

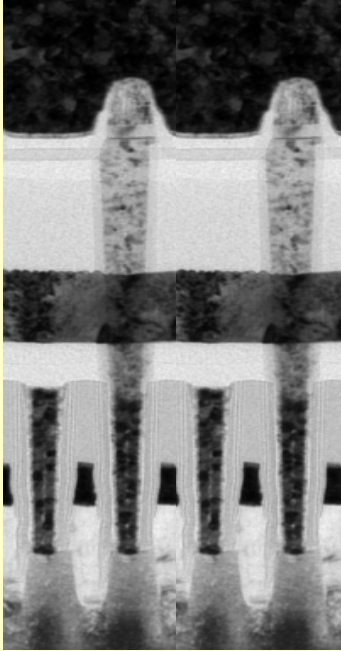
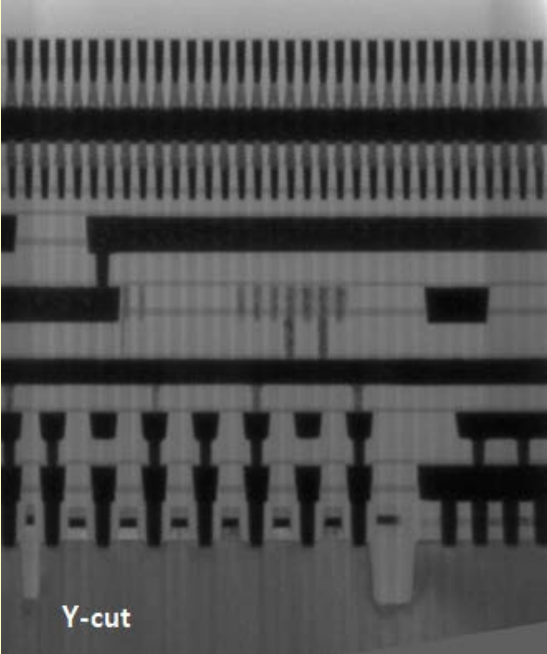
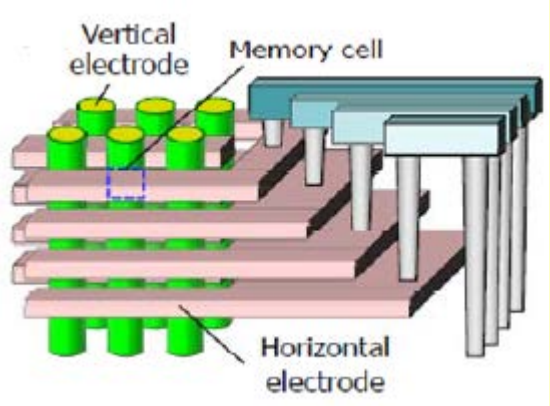
# Standalone RRAM Potentials and Challenges

