

Embedded ReRAM is making good progress

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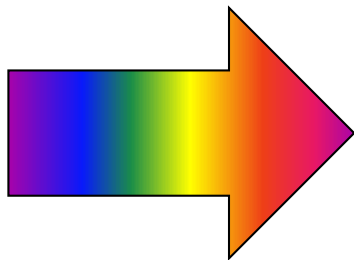
Panasonic Semiconductor Solutions Co., Ltd

Application: from Chip to Consumer Electronics

0.18 μm 1-Mbit ReRAM



Long drive
System cost reduction
High-speed rewriting



Security



Eco-management

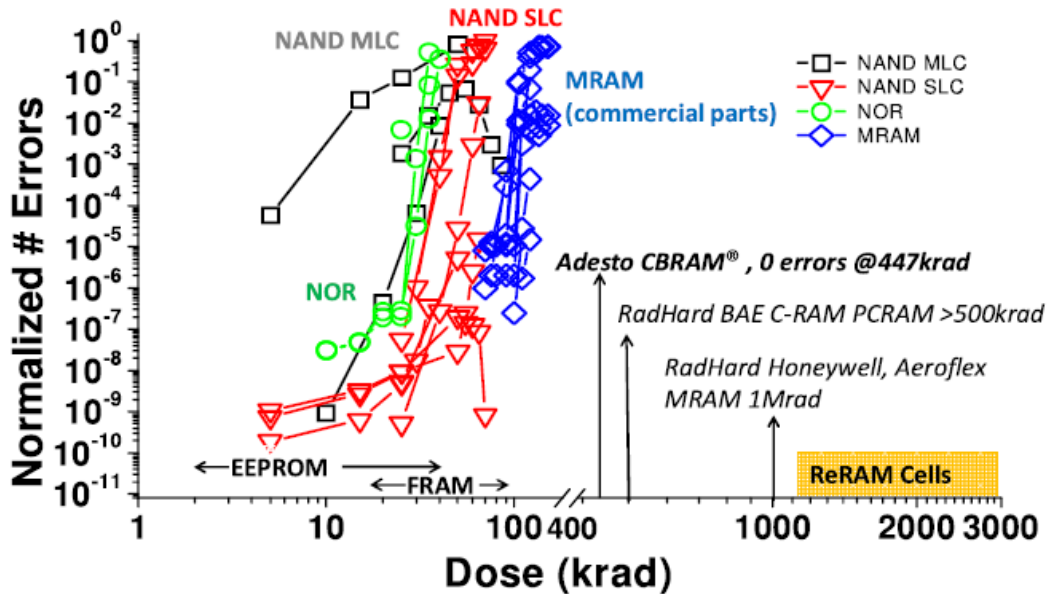


Smart meters

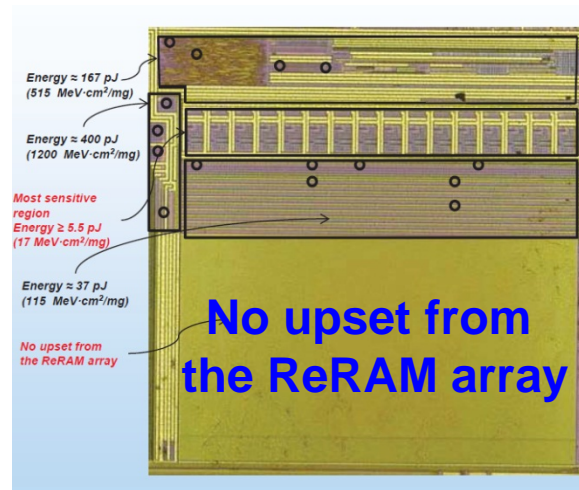


Portable electronics

Radiation Hardness



Panasonic TaOx Array

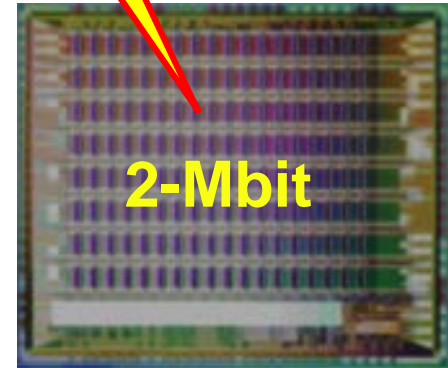
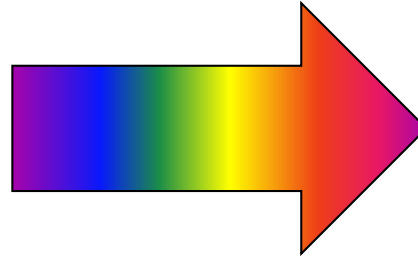
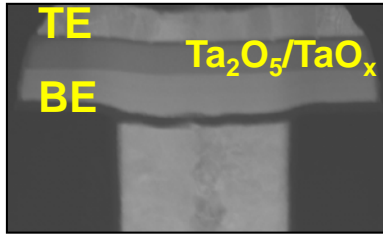


