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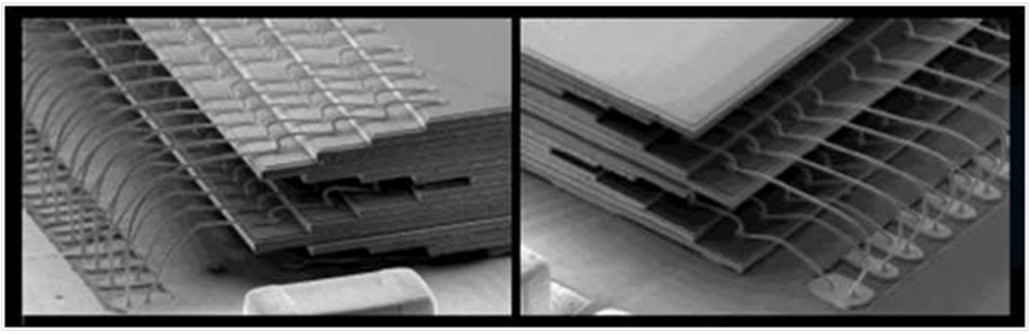
Is Complex Packaging in High Volume Manufacturing (HVM)?

Over the past year…
The amount of 2.5/3D articles published continues to gain momentum. Some articles discuss when HVM will be achieved, others discuss costs from chip to system levels, how to evaluate options, design and verify, etc. All articles are based on facts gleaned from various articles, presentations and conferences that authors have viewed or participated. These facts are based on what information was available to each author but some information is always protected by developers from the public dissemination: call it 'secret sauce', competitive advantage, etc. But there exists service providers that perform 'tear down' and/or benchmark analysis that dismantle products and provide an independent perspective on the technologies used to create a product. These insights can be invaluable to see what is actually being manufactured today.

While researching to upgrade my computers….
Recently, I have been upgrading my computers with additional memory and looking to swap out my old hard disk drive for a new solid state drive (SSD). SSDs are starting to increase their sizes while their prices are starting to decrease. SSDs can significantly reduce your startup time (critical for laptops that travel) and also improve program execution (laptop and desktop). I have started to accumulate information on SSDs such as: manufacturers, data stored, power consumed, read/write access times, prices, etc. Anandtech posted a review on SandDisk's 128GB iSSD product and another report on Samsung's SSD 850 Pro products[1, 2]. The reports go into detail how the products are manufactured and how they compare to other SSD products. SanDisk and Samsung have chosen different paths but are driven by the same metrics: density, performance and cost. Below are brief overviews on a selected aspect for both SSDs and I would encourage the readers wanting a 'deep dive' to read both reports.

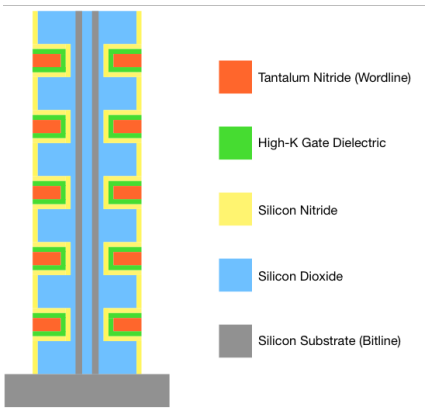
Path 1: Complex packaging with newer silicon technology
The AnandTech SanDisk report was augmented with a few pictures and one caught my attention (shown below).



It might be difficult to count the 16 stacked die but you can see the offset die and the stitching wire bonds that are used to connect all 16 die into a package: quite impressive. The beauty of this system: the use of 'flexible' bond wires to interconnect each die. This is a little more flexible than aligning small TSVs for stack alignment. SandDisk probably did numerous economic and engineering analyses proving that this structure could be manufactured in high volumes (yields) while remaining profitable. 16 stacked die is used for 960GB, 8 stacked die for 480GB and 4 stacked die for the 240GB SSD. These packaged modules and a controller chip are then attached to a single sided PCB in on SSD capacity required. So the complexity resides in the complex packaging and the PCB is an inexpensive 'trivial' design.