14. Aug. 2013

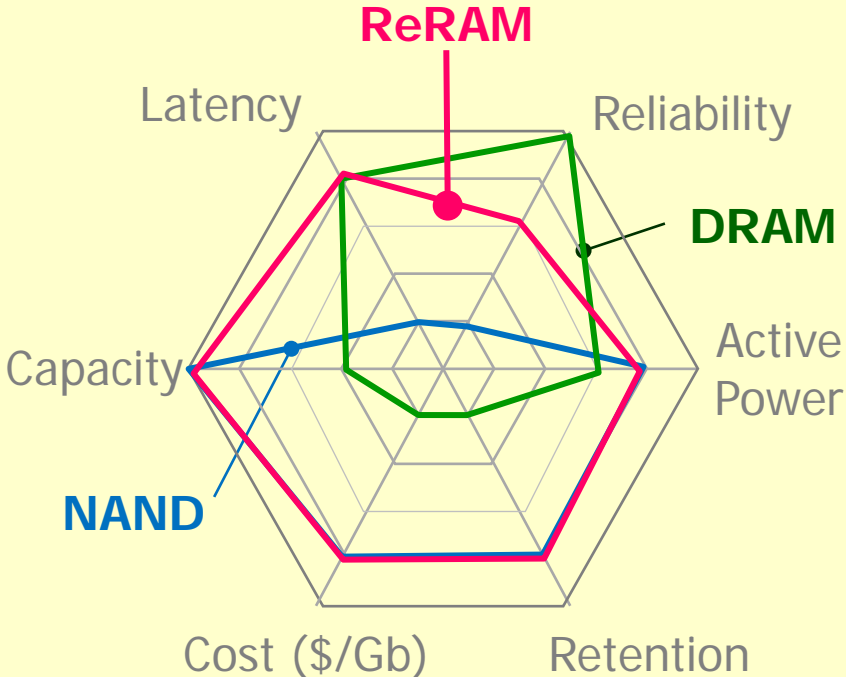
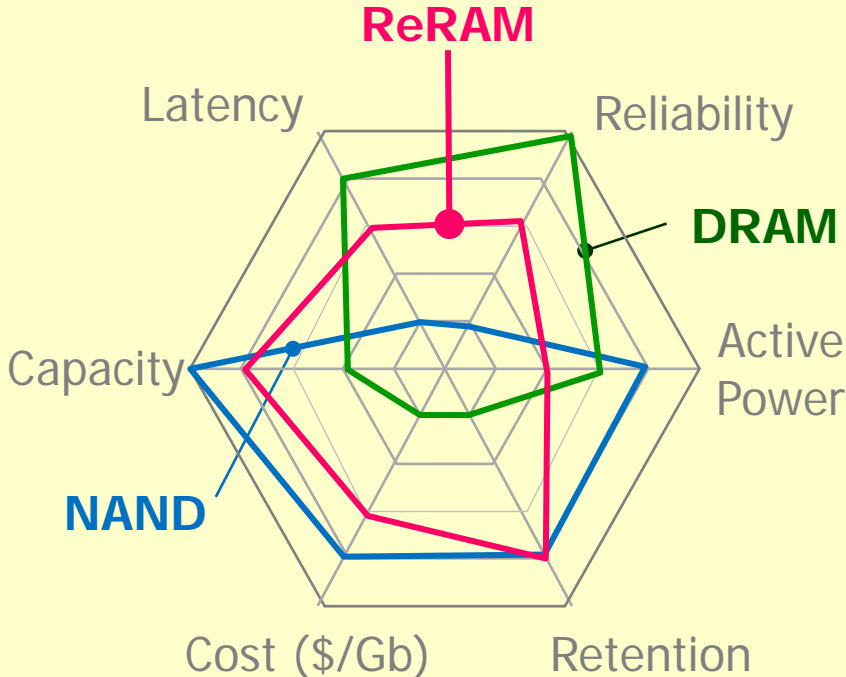
SuOck Chung

SK hynix R&D Div.

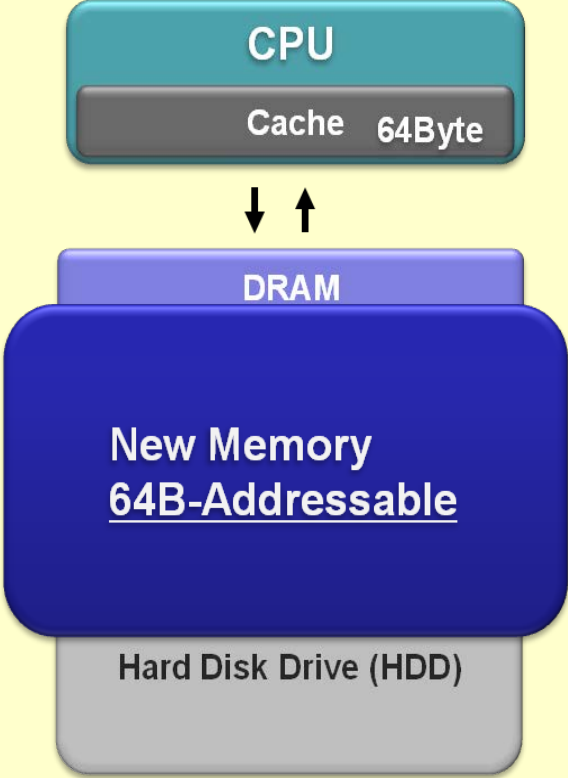
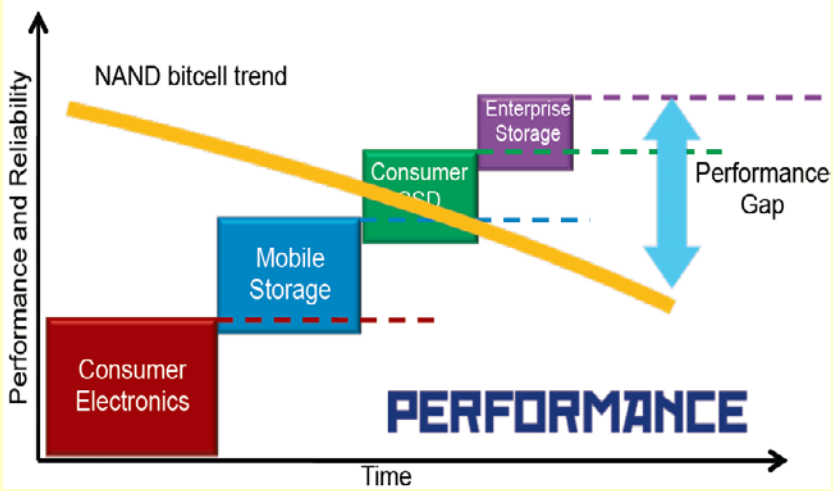
# Array candidates for stand-alone