Ref. Y. Gonzalez-Velo, et al, EDL, 35, 205, 2014

D. Chen, IEEE TRANSACTIONS ON NUCLEAR SCIENCE, 61, 3088, 2014

Process:

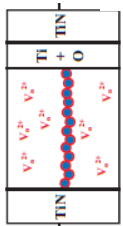
from 0.18 μm to 40 nm



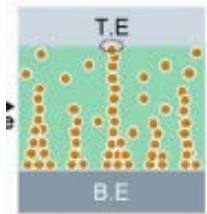
Successfully scaling down to 40 nm

Filament: from Qualitative to Quantitative

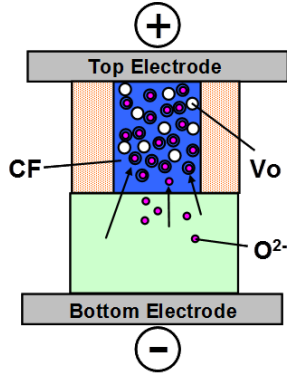
Qualitative



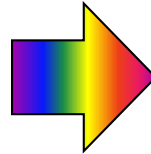
H.Chang, 2011



J.Shin, 2011



S. Muraoka, 2013

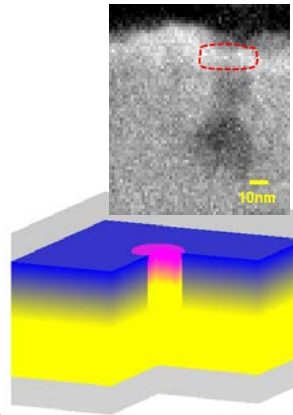


Quantitative

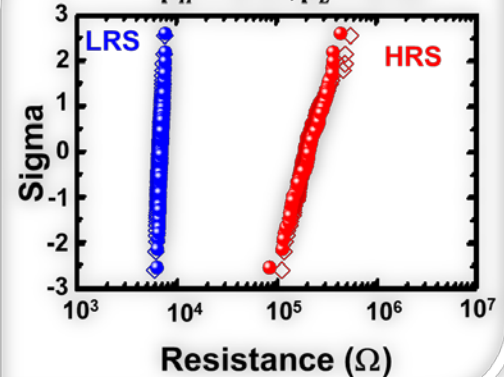
Percolation Estimation Model

$$\varphi \approx 30 \text{ nm} \iff \varphi = 2d \sqrt{\frac{n_x n_y}{\pi}} = 27.2 \text{ nm}$$

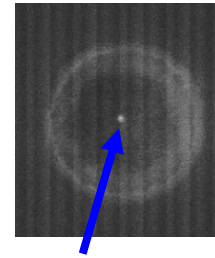
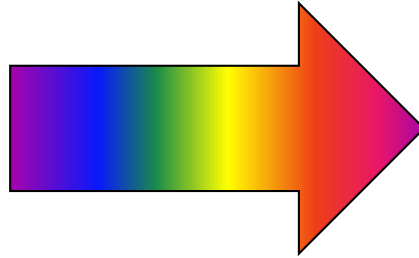
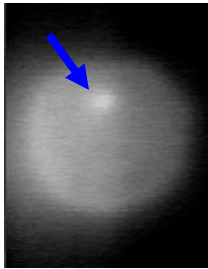
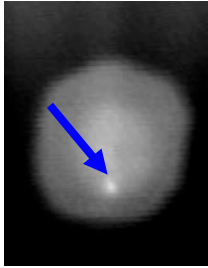
EELS Results



$$n_x = 35, n_y = 35, n_z = 22, \\ p_H = 0.17, p_L = 0.44$$



Filament: from Everywhere to Centralizing



Filament

Side oxidation and other technologies
centralize the filament

Summary

- ReRAM is already in our daily life.
- ReRAM is successfully scaling down to 40 nm.
- Filament dimensions can be estimated for each bit in memory array.
- Filament position is controllable.