Path 2: Reverting to older silicon technology (with a twist) coupled with complex packaging
The Samsung report was augmented with a lengthy discussion and some pictures on their 3D NAND structure. Silicon pricing is based on 2 dimensional pricing (X and Y dimension), similar to purchasing acres of land. The elevation or height of the silicon has minimal impact on price. But two other critical benefits are achieved with vertical stacking. The separation between bit cells can be larger thereby reducing interference from nearby cells. In addition, the amount of charge that can be stored stacking versus lateral is higher which provides additional protection against 'losing' information. Lateral (linear) scaling reduces the size of the floating gates thereby reducing the number of electrons that can be stored; vertical does not. These two factors have a large impact on reliability and density that can be achieved using V-NAND architecture. With V-NAND, Samsung can use older technology (40nm) rather than

leading edge, costly 16nm (or lower processing). Remember, the lateral cell arrangements cannot continue to scale due to the interference and charge that can be stored. Although the process can be scaled lower, the bit cells themselves must have increased separation and might even need to limit how much the bit cell can be scaled (for charge). Below is a picture of Samsung's stacked bits and a chart showing a comparison between Samsung and Micron's NAND capabilities (from AnandTech report). The area die size is significant and can support higher bit capacity by increasing the vertical stacks (grow taller, not wider).



	Samsung 2nd Gen V-NAND		Micron 16nm NAND
Process Node	40nm		16nm
# of layers	32		-
Die Capacity	86Gbit		128Gbit
Die Size	95.4mm^2		173mm^2
Cell Size	40,300 nm^2		1312nm^2

High volume manufacturing (HVM)?

Memory Cards, USB Flash Drives and Solid State Drives are all part of the same family of solid state memories. Just different densities and form factors based on required use. If you look at all the Memory Cards consumed for cameras/phones are expected to reach $21.3B sales in 2018[4] and USB Flash Drives are expected to hit 561 million units in 2018[5], our appetite for solid state memory is tremendous. All augmenting how we live and capture moments in our lives. SSD's are approaching 20+ million units per year, small compared to other solid state memory products. The primary reasons for SSD's lower volumes have been limited usage, density and prices for these drives. As a comparison, iPhone sales hit 75 million units in Q1 2015 (one quarter) [6]. Each cell phone generation has more functionality and performance; I could see an SSD being incorporated into a future cell phone for OS, application SW and data storage. With many phones incorporating multiple processors and many functional capabilities, it is only a matter of time. Given the volumes of these solid state memories, they are using complex packaging in HVM. These devices do not need 3D TSV enabled technology; the alternatives found by SanDisk and Samsung seem to meet their requirements and are successful in the consumer market.

Two different approaches and consumers win…

Consumers are benefiting from the competition in this space, as I mentioned both disk capacity is increasing while costs are decreasing. Both approaches are interesting and in time, we will see which technology choice is the better for future generations of SSDs. My bet: vertical stacking will have the edge until a newer architecture is discovered based on competition.

Notes:

1 http://www.anandtech.com/show/8170/sandisk-extreme-pro-240gb-480gb-960gb-review
2 http://www.anandtech.com/show/8216/samsung-ssd-850-pro-128gb-256gb-1tb-review-enter-the-3d-era
3 http://www.storagenewsletter.com/rubriques/market-reportsresearch/trendfocus-ssd-market/
4 http://www.storagenewsletter.com/rubriques/market-reportsresearch/global-industry-analysts-sd-cards/
5 http://www.mynewsdesk.com/uk/pressreleases/usb-flash-drives-market-to-reach-volume-sales-of-561-million-units-by-2018-939103
6 http://www.statista.com/statistics/263401/global-apple-iphone-sales-since-3rd-quarter-2007/