM Comes of Age

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# Historical Tale of RRAM....

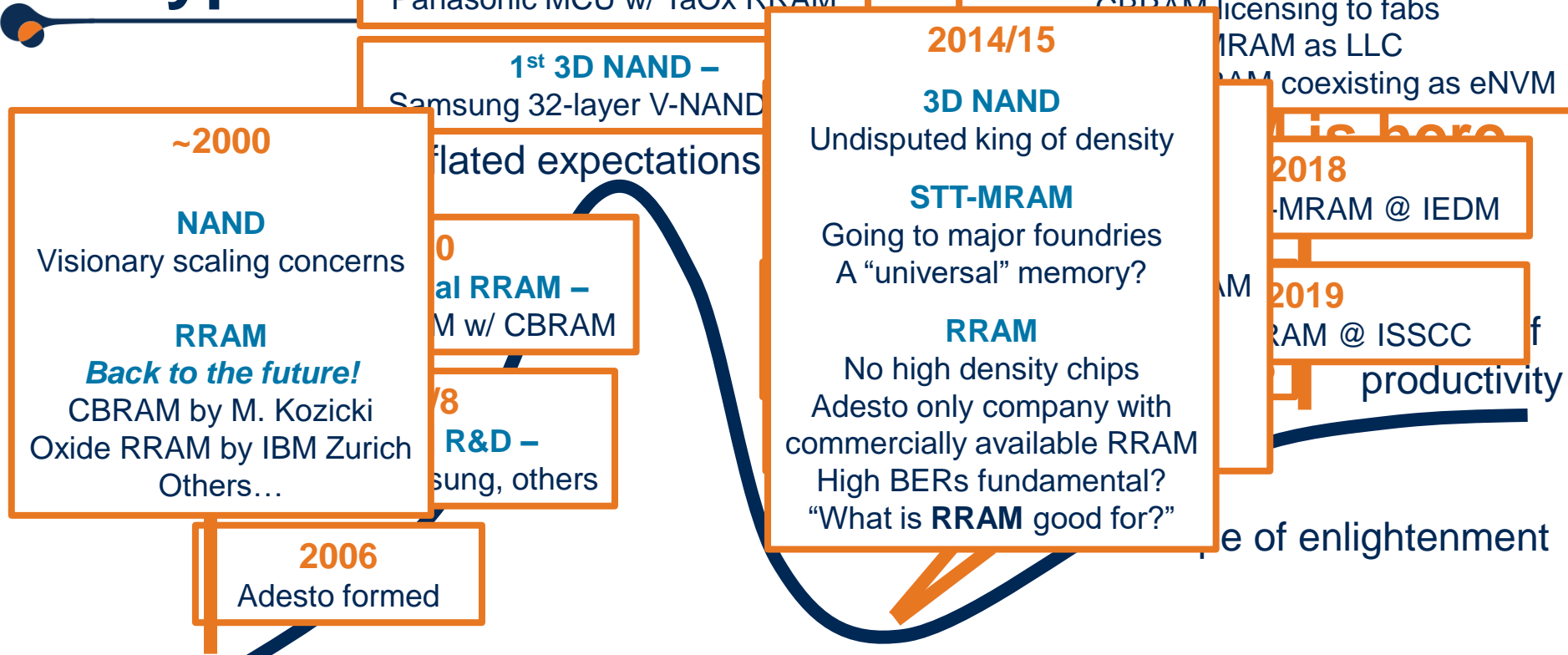
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**Where did it come from?**

**Why is it still here?**

**Where is it going?**

# Hype Cycle



Technology trigger

Trough of disillusionment

# CBRAM vs. STT-MRAM as eNVM w/ Solder Reflow

	CBRAM	STT-MRAM	Comment
Endurance	$10^5$	$10^7$ [1]	MRAM: Endurance is beyond practical eNVM requirements
Write speed	Comparable	250ns [2]	
Write current	>100uA	>100uA	For both, current driven by need for high-T retention
Write voltage	<3V	<2V	
Forming	Needed	Not needed	CBRAM: Can do forming economically at SORT
Cost	1 mask adder	> 30% cost adder	STT-MRAM: 3-4 masks, many layers, difficult etch
Complexity	3-4 thin films	20-30 thin films	STTMRAM: Increased tool costs & lower throughput

[1] M.-C. Shih et al., "Reliability study of perpendicular STT-MRAM as emerging embedded memory qualified for reflow soldering at 260°C," VLSI 2016.

[2] L. Thomas et al., "STT-MRAM for embedded memory applications from eNVM to Last Level Cache," 978-1-5386-1/17/\$31.00 ©2017 IEEE

# Historical Tale of RRAM....

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## Where did it come from?

