3D: Beyond Conventional Flash and into the Future

Alper Ilkbahar
VP, 3D Memory Group
SanDisk Corp
NAND Flash Industry Growth

NAND Flash ASP and Revenues

Source: Gartner
What drives cost-per-bit?

- Multiple bit per cell (MLC) technologies
- Economies of scale
- But beyond everything SCALING
"If we build it (at the right price), they will buy it"

Exponential ASP reduction needed to drive industry growth

We need to continue scaling

Rev = $23B – 7.9 x log (ASP/GB)
Can stacking layers of memory solve our scaling problem?

Relative Cost vs. Number of stacking layers

- Relative Cost
- No of Layers

- Ideal line

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Alper Ilkbahar, SanDisk 3D
Examples of stacked memories: 3D NAND

Samsung, IEDM ’06, ISSCC ‘08
Additional Layers are not free

- Die size overhead and additional process steps increase cost
...and yield of each layer is <100%

- Stacking may provide one-time cost benefits, but it alone is not a replacement for scaling
3D: Vertical Devices

- Another perspective of 3D:

  Can we build memory devices in the vertical dimension that are easier to scale?
Example of Vertical Devices in a 3D stack: Bit-Cost Scalable Flash

Toshiba, IEDM '07
Ultimate 3D Memory - Scalable and Stackable Cross-Point Diode Array

Resistance Change Materials

- Chalcogenides (PCM)
- Metal Oxides
- Solid Electrolytes
- Magnetic materials
- and others…

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Ultimate 3D Memory - Scalable and Stackable Cross-Point Diode Array

4 Layers of Memory

Periphery Circuits
Five Generations of 3D Diode Arrays

SCALABLE
&
STACKABLE

250nm

130nm

80nm

8-Layers

45nm

4-Layers

1-Layer

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- NAND Flash will continue scaling beyond current predictions through not only process and device but also system-level innovation.

- Investment in alternative technologies that do not have a long-term scaling path will have limited returns.

- 3D diode arrays with the right switching material will replace Flash.