2012 NAND Flash market annual report

Industry analysis report

January 13, 2013

■ Smartphone embedded storage solution steering to eMCP/eMMC

The eMMC standard was designed mainly to solve the quality issue and reliability issue caused by the upgrade of Flash nanometer process technology, and to fulfill the customer's needs on high performance and high reliability storage. It mainly applied on the hand-held terminal products which require large capacity data storage. With the continuously improvements on product feature and speed, eMMC have been widely applied on Smartphone, medium & high-end Tablet PC, Ultrabook …

■ Windows 8 opens the new opportunity for SSD popularity

Under Windows 8 system, it upgraded the original defragmentation tool, made optimization special for SSD and also disk judgment on mechanical hard drive or SSD drive. And automatically make corresponding strategy (e.g. Mechanical hard disk to handle defragment, plan trim process on SSD.), thus, operates on the entire volume when the SSD is idle rather than NTFS send Trim command to controller. As a result, systems start from Windows 8 or later version will be able to adopt …

■ Market trend of NAND Flash market situation in 2012

Source:www.chinaflashmarket.com

■ NAND Flash consumption by Emerging-markets

Apart from the big NAND Flash consumption by Smart phone and Tablet PC, the growth of some Emerging-markets such as Smart TV and Multi-screen interactive also boosts the NAND Flash demands.

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Table of contents

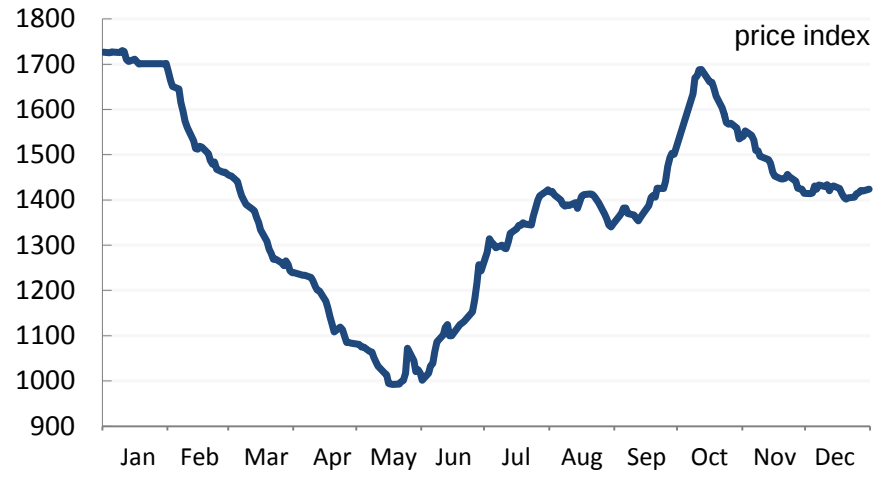
Market trend of NAND Flash market situation in 2012

Market demand for NAND Flash downturn in the first half of 2012 with excess supply, consumer flash products: such as USB drives, SSD, memory cards and NAND flash decline heavily, affecting the overall price index from January to May, the trend continued down to decrease 42% in the first half year, while in 2011 the overall price index fell to 48%. The price decline of NAND Flash in the half year of 2012 has been doubled up of the decline in the whole year of 2011. The price of NAND flash products fall in a dilemma in the first half year in 2012.

Rebound effect in the overall price index in June, many manufacturers strictly controlled the supply of NAND Flash, Toshiba takes the lead in reducing the outputs. NAND flash, memory cards, USB drive price increases to boost the overall price index continued to two monthly increases, but the market demand is still limited, eMMC, SSD product prices continued to decline from the high prices. In August ,there are signs of a slight decline under the pressure from trading at high prices and limited demand influence, but the market is affected significantly in September by introducing of new

Exhibit 1

NAND Flash price index trend in 2012



Source: www.chinaflashmarket.com

stockings, memory cards, USB drive prices again continued to rise, eMMC, SSD price kept in an average price, the overall price index upward trend continued into early October. November in the impact of weaker demand, the price is a down trend, although in December there are the small peak season to help out, but there is no significant signs in price increasing.

NAND Flash manufactory technique process and market structure

1. NAND Flash nanometer process technology access to 2xnm era

In 2012, major NAND Flash manufactory nanometer processing technology access into 2xnm era, Samsung the amount of production is based on 21nm technology, Toshiba/ SanDisk continue to enhance producing the 19nm technology production proportion, Micron, SK-Hynix starts the transformation from 20nm technology mass production to 1xnm technology, at the same time began to increase the production of nanometer process technology

NAND Flash manufactory which is started by MLC NAND Flash structure framework to TLC NAND Flash, this will improve capacity significantly meanwhile costs are reduced as well.

Exhibit 2：Main NAND Flash manufactory nanometer processing technology roadmap

Technology / Manufactory	2008	2009	2010	2011	2012	2013
Samsung	42nm	35nm	32nm	27nm	21nm	16nm
Toshiba/SanDisk	43nm	43nm	32nm	24nm	19nm	1xnm
Micron	34nm	34nm	25nm	25nm	20nm	18nm
SK- Hynix	46nm	46nm	35nm	26nm	20nm	15nm

Source:www.chinaflashmarket.com

2. NAND Flash interface transferring rate up to 400MB/s

NAND Flash is using the two high speed interfaces standard: ONFI and Toggle DDR standard, they are the quickest access to the standard interface between the controller and Flash. The ONFI V1.0 specification from Intel, Micron, Phison, SK-Hynix, Seagate equal to 2006 published version, is committed to simplify NAND Flash applications in consumer electronics products, as the introduced with the new specification, ONFI V3.0 400MB / s transferring speed up from the ONFI V1.0 of 50MB / s, and also adds new features, such as supporting for interleaved operation, extended ECC Information, EZ -NAND ECC offload, differential signal technology etc. Samsung, Toshiba and SanDisk adopted another interface standard, from 2010 Samsung produced the Toggle DDR V1.0 interface standard NAND Flash, Toggle DDR NAND using two-way DQS signal control read and write operations, while increased the transmission speed up to 133MB/s, but also lowered the power consumption compared to the previous SDR interface. Toggle DDR V2.0 interface standard was released in 2010, the brand new Toggle DDR2 interface increased the NAND Flash data transfer rate up to 400MB/s, 3 times faster than Toggle DDR1 interface which speed reaches 133MB/s, compared to SDR NAND Flash data transfer speed of 40MB/s 10 times faster.

3. NAND Flash from production expansion to production reduction

NAND flash plant continue to enhance the proportion of 2xnm production in 2012, and TLC NAND Flash structure continues to mature, to procure NAND Flash costs falling and doubled output, Samsung Fab 16,Toshiba Fab 5, Micron IM Flash factory capacity constantly output the driven NAND Flash market volume of output of the production capacity in 2012 of approximately nine million 12-inch Wafer equivalents.

