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Flash Memory Applications and Markets:

2010 – 2015

Report Number

CS100FA-2010

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Key Findings

In its basic simplicity, Flash is used to easily record a digital experience and store it on a small sized, solid state and relatively low cost component that can be re-played anywhere at any time. During Flash's evolution, both the technology and its corresponding markets were developed hand-in-hand migrating from the low performance NAND storing media in the consumer market to the XIP use in the Mobile market and finally to providing high endurance/performance Flash for the computing market. In its first usage model, NAND Flash was used in media storage for taking a picture, recording a song or video. These recording and retrieving tasks are simplistic or not very taxing on the memory nor were they highly valued by the user. As the mobile market developed with the growth of cell phones, Flash usage became more sophisticated, requiring executable NOR for memory functions and reliable NAND for storage. The mobile market technology requirements pushed NOR to its upper limit of functionality with sophisticated execute in place and forced NAND to become more reliable and shrink its footprint. Even as the functionality increased, the cell phone vendors still demanded Flash prices to decline. Currently, Flash has entered the computing market, where it acts as a performance accelerator for Flash cache and as a SSD replacement of the hard disk in notebooks and netbooks. As solid state performance improvements are increased through better ECC and controller developments, Flash is being configured in the enterprise-computing-internet market. Here Flash assists in improving the computing platform in many ways: by removing bottlenecks and tremendously accelerating throughput, reducing power consumption and enhancing reliability; all with the goal of improving storage and computing systems to handle the increasing processing loads associated with the growth of the internet, especially social networking.

Although the demand for Flash continues, the Flash market is not impervious to the effect of supply and demand cycles within the industry, or to macroeconomic trends affecting the global financial markets and world economy. Especially in the most recent financial crisis, the Flash vendors feared lack of credit and expected consumer demand to drop dramatically, so they cut back on production in early 2009. Unfortunately, the vendors miscalculated the financial fears of consumers who did not react strongly to cutting their spending/demand for 'essential' electronics. Throughout 2009, NAND prices rose 50-100% or more as supply returned to 2008 levels, but demand became even stronger. The working population (in the U.S. with 9.6% unemployment – resulting in 85% working) is still buying essentials and some are buying like they did before the recession, which shows the continued demand in the 2010 market. What happened seems to point that certain sectors of the economy have cut costs in 2009 and in the

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first three quarters of 2010 and are showing profitability, but they are not basing this recovery/growth on generating new sales nor on job creation.

Whether this current demand will trigger more spending or just enough to satisfy the essentials, will determine whether the economy will continue to rebound or will it suffer another correction. Most corporations have cleared out much of middle management and are forcing those who are remaining to produce 3x more than in the past. Nor will the corporations add back jobs in the old business model, so only specialized jobs will be added and new business models will emerge to bring back more job growth. Consequently, it is reasonable to view the Flash market experiencing a bumpy cycle with a possible correction that ends with the potential return of consistent demand in mid 2011-12. Therefore, this forecast tries to provide a view of how demand will resurface, what computing applications will be the major drivers leading this growth in 2011-2015, and whether the NAND vendors can invest in additional capacity to satisfy this modified demand.

Throughout 2010, the Flash memory market is facing some unique and more difficult challenges than last year. Despite consolidations and exiting from some of the NOR Flash vendors, prices were experiencing stability or slight increases in the first half, but as the NAND, NOR and other electronics supply began to catch up with demand in Q3 and Q4, prices began to recede. The net result shows that both NAND and NOR should see a more normal or seasonal outlook for 2011 and possibly for the next few years. During this time the overall capacity will be gradually increased to allow the new demand to catch up with supply. Nevertheless, Flash will return to a growth phase that should generate growth rates for all Flash in the next six years in the 13.4% range producing revenues of $26.2 billion in 2010, $29.2 billion in 2011 and $49.1 billion by 2015.

On the technology front for Flash, NOR-type EcoRAM that was slated to replace read optimized server DRAM has been discontinued and replaced with Server NAND RAM in storage systems, while the NOR-type Phase Change Memory is shipping sporadically from Samsung and Micron (Numonyx) and 256Mbit serial NOR has been released with minor shipments; and on the NAND side, the 3-bit per cell MLC NAND from SanDisk/Toshiba is in production, production has come from Hynix, some 3-bit per cell from IMFT and low quality 3-b/c from Samsung is also shipping. On the 4-bit MLC NAND-type components development, SanDisk/Toshiba are shipping 43nm parts. Overall, there are major reliability issues with the NAND process migrating to 2xnm for Toshiba and Samsung, yet IMTF has mastered their production at 34nm and 25nm. On the 3-bit production many vendors are still having reliability problems and cycling is deteriorating rapidly, but this will be remedied by additional controller and process

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enhancements over time. All these developments in NAND will enable higher density parts to be produced as the technology node shrinks culminating in a 3-bit 256Gbit part that could be produced by 2014. These various types of NAND have been quantified by their consumption in the consumer, mobile, and computing end use application markets.