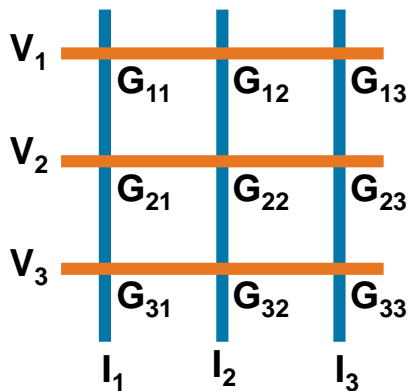
*Heaven or Hell, depending on your experience*

## Why is it still here?

*Excellent as eNVM – Adesto engaged in multiple fab insertions*

## Where is it going?

# CBRAM for AI (a.k.a., neuromorphic, in-memory, etc.)



*Analog NVM enables the fast, low-power vector-matrix multiplication used in AI*

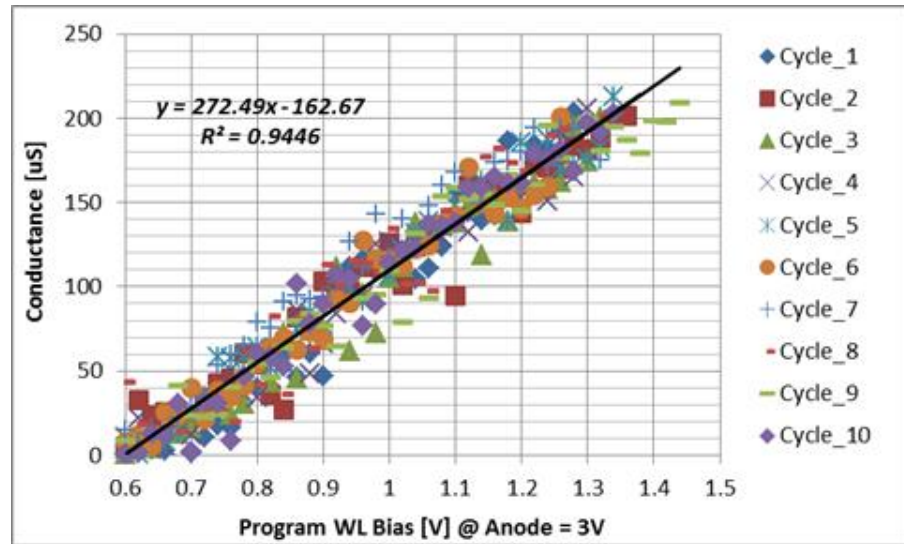
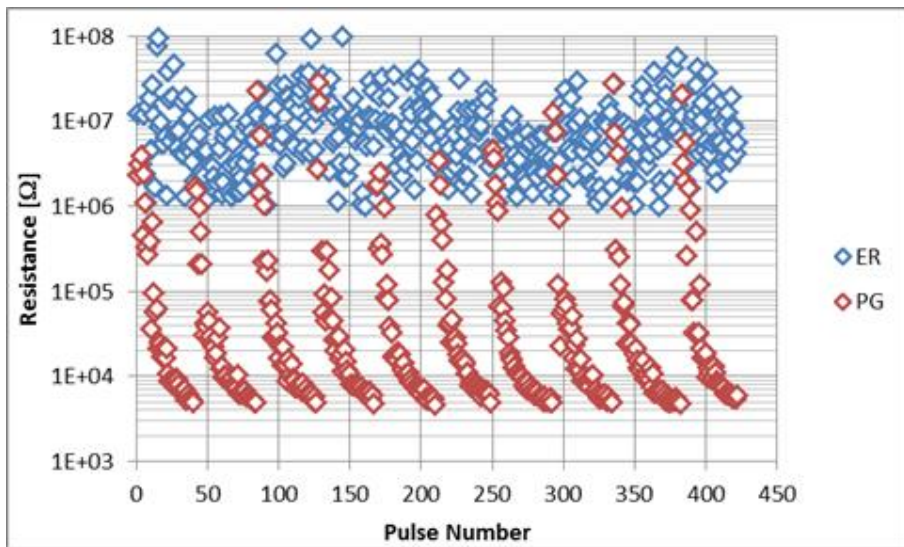
## Desired characteristics

	Small changes possible	Stable over time, temp & usage	Low current / power during inference	Linear IV curve	Low weight-to-weight variation	Low cycle-to-cycle variation	Small Size
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Technique	Small changes possible	Stable over time, temp & usage	Low current / power during inference	Linear IV curve	Low weight-to-weight variation	Low cycle-to-cycle variation	Small Size
Control circuitry & algos	X				X	X	
Use high-G regime of cell		X		X			
Proprietary arch/circuits	X		X		X	X	X
Proprietary algos	X	X	X		X	X	
Scaling and/or 3D							X

# CBRAM for AI?

Analog NVM → Fast, low-power vector-matrix multiplication



Cells must provide a stable “analog” conductance

# Historical Tale of RRAM....

## Where did it come from?

*Heaven or Hell, depending on your experience*

## Why is it still here?

*Excellent as eNVM – Adesto engaged in multiple fab insertions*

## Where is it going?

*AI? – Adesto leveraging IP/maturity and collaborating with partners*





**Adesto**

**Thank you**