There's only little difference between NAND Flash and DRAM production equipment, and fluctuations in the market price of NAND Flash and DRAM are very big. The price is dropping heavily of PC DRAM in 2012, even heavier than NAND Flash. The Flash vendor cannot transfer more NAND Flash into PC DRAM, but mobile DRAM is using lot in the smart phone industry, price stability and profit contribution of the original than PC DRAM

Exhibit 3：NAND Flash interface standards development of different manufactories

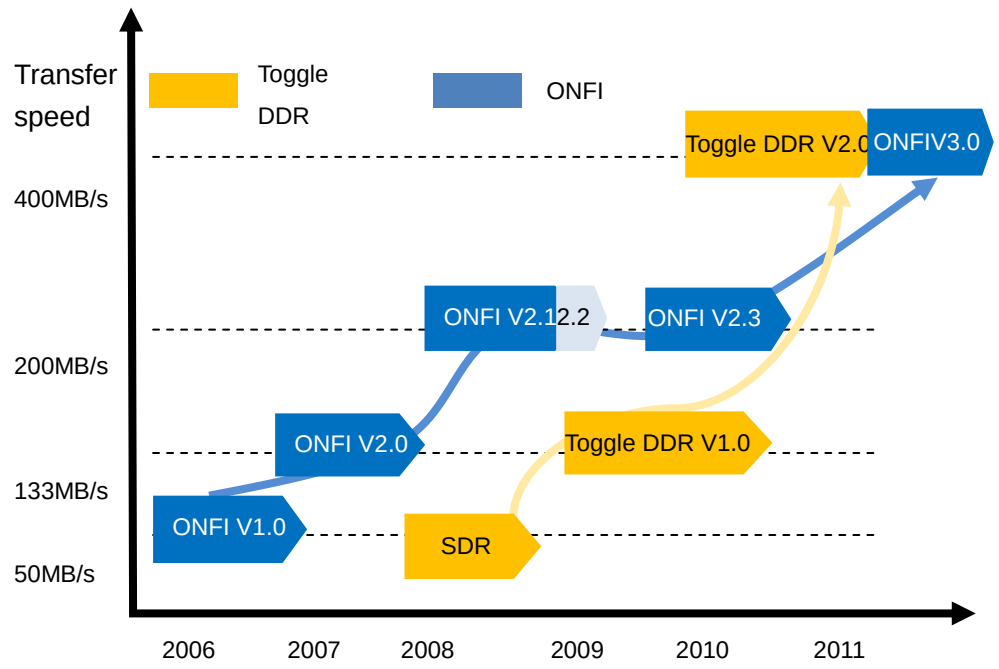


Exhibit 4：2012 NAND Flash manufactory output situation

Vendor	Manufactory	Technology	Capacity unit:per month	Remark
Samsung	Fab 12	27nm	100K piece	
	Fab 14	27/21nm	150K piece	
	Austin	27/21nm		Transfer to logic chips
	Fab 16	21/1xnm	300K piece	
	China	1xnm	100K piece	Output in 2014
Toshiba	Fab 4	24nm	200K piece	
	Fab 5	19nm	300K piece	
Micron	IM Flash	25nm/20nm	150K piece	
SK- Hynix		26/20nm	150K piece	

Source:www.chinaflashmarket.com

and NAND Flash partial remission of DRAM output pressure. In the second half of the year, the original conversion of part of the NAND Flash and DRAM to mobile DRAM, NAND Flash price stability have made great contributions, which also led to the PC DRAM prices.

Global fully able to meet the requirements of low-power standard smart phone mobile DRAM manufacturers Samsung, SK-Hynix, Elpida. Micron's mobile DRAM Micron's product line due to the limitations of the technology process and higher power consumption, and other reasons, resulting in the

lack of the niche storage products, from the Micron 2012 financial reports show, every quarter 2012 loss of $ 250 million or more. In 2013 Micron lack of embedded flash memory products and mobile DRAM products to support its Memory profit contribution may lead Micron NAND Flash flowing into the market.

In addition, in order to meet the increasing demand of the Tablet PC, smart phone and SSD, NAND Flash factories have set up new production lines or increase production capacity in the first half year of 2012. Samsung has not only began construction of the NAND Flash factory in Xi'an, China, but also increased investment in the 16 production lines of FAB 16, and rise the investment by 2012 to 47.8 trillion WON; Toshiba has been commenced the construction of Fab 5 two new plant in the summer of 2012, production is expected in 2013; Micron bought the shares held by Intel in IM Flash, IMFS and MTV becomes Micron wholly owned; Intel first half of the 2012 capital expenditures rise up to 12.5 billion USD; SK-Hynix M12, Wuxi factory plans to produce NAND Flash, planning 2012 capital expenditures to increase by 20% from the original 4.2 trillion WON to 5 trillion WON.

The second half of 2012, in order to reverse the decline in prices, improve market supply, Samsung began to shift to enhance the proportion of non-storage business, planned production of Fab 14, the Giheung Fab 9, the American Austin plant to transfer to system logic products and manufactory, 60 thousands 12-inch capacity of Apple OEM production of chips, NAND Flash Factory in Xi'an China has the output by the end of 2013, Toshiba slows down the construction of 2 nd phase projects in Fab 5. The SK-Hynix Korea Cheongju M12 production line of the factory change to mixed production line for DRAM and NAND Flash, the Wuxi plant production NAND Flash program also will be a stay of execution, but the M8 production line in Cheongju start to take the foundry business as the center of gravity. NAND Flash manufactory will reduce the volume output of NAND flash in the second half of the year, Toshiba has announced production cuts of 30 percent, Samsung, SK-Hynix NAND Flash reduce cut output by about 10% due to the production line to produce other products; the purpose is to maintain the stability of the market price.

Exhibit 5：Micron share changing in IM manufactory

Manufactory	Before combination	After combination
	51%	100%
	51%	51%
	78%	100%

4. NAND Flash supply excess becomes scarce

In the high expectations of the 2012 original smart phone and SSD market demand, increased NAND Flash production capacity and high-capacity NAND Flash products, single MLC DIE 64Gb and 128Gb (Micron L85 products), but because of the improvement of Android system, upgrade from Android 3.2 to Android 4.1, CPU shift from single-core to dual-core and quad-core, it puts off parts of the smart phone demand in the first half of 2012; in the other hand, delayed launch of Windows 8 and steady high cost of the SSD make the SSD cannot rapidly popularized. These two factors make a large number of factory output NAND Flash cannot be consumed and thus forced to be transferred to the consumer market which cause the market plummeted in the first half of 2012. In the consumer market, SanDisk and Kingston in order to grab market share in the first half of the year, low-cost shipping, setting off a series of bargain war lead to market low-priced products out in force. SanDisk cost advantage in low-cost TLC Flash, in order to get more market share, Kingston use the brand advantages also slashed the flash memory card, USB drive and other NAND Flash product line price, once monthly price fell by about 15% . SanDisk and Kingston is a major supplier of flash memory cards and U disk market, the total market share of more than half, so the bargain battle lead the mainstream flash card, USB drive decline in value of serious drag on the overall trend of the price index.

January to May 2012, most of the supply chain vendors feel the pressure of price dropping after a serious decline in price, which nearly close to the production cost, in order to reverse the market decline, NAND Flash

manufactory began only supplies to the smart phone, tablet, computer and electronic product brand factory, take a small amount of strategy to supply or not to supply a number of small and medium-sized distributors, also resorted to the strategy of insured SanDisk and Kingston is no longer cheap shipping. In respect of nanotechnology, some NAND Flash manufactory nanotechnology facing a challenge when transfer into 2xnm, some slack 2xnm output leading to reduced output of NAND Flash. However, the problem was quickly resolved, prices have begun to appear obvious gains after market supply been reduced, especially in September, stocking season, the market appeared supply shortage, NAND Flash supplier, however, the supply strategy is still not relax.