<p>DRAM-like Array (SK hynix, 2011 VLSI)</p>	<p>Multi-plane X-bar array (SK hynix, 2 planes)</p>	<p>Vertical array (Samsung, 2012 IEDM)</p>
	 <p>Y-cut</p>	 <p>Vertical electrode Memory cell Horizontal electrode</p>
<p>1T1R unit cell</p>	<p>1R or 1S1R unit cell Buried core circuits</p>	<p>1R or 1S1R unit cell</p>

# RRAM features

Initial expectation (unit cell level)	Current status (Array level)
 <p>Initial expectations for ReRAM, DRAM, and NAND across five metrics: Latency, Reliability, Active Power, Retention, and Cost (\$/Gb). ReRAM (red) shows high Reliability and Retention but low Capacity and Cost. DRAM (green) shows high Reliability and Retention but low Capacity and Cost. NAND (blue) shows high Capacity and Cost but low Reliability and Retention.</p>	 <p>Current status for ReRAM, DRAM, and NAND across five metrics: Latency, Reliability, Active Power, Retention, and Cost (\$/Gb). ReRAM (red) shows high Reliability and Retention but low Capacity and Cost. DRAM (green) shows high Reliability and Retention but low Capacity and Cost. NAND (blue) shows high Capacity and Cost but low Reliability and Retention.</p>
<p>Promising storage candidate : Fully cover NAND</p>	<p>Shrunken position : Vertical NAND Low power efficiency : Sneak current Intermediate position : DRAM ~ NAND</p>

# Memory technology trend : SCM

SK hynix, 2012 FMS	Rambus, 2012 FMS
 <p>CPU Cache 64Byte</p> <p>↓ ↑</p> <p>DRAM</p> <p><b>New Memory 64B-Addressable</b></p> <p>Hard Disk Drive (HDD)</p>	 <p>Performance and Reliability</p> <p>NAND bitcell trend</p> <p>Enterprise Storage</p> <p>Consumer SSD</p> <p>Mobile Storage</p> <p>Consumer Electronics</p> <p>Performance Gap</p> <p><b>PERFORMANCE</b></p> <p>Time</p>
<p>DRAM-like Byte Accessibility, Fast &amp; Direct transfer between CPU and High Density Storage</p>	<p>NAND performance degradation</p>

## RRAM vs NAND : Brand-new

- Totally different one : architecture, operation
  - No block/string operation : Byte accessible
  - Better performance : Latency & Endurance
- Very tricky to reduce cost
  - Multi-planes X-bar array : high process cost
- Vertical RRAM
  - Lateral disturbance issue

**High performance & a little expensive (vs NAND)**

**Need to setup Eco-system (Controller, Protocol)**

**Check the competitor's status**