In the End-Use market chapter, Web-Feet Research forecasts fifthy end-use markets using over 165 individual applications that supply the individual inputs for revenue, units, and Megabits that are consolidated to build the 'bottoms-up' demand forecast. In the mobility market, Flash cards and internal NAND or Embedded Flash Drives in cell phones have become one of the Flash application leaders. Consumer applications such as Digital cameras, MP3 and Media Players, along with camcorders, photo albums, television and Set top Boxes and all other games and consumer devices are maintaining a large share of Flash consumption. Flash cache as Express Card modules, SSDs in notebooks, tablets and netbooks, along with desktops and nettops and Enterprise are building this large computing base that will become the largest consumer of Flash from 2013 and beyond. Server-based Flash cache with Server eNAND RAM and Phase Change Memory were added in the computing market as well as Enterprise Solid State Drives are the new applications. NOR Flash for program storage were re-forecast to have serial Flash as a replacement for parallel Flash in digital cameras, Media (PMP) players, printers, LCD monitors, Bluetooth, modems, Smart Grids, Set Top Boxes, networking, GPS, Photo Albums, and optical drives including Blu ray.

Finally, in the Flash memory market shares by vendor section the 2009 Flash revenue by vendor is compared to the 2008 revenues. In 2009, Samsung maintained its leadership of all Flash with 33.3% market share, down -0.6 points from 2008. Toshiba stayed in second with 21.7% market share, while gaining over 4.7% the most points of all vendors. SanDisk moved up three places from sixth to third on 10.5% and gaining 2.8% the second largest gain. Numonyx fell from third to fourth on a market share of 8.5%, losing 2.9 points the third largest drop in the industry. Spansion also fell one place in the rankings as the NAND vendors improved, achieving only 6.8% share, a loss of 4.4 points the largest. Micron rose one place overtaking Hynix for fifth place and gaining 2.1 points third largest gain. Hynix dropped two places to seventh, after failing to add capacity and ride the NAND upswing like the other NAND vendors. Intel maintained eighth place while generating only 4.1% share and gaining 1.3% due to the increasing NAND market. Macronix also maintained ninth place and grew their business by 0.6 points. SST held on to tenth with 0.8% share but lost -0.3%. These are the top ten Flash vendor 2009 rankings that have their preliminary 2010 ranking estimated in the Market Shares section on page 300 by Web-Feet Research.

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Analysis and Reporting Methodology

The Flash Memory Applications and Markets Forecast report from Web-Feet Research includes a variety of methodologies for different sections of this report. On the application side, Web-Feet Research surveyed many application companies, Flash manufacturers, and other vendors to obtain the application forecasts. Utilizing this information, Web-Feet Research developed a 'bottoms-up' Flash demand forecast by projecting over fifty end-use application unit forecasts and the associated internal Flash, Embedded Flash Drives and Flash card memory content for each of these end-use applications. Concurrently, Web-Feet Research uses a macro-model based on the Flash Memory Reporting Association (FMRA) that summaries and forecasts, and then projects a 'tops-down' demand forecast to cross check the 'bottoms-up' results. These two forecasts are then reconciled to one overall Flash demand forecast.

Within the 'bottoms-up' demand forecast, each application has the Flash revenue, units, and Megabits (Mbits) calculated and then consolidated into the overall totals for each year of the forecast. The revenue, units and Mbits for both NOR and NAND types of Flash are calculated separately for density and then summarized for each application.

Web-Feet Research was able to use the FMRA summary of revenue, units, Mbits, and ASPs segmented by NOR and NAND Flash types. This data was submitted by the top 15 Flash manufacturers in 2008, 2009 and part of 2010 to establish the baseline of the Flash memory market size. These FMRA baselines provide density breakouts from 256Kbit-256Gbit for each Flash memory type including NOR, MLC NOR, Serial NOR, NAND, MLC NAND, 3MLC NAND, 4MLC NAND, and Combo (Flash + SRAM/xRAM) NOR and Combo NAND devices. New to this forecast are the Storage Class Memories: Server NAND RAM and Phase Change Memory components that are attempting to replace server DRAM for RAM-optimized servers. In conclusion, Web-Feet Research compares the forecasts between the FMRA baseline and the WSTS-based baseline projections. Finally, a NAND capex forecast by vendor has been updated in chapter 8. Page total 304.

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About Web-Feet Research

Web-Feet Research (WFR) is a professional services organization that assists clients in the semiconductor, electronics and finance industries build value, solve complex business problems, and enhance their ability to improve performance.

The company has consistently identified the emerging trends in the electronics industry and has been the first to forecast their impact in the Flash and nonvolatile memory markets since its inception in 2000. Some of WFR's firsts are in the following areas: SSD, Flash cache/Hybrid Flash, Embedded Flash Drives, Ultra Low Cost PC, Mobile storage, MP3, NAND MCP, USB Drives, Flash SIM cards, micro Flash cards, 3-bit/4-bit per cell NAND and serial NOR Flash.

The company offers a full complement of technology consulting services, management consulting services and market research for nonvolatile memory, solid state storage technologies and mobile hard disk drive products. Special emphasis has been focused on the development and growth of Flash memory, Flash cards and SSD markets.

The subscription services offered by Web-Feet Research concentrate on the Non-Volatile Memory and Storage Portfolio, which is segmented into three services: Manufacturing / Technology, Storage Systems, and Memory Components.

The company also organizes annual public and on-site presentations, the NVM conferences, which supplement the consulting and research services. These conferences focus on technology evolution, product development, storage markets and industry / economic trends.

Web-Feet Research also provides custom studies, technology evaluation and competitive analyses of mobile, portable and stationary technologies, products and industry trends. The professional services and syndicated studies give Web-Feet Research, its clients and its clients' clients a competitive edge in their respective markets.