NAND Flash related product application market

1. eMMC / eMCP will dominate the mobile device embedded storage

eMMC adopt a unified the MMC standard interface, NAND Flash and its controller packaged by a BGA. eMMC can well solve the difficult problem of NAND Flash management, customers only need to select the desired capacity eMMC chip, without paying attention to the series of Flash management challenges NAND Flash brand differentiation, changes in process technology, compatibility, so as to simplify end-product storage program designed to shorten the time to launch new products in the market. eMMC performance and reliability than ordinary memory card location, helping customers to launch competitive functionality applications (such as high-speed write performance: eMMC, can help moblie phone customers to develop a variety of high-definition video and image application functions) to improve the users experience and user viscous products.

1.1 Development of eMMC Specification promotes continuous application expansion

The eMMC Specification was grown from 2008 V4.2 to V4.5. The theory write speed also improved from 10MB/s to 200MB/s. It added lots of new features according to the needs of embedded product design, and substantially enhanced data protection and treatment efficiency. V4.41 eMMC became the market mainstream in 2012; each manufacturer also started producing V4.5 EMMC. Hopefully, in the second half of 2013, V4.5 eMMC will replace V4.41 eMMC and become the mainstream.

The eMMC standard was designed mainly to solve the quality issue and reliability issue caused by the upgrade of Flash nanometer process

Exhibit 6：eMMC Specification development history

Exhibit 7：eMMC Standard Feature Evolution List

Feature	eMMC4.2	eMMC4.3	eMMC4.4	eMMC4.41	eMMC4.5
Mass Storage	√	√	√	√	√
Boot Support	X	√	√	√	√
Sleep Mode	X	√	√	√	√
Reliable Write	X	√	√	√	√
DDR I/F	x	x	x	√	√
Partitioning	x	x	√	√	√
Protection Modes	x	x	√	√	√
Secure Write	x	x	√	√	√
HW Flash Lock (Reset pin)	x	x	√	√	√
1.2v IO	x	x	√	√	√
High Priority Interrupt	x	x	x	√	√
Background Operations	x	x	x	√	√
Higher Speed 200MB/s throughput	x	x	x	x	√
Packed Command	x	x	x	x	√
Context ID	x	x	x	x	√
Large sector 4KB size	x	x	x	x	√
Power off notification	x	x	x	x	√
Package case temp	x	x	x	x	√
Real Time clock info	x	x	x	x	√
Dynamic device capacity	x	x	x	x	√

technology, and to fulfill the customer's needs on high performance and high reliability storage. It mainly applied on the hand-held terminal products which require large capacity data storage. With the continuously improvements on product feature and speed, eMMC have been widely applied on Smartphone,medium & high-end Tablet PC, Ultrabook, Smart TV as well as Cloud server.

1.2 Smartphone embedded storage solution steering to eMCP/eMMC

In the early stage, the mainstream embedded storage solution of Smartphone is NAND MCP, which packed SLC NAND Flash together with the low power consumption DRAM; Low production cost and relative mature technology are the advantages of this solution. But with the higher capacity requirements of Smartphone, NAND MCP is mainly used in low-end Smartphone at present; the main SPECs are 4+2 (SLC:4Gb,LPDDR1/2;2Gb), 4+4 (SLC:4Gb,LPDDR1/2:4Gb)and so on.

With the larger and larger program code capacity of mobile phone's OS, especially the widespread Android OS, manufacturers hope to preload a large number of programs and software into mobile phone; SLC Flash is hardly to meet mobile phone's demands on Flash storage capacity. Manufacturers like Samsung started packing eMMC together with the low power consumption DRAM so as to fulfill mobile phone's higher capacity demands. eMCP storage solution started being accepted by customers, and be widely used in mobile phone industry. Even though, currently only have few manufacturers such as Samsung and SK-Hynix have complete product SPEC and stable supply ability, meaning there are still quite big purchase risk for end users. At present, the most popular eMCP SPEC have 4+4 (eMMC: 4GB, LPDDR1/2:4Gb), 4+8 (eMMC:4GB, LPDDR2:8Gb), 16+8 (eMMC:16GB, LPDDR2:8Gb) and so forth. So far, mobile phones adopted MTK MT6577 platform are all using eMCP storage solution.

Due to the limited PCB space of high-end Smartphone, and the factor of high frequency communication between CPU and DRAM, medium & high-end mobile phone customers prefer to pack processor and LPDDR2 together by POP packing method; plus single eMMC storage solution, which reduces the difficulties of PCB design for engineers and reduce the communication signal interference between processor and DRAM, so as to improve the end product performance. Currently, mobile phones using platforms like Qualcomm MSM8260/MSM8960 and STE U8500 all adopted this solution.

Exhibit 8：MCP, eMCP, eMMC Storage Solution Schematic Diagram

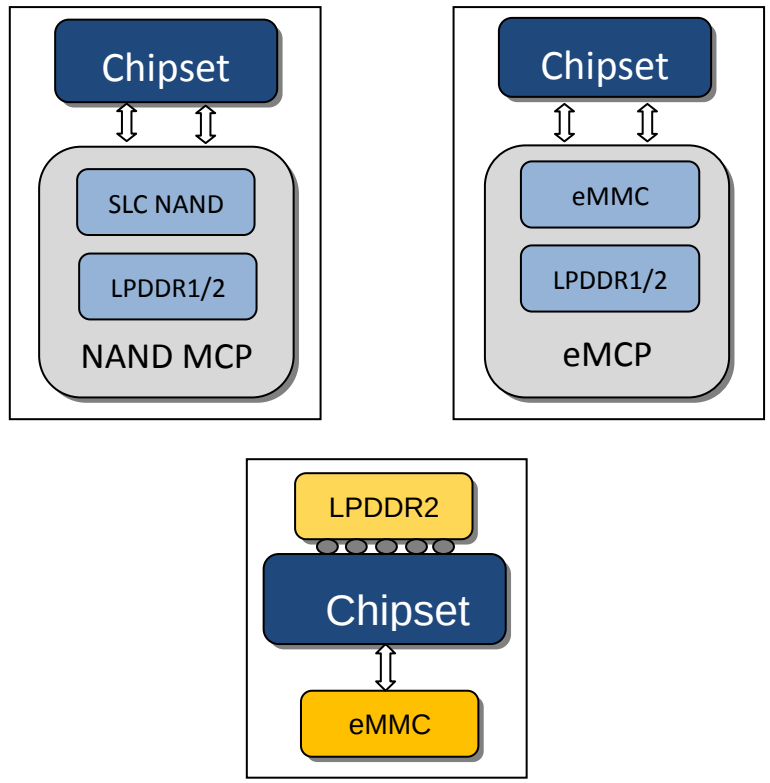


Exhibit 9：MCP, eMCP, eMMC embedded storage solution comparison

	Size	Manufacturer	Solution	Reference Average Price (USD/pc)
MCP	10.5*13	Samsung,Toshiba Micron SK- Hynix…etc	512MB SLC NAND+2Gb LPDDR 512MB SLC NAND+4Gb LPDDR	$3.7 $6.5
eMCP	11.5*13 12*16	Samsung	4GB eMMC+4Gb LPDDR II 4GB eMMC+8Gb LPDDR II	$7.5 $13
eMMC	11.5*13 12*16	Samsung,Toshiba Micron SK- Hynix…etc	POP LPDDR2 With single wafer: 8GB/16GB/32GB eMMC	$6.8/$11.5/$22

Source:www.chinaflashmarket.com

1.3 Latest eMMC products from main eMMC suppliers

In 2012, eMMC manufacturers mainly focus on eMMC 4.41 Standard. But Samsung, SanDisk already introduced eMMC 4.5 Standard, such as eMMC Pro Class 1500 and eMMC Pro Class 2000 from Samsung; and 128GB iNAND Extreme™ product from SanDisk; Innostor eMMC 4.5 SPEC controller IS510 already started delivery; the upcoming eMMC V4.5 SPEC new controller IS511 will become the one of the main growth motivations in 2013.

1.4 Price slipped promoted the demands of Smartphone and Tablet PC, which continuously pushing up the demands of eMCP/eMMC

Smartphone got excellent market demands. Samsung Galaxy series Smartphone have been selling like hot cakes. The sales volume of Q3 achieved 56.3 million units in one fell swoop. Be benefited by launching iPhone 5, Apple's iPhone sales volume in Q4 of 2012 will increase to 40-50 million units. High-end Smartphones are mainly embedded with 16GB/32GB/64GB eMMC. The growth of branded Smartphones became the main driving force of eMMC shipment volume.

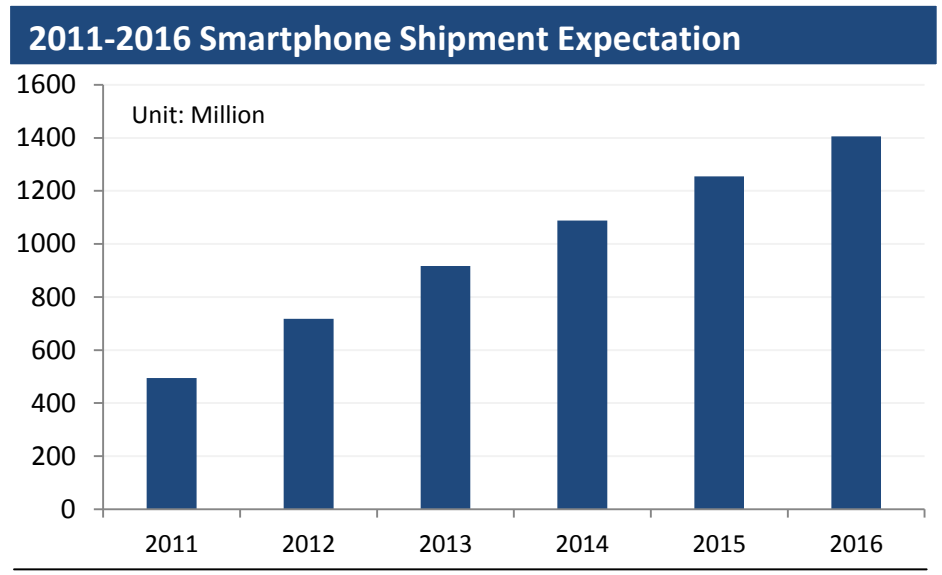
While the high-end Smartphone continuously growing, MTK and Qualcomm warmed up the development of eMMC/eMCP on low-end Smartphone. In the second half of 2012, MTK and Qualcomm started adopting eMMC/ eMCP on their platforms. MT6575/MT6515, MT6577/MT6517 all support eMMC/eMCP. Besides, MTK launched Quad-core chip MT6589. Apart from their dual-core, Quad-core MSM8225Q and MSM8625Q, Qualcomm launched two new Quad-core chipsets: MSM8226 and MSM8626, sample would be ready in the Q2 of 2013. The introduction of Quad-core not only improved the eMMC/eMCP penetration rate on low-end Smartphones, but also stimulated the upgrade of eMMC embedded storage from 4GB/8GB to 16GB, which may strongly spur the promotion of Dual-core Smartphone popularity. IDC data report says, the global Smartphone shipment volume in 2012 would be able to reach 717 million; it's about 45% increase than that of 2011. The shipment volume will keep increasing in 2013, which means the eMMC and eMCP demands will rapidly growth accordingly.

Exhibit 10：eMMC solutions from each manufacturers

Manufacturers	Brand	eMMC SPEC	Technology	Max Capacity	Flash	Main Package SPEC
Samsung	Samsung	eMMC4.5	21nm	64GB	MLC/TLC	FBGA 12*16*1.2 11.5*13*1.2
SanDisk	SanDisk	eMMC4.5	19nm	64GB	TLC/MLC	
Toshiba	Toshiba	eMMC4.41	19nm	64GB	MLC/TLC	
Micron	Micron	eMMC4.41	20nm	64GB	MLC	
SK-Hynix	SK-Hynix	eMMC4.41	20nm	64GB	MLC	
Netcom	FORESEE	eMMC4.41	21nm	32GB	MLC	
Kingston	Kingston	eMMC 4.41	21nm	32GB	MLC	

Source:www.chinaflashmarket.com

Exhibit 11：



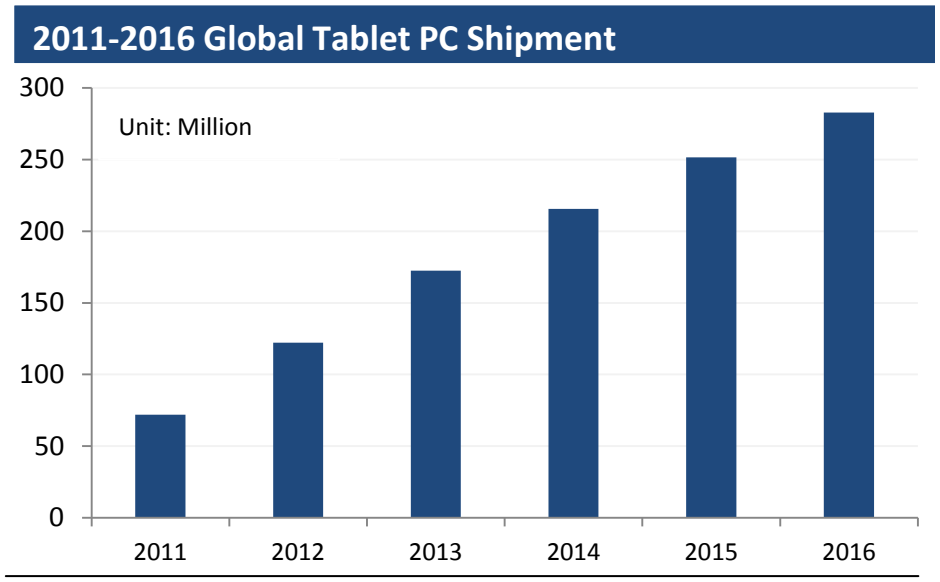
Source: IDC research institution

In the Tablet PC field, iPad still occupied the major market; however, under the continue mass production promotion of Allwinner A13, Rock-chip RK2918 and Amlogic AML8726-MX dual-core chip, domestic Tablet PC grown rapidly like army of ants trend. Some domestic Tablet PC processers pointed out that the Tablet PC shipment in 2012 would be able to achieve 50-60 million, there will be multiple growth comparing with 14 million shipping volume in 2011.

A31, RK3188 Quad-core Tablet PC chip launched by Allwinner and Rock-chip, such motivation leads to domestic Tablet PC's further improvements. The global Tablet PC total demands would be able to reach hundreds million or above in 2013. Besides, eMMC will be widely applied on Tablet PC, the embedded storage capacity also will grow towards high capacity. Meanwhile, eMMC may also penetrate into more industries such as Automotive, Learning machine, Digital TV, IPTV STB (Set Top Box), the total eMMC demands will be further expanded.

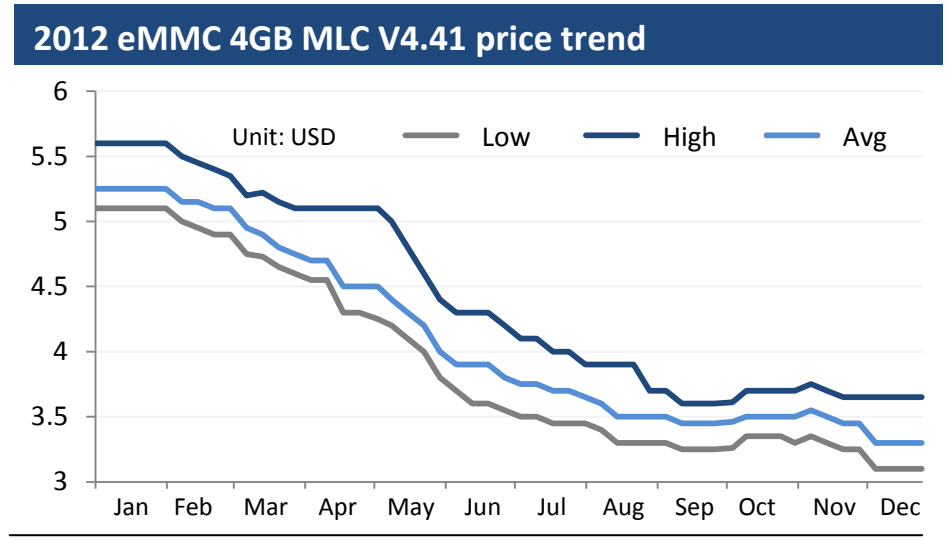
In addition, NAND Flash cost goes down and eMMC controller technology becomes mature, which enables eMMC price keeps reducing. According to the price from China Flash Market, the average price of eMMC 4GB dropped from early 2012 US$5.25 to US$3.3; that's 37% cost down. 8GB average price dropped from US$9.25 to US$6.15; that's 33.5% cost down. In the view of the currently price,8GB price is close to 4GB price in early 2012. With the eMMC price reducing, manufacturers prefer to adopt 8GB eMMC, and will shift towards 16GB eMMC.

Exhibit 12：



Source: IDC research institution

Exhibit 13：2012 eMMC Price Trend



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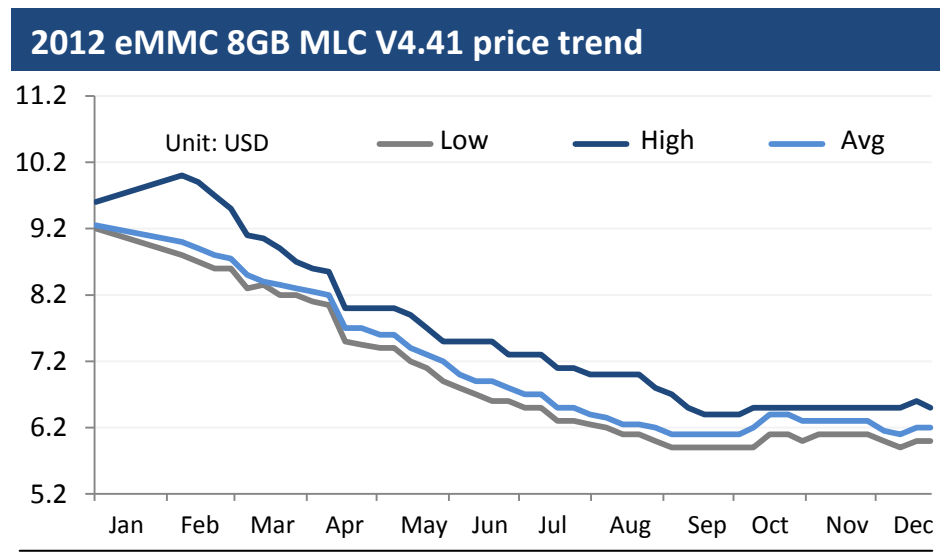


Source:www.chinaflashmarket.com

2. SSD replacing traditional hard disk is an irresistible trend.

In the past decade, CPU performance improved more than 150 times, while the traditional hard disk only improved merely 1.5 times. Such unbalanced developments strongly impacted the entire performance increasing, especially on I/O. Comparing with traditional hard disk, SSD has no magnetic head, motor and disk such components; it carries NAND Flash to work as storage medium. It is far away for traditional hard disk to compare with in terms of running speed, power consumption and lightweight.

Due to the low cost factor, currently, the traditional hard disk still occupied major hard disk market. However, with the SSD's continuous cost-down, technology improvements and better system supporting, the current mainstream laptop all have SATA and mSATA interface configured, including Ultrabook which must carry SSD to achieve 'Lighter, Faster and Lower power consumption'; SSD replacing traditional hard disk is obviously an irresistible trend.

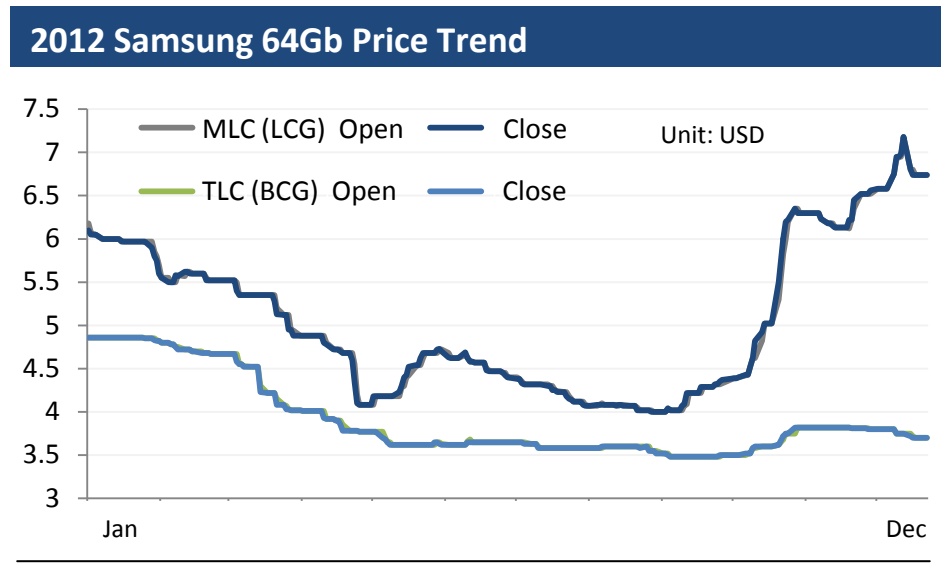
2.1 SSD NAND Flash structure is developed from SLC towards TLC

SSD is mainly constituted by SSD controller and NAND Flash. The NAND Flash controller management performance directly affects SSD performance. NAND Flash is divided into SLC, MLC and TLC according to its storage technology. The major SSD controller suppliers at present are Samsung,SanDisk, Marvell and SandForce (LSI). There are also some processers from Taiwan such as SMI, JMicron and Phison.

In 2012 SandForce 2281 controller was adopted by the SSD from Intel and Kingston. Marvell's latest SSD controller 88SS9187 has powerful ECC function and support SATA III; it's going to attach the consumer market, portable platform and enterprise market; SSD from Micron, SanDisk and SK-Hynix all carried this chip. Samsung SSD adopted its own designed LSI SSD controller. SanDisk designed controller applied on low-end SSD. With the continuous upgrade of SSD controller, both reliability and ECC ability have been further improved; the cost and energy consumption was also significantly reduced.

While SSD controller chip entered a new stage, SSD NAND Flash technology also stepped in a new period. The previous NAND Flash

Exhibit 14：2012 NAND Flash and SSD Price Trend



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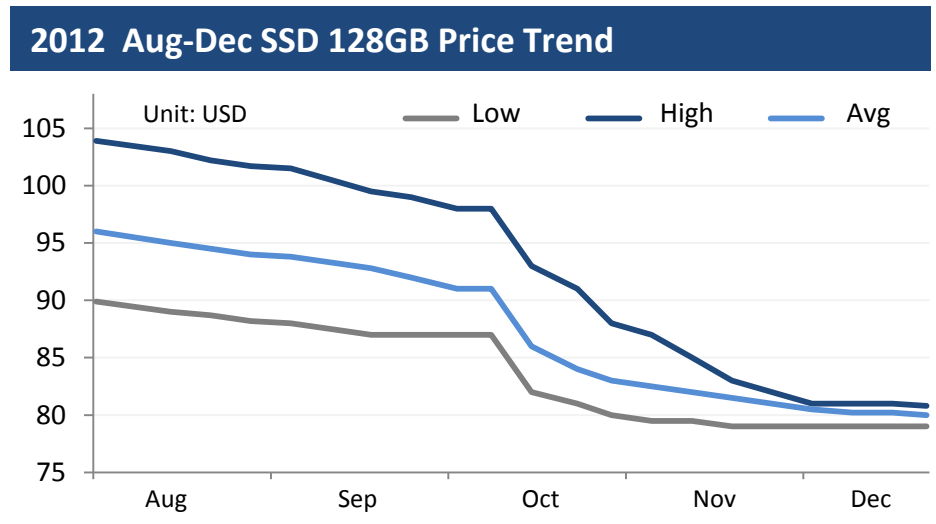


Source:www.chinaflashmarket.com

adopted by SSD was mainly 24nm-27nm MLC; but now NAND Flash with 19nm-21nm have become more and more popular in SSD production; moreover, the PM840 SSD launched by Samsung adopted 21nm TLC NAND Flash, hopefully, they'll adopt 1xnm technology in 2013. Samsung opened the prelude of steering SSD MLC to TLC era afterwards. It is believed that Micron, Intel and SanDisk will also follow the TLC SSD.

Further analysis, quotation of December from China Flash Market shows that Samsung 128Gb MLC (HDG) price was around US$11; Samsung 128Gb TLC (BDG) price was about US$7.1; Samsung 64Gb MLC (LCG) price was about US$5.5; Samsung 64Gb TLC (BCG) price was about US$3.75; price for the same capacity TLC NAND Flash was about 30% lower than MLC price. SSD price can be reduced at least 20% -30%; NAND Flash nanometer process technology stride forwards to 1xnm. It is not impossible to reduce 50% price on SSD products; SSD SATA III controller chip price was around US$15 or above, the future target is to cost down to US$5, this definitely will be a cross-era reform for SSD, which also represents the beginning of SSD civil use market. As is well-known, the read & write speed of TLC dropped a lot than that of MLC. Solution for improving TLC SSD lifetime and performance issue is the severe challenge that each manufacturers are facing. The reliability and compatibility of TLC SSD will also be tested by the complex market application.

2.2 Windows 8 opens the new opportunity for SSD popularity

The Windows series OS have been the mainstream OS of computer. OS strongly affects the lifetime and read/write speed of SSD; however, both Windows XP and Windows Vista didn't emphasize the optimization of SSD. SSD multi-thread simultaneously write & read data, each piece of data firstly use the idle space of NAND Flash to write in; but when NAND Flash is fully filled up, there is no spare room to be used, the system speed will slow down and performance will be reduced. Besides, it will reduce the SSD lifetime if the OS frequently read & write SSD. As a result, Windows XP OS only can adopt the best performance but also most expensive SLC NAND Flash SSD. When Windows 7 launched, it made quite a lot optimization on SSD. For instance, Windows 7 forbidden auto defrag function, which reduced wearing of SSD. Windows 7 is able to partition storage device, which solved the performance reduction issue caused by the partition method of Windows XP under Read-Modify-Write operation. Above all, Windows 7 specially support Trim engine, which enables detective and average the use ratio of each SSD storage unit. That's the reason that Windows 7 adopts MLC NAND Flash SSD. But the Trim command is sent by NTFS system document, and it was trimmed by controller; there may be trim command delay when the controller is busy.

Under Windows 8 system, it upgraded the original defragmentation tool, made optimization special for SSD and also disk judgment on mechanical hard drive or SSD drive. And automatically make corresponding strategy (e.g. Mechanical hard disk to handle defragment, plan trim process on SSD.), thus, operates on the entire volume when the SSD is idle rather than NTFS send Trim command to controller. As a result, systems start from Windows 8 or later version will be able to adopt TLC NAND Flash SSD.

Exhibit 15:

OS	Windows XP	Windows 7	Windows 8
SSD Type	SLC SSD	MLC SSD	TLC SSD
	Made improvements on SSD.	No optimization on SSD.	Made improvements and optimization.	Optimized on SSD.

Operation system upgrades from Windows XP to Windows 7, and then to Windows 8; SSD turning from SLC to TLC. Intel core product Ultrabook equips with Windows 8; except the fast booting speed, system running and internet browsing, price competitiveness will also be an extra advantage of SSD storage; by that time there will be soar market demands for SSD. Windows 8 is opening a new opportunity for SSD popularity.

2.3 Samsung, Intel, Micron, SanDisk and other manufactures treat SSD as the prioritized product and market

Since early 2012, main SSD manufacturers like Samsung, Intel, Micron and SanDisk started accelerated layout the SSD market and have launched new SSD to grab the market. In the first half year, Samsung intended to expand the supply of SSD. In the second half year, they introduced PM840 SSD with 21nm TLC NAND Flash, which definitely fed the industry's sight on. In 2013, the NAND Flash SSD will stride forward to 1xnm. New SSD series of Intel already adopted 25nm MLC NAND Flash, and started using their own controller chip. Toshiba MCL NAN Flash SSD still focuses on 24nm technology, so does SanDisk.

Exhibit 16:SSD Latest products of various manufacturers

Manufacturers	Representative Products	NAND Framework	Technology	Controller Chip	Density	Interface
Samsung	PM830	MLC	27nm	Samsung MCX	256/512GB	SATA III
	PM840	TLC	21nm	Samsung MDX	120/250/500GB	SATA III
Toshiba	SSDN-3T120B	MLC	24nm	TC58NC5HJ8GSB-01	60/240/480GB	SATA III
Intel	520 series	MLC	25nm	SandForce	60~480GB	SATA III
	335 series	MLC	20nm	SandForce	240GB	SATA III
SanDisk	U100	MLC	24nm	SanDisk	8-256GB	SATA III
	X100	MLC	19nm	Marvell	64-1024GB	SATA III
Micron	RealSSD P300	MLC	25nm	Marvell	50-400GB	SATA III
	RealSSDP400e	MLC	25nm	Marvell	50-400GB	SATA III
SK- Hynix	SH910 series	MLC	26nm	SandForce	128GB/256GB	SATA III

2.4 SSD interface Changing from SATA II to SATA III

The max transfer speed of SATA II is 300MB/s. In 2012, consumer products in response to the needs of high-speed transmission, SSD SATA interface begins turning into SATA III from SATA II; the transmission speed was increased from 300MB/s to 600MB/s. Enhancing SSD interface speed is mainly to improve SSD overall transfer speed. But firstly let's take a look at the NAND Flash transmission speed.

Two years ago, Samsung and Toshiba started developing Toggle DDR2 interface NAND Flash. The grade of Samsung 21nm NAND Flash has been upgraded from Toggle DDR to DDR2 and applied on 840 series SSD. Toshiba also have started mass production 19nm Toggle DDR 2 NAND Flash. Intel, Micron and SK-Hynix developed ONFI V3.0 standard together, and the NAND Flash interface speed increased to 400MB/s. From the NAND Flash interface transmission speed we can tell, 300MB/s of SATA II is far away to meet NAND Flash transmission speed requirement. NAND Flash with Toggle DDR V2.0 and ONFI V3.0 are all aimed on 4G Smartphone, multi-core Tablet PC, SSD and USB3.0 such products with large capacity and high transfer speed market application. SATA III is just enough to fulfill market trend. Therefore, the transition from SATA II to SATA III is inevitable. Due to SATA III design is more difficult than SATA II design, SATA III controller chip price is above 15 dollars, comparing with the price 3 dollars of SATA II controller chip there is still big difference. But with the growth of controller chip, the price issue will be solved quickly. Currently, Samsung,Intel, Micron, SanDisk and Kingston all have launched SATA III SSD; all the SSD controller chips support SATA III interface. SSD will perform maximum efficacy on consumer products by the time entering SATA III high speed era.

Exhibit 17:

Interface Standard	Transmission Rate
NAND interface Toggle DDR 1	133MB/s
NAND interface Toggle DDR 2	400MB/s
Device interface SATA II	300MB/s
Device interface SATA III	600MB/s

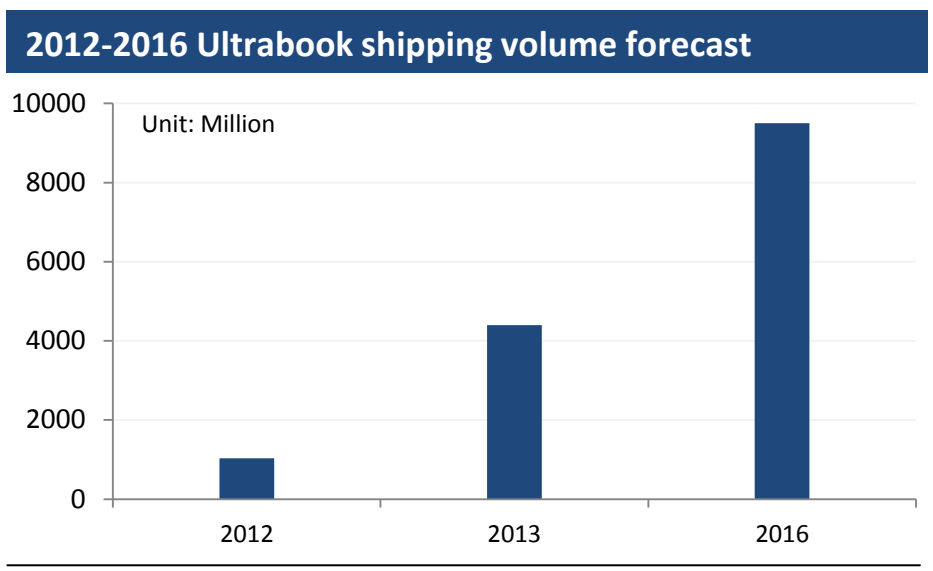
2.5 Expanding SSD Market Applications

SSD is mainly applied on large internet data base such as, Google, Facebook social internet data centre, enterprise server, aerospace military, Auto PC, commercial PC and Personal Computer such enterprise users and personal consumer field. There are different SSD interface according to different application field (e.g. SATA, SAS, PCIe, mSATA).

2.5.1 SSD located data base and enterprise storage high end application market

The transmission speed of PCIe interface is the fastest. PCIe interface second generation provides high speed up to 5GT/s; it is possible to achieve 8GT/s or higher in the future. Therefore, SSD with PCIe mainly aimed on high end storage environment such as data centre, server cluster, and cloud computing. Mini PCIe SSD is suitable to improve the speed of I/O intensive applications; or work as the ideal cache solution to improve the performance of server and workstation. Currently, most SAS support speed of 600MB/s and improving towards 1200MB/s or higher speed. Hence, SAS SSD is supposed to handle enterprise storage with read/write intensive applications. PCIe/SAS SSD aimed customers not only need high speed, but also need high stability. High stability SLC NAND Flash based general storage, with the SSD becoming mature, enterprise server storage started turning into MLC NAND Flash SSD.

Exhibit 18:



Source:IHS iSuppli

2.5.2 SSD Application on consumer electronic

SSD with SATA interface is quite suitable for handling light work load products such as PC, Tablet PC, Ultrabook, Commercial PC and so forth. In order to cater to portable products development, most manufacturers introduced mSATA SSD small-scale or embedded system storage solution to be applied on Tablet PC.

In the end of 2012, the SSD average price of each GB unit was USD0.6, which already dropped below 1 dollar. But 128GB SSD still need 80 dollars. SSD price is slightly high, which makes it difficult to improve the SSD penetration rate in the consumer products. Even Ultrabook is the perfect product to carry SSD, the price of pure SSD is still high. Furthermore, high price during the Windows 8 initial applications is inevitable and the stability is also to be tested. Intel is not willing to reduce the price on their processor, the sales price of Ultrabook with 128GB SSD are all over 10K CNY, which resulted in poor market demands of Ultrabook in 2012. In considering of the cost, some of the manufacturers introduced storage solution of small capacity SSD such as 24GB/32GB/64GB plus High capacity in to the market. Seldom seeing any Ultrabook carries pure SSD in the market.

Even though, the future prospect of SSD is still sizable. SSD cost keeps going down; plus Windows 8, SATA III applications becoming mature; SSD manufacturers continuously and actively introducing different SSD products. All these will create a good growth environment for SSD. Hopefully, the demands of SSD in 2013 will be doubled.

3. USB3.0 interface become mature, market demands warming up

The development from USB2.0 to USB3.0 has been long expected by processers. The main improvement was the interface transmission speed improved from 48MB/s of USB2.0 to 500MB/s of USB3.0. Such high speed with USB3.0 is quite tempting. In the last year, USB3.0 encountered market and other factor affects. At present, the USB3.0 products in the market are with various speeds from 10MB/s to 90MB/s. There are sharp speed differences in the market. Although USB3.0 seriously stirred the industry in 2012; each processer introduced he's own standard products; there wasn't any unified regulation. Besides, it was proved that USB2.0 still stay in the leading position. USB3.0 experienced one year's frostbite, it finally meets fragrance assailing the nostril. This is just the beginning, however, enhance promotion is still necessary in the coming year.

3.1 Intel processor, Windows 8 system provides growth platform for USB3.0

The transmission speed of USB3.0 is 10 times faster than that of USB2.0. USB3.0 has excellent performance. Intel Ivy Bridge processor integrated with USB3.0, which encouraged the growth motivation of USB3.0. In 2012, Intel flagship product 22nm Ivy Bridge processor chip set nature support USB3.0. Some chip set motherboards like Z77/B75/H77 with the latest Ivy Bridge framework all support native USB3.0. Native support USB3.0 means the motherboard integrated with USB3.0 controller chip. When using the USB3.0, it directly actives by the processor which integrated by South Bridge, no need any driver to be installed, which brings lightly speed improvements on USB3.0. Currently, the motherboard suppliers can avoid the impact of performance difference of different third-party USB3.0 controllers; they can also reducing the motherboard design complexity and at the same time save cost. Investment on USB3.0 will be continued. Now USB3.0 has the support from Intel, it appears superior to USB2.0.

After Windows 8 launched, it originally support USB3.0 standard. Microsoft compared the difference between USB3.0 and USB2.0 by demonstrating copy 2GB video and 1GB pictures, Windows 8 can finish the operation within few seconds. If use the motherboard which originally support USB3.0 function to activate and install Windows 8 from an USB3.0 U Disk, the whole installation process only takes 8 minutes and 2 seconds. Copy documents from an USB Drive with USB3.0 interface takes only 3 minutes and 53 seconds. It only takes 4-5 minutes for system installation, and less than 10 minutes to finish Windows 8 system installation.

3.2 USB3.0 controller technology promotes the growth of USB3.0 peripheral products

Nowadays, both hardware and software support USB3.0. The demands of USB3.0 peripheral products are warming up gradually; especially the growth of USB3.0 drive will be a great leap forward. As far as we see, USB3.0 controller chip factories such as SMI, Innostor, Phison, Etron, ASmedia and Genesys are all quite positive about the growth of USB3.0 peripheral products; their shipping have greatly improved in second half of 2012; in 2013 they'll full sprint USB3.0 products. Among of these USB3.0 controller chip factories, Innostor shipped USB3.0 controller chip amounted 1.8 million in 2012, will challenge 2 million in 2013; the shipping volume of Phison have increased to 1 million in 2012; ASmedia could reach 36 million shipping volume of USB3.0 peripheral application chips. With the processers' continuously improvements of USB3.0 controller chip technology, the price of USB3.0 controller chip is around USD0.6~0.8; there is no big difference on the price comparing with USB2.0 controller chip price of USD0.2~0.4. However, the USB2.0 products and USB3.0 products in the market right now still have certain differences on price and transmission speed.

Exhibit 19:USB2.0,USB3.0 interfaces standard

USB standard / SPEC	USB2.0	USB3.0
Time of Publication	2000	2008
Theoretic transmission speed	48MB/s	500MB/s
Controller chip price	US$0.2-$0.4	US$0.6-$0.8
Max transmission distance	5 meters	5 meters
Communication mode	Half-duplex	Full-duplex
Signal number in cable	4 bar	9 bar
Power supply capacity (Low /high)	100mA/500mA	150mA/900mA
Peripheral applications	PC peripheral/HDD/ODD printer/ U Disk and so forth.	PC peripheral/HDD/ODD printer/ U Disk and so forth.

3.3 USB3.0 Current problems and outlook of the coming year

The market share of USB3.0 products especially the newly listed higher quality product is limited. Currently, the price compares with USB2.0 is still a bit higher. One of the reasons that USB3.0 still have no heavy demands is that the corresponding peripheral equipment support and upgrade quite slow. The user's old motherboards and host machines are mostly equipped with USB2.0 interfaces. There is no USB3.0 interface design. Speaking as a normal user, it's not likely to get the PC replaced specially for adding an USB3.0 interface. Therefore, the USB3.0 Flash memory device application is still constrained. The good news is: Products displayed in Suning, Gome as well as E-commerce vendors already equipped with USB3.0 Interfaces. We can see the booming market of USB3.0 in the near future.

The second reason that there are small demands on USB3.0 because of the market expansion of Tablet PC; personal work equipment and entertainment equipment have significant watershed; personal computer completely be used for personal work and company work device; however, Tablet PC completely applied on personal entertainment. Such update will result in less and less demand on Laptop as the expansion of Tablet PC. In Tablet PC field, the demand of USB3.0 is not so urgent due to the majority usage of embedded storage.

In 2012, the industry processers are optimistic about COB 3.0 products, and have very positive forecast of COB 3.0 for 2013. But in fact, there is no unified standard of COB 3.0 dimension among these manufacturers. Currently, the standard base of size and connector is about 10 types existing. While we all feeling it's the advent of COB 3.0's spring, unified the COB standard should be the urgent need for each manufacturer.

4. Flash Memory Card mainstream application demands began to recession

4.1 The Development of SD Specification

SD SPEC developed from 1.1 to 4.0, the most prominent is that the capacity speed continue to increase. The maximum theoretical value is only 12.5MB/s. As the consumer demands for capacity and transmission speed, the SD Association introduced SD2.0 Specification, the maximum theoretical speed doubled to 25MB/s. It also clearly specified the product transmission speed level in response to the speed requirements of different products.

With the booming of mobile storage devices, SD Association specified exFAT document format so as to fulfill the needs of large file storage, and introduced SD3.01 Specification (UHS-1 Bus Interface protocol) to meet high speed transmission of large documents and application on different OS. It also allows seamless connection between desktop computers and mobile devices for file copy. The future SD 4.0 UHS-II transmission speed would reach max 312MB/s, which is one of the representatives of high-speed transmissions.

Exhibit 20:SD Specification Development

BI	Category	BI Speed Mark	BI Speed	SPEC Version
Normal Speed	SD,SDHC, SDXC	-	12.5MB/s	1.01
High Speed	SD,SDHC, SDXC	-	25MB/s	2.00
UHS-I	SDHC SDXC	I	50MB/s(SDR50，DDR50) 104MB/s(SDR104)	3.01
UHS-II	SDHC SDXC	II	156MB/s 312MB/s	4.00

4.2 Flash memory card application market changes

4.2.1 The further recession of Flash memory card application in mobile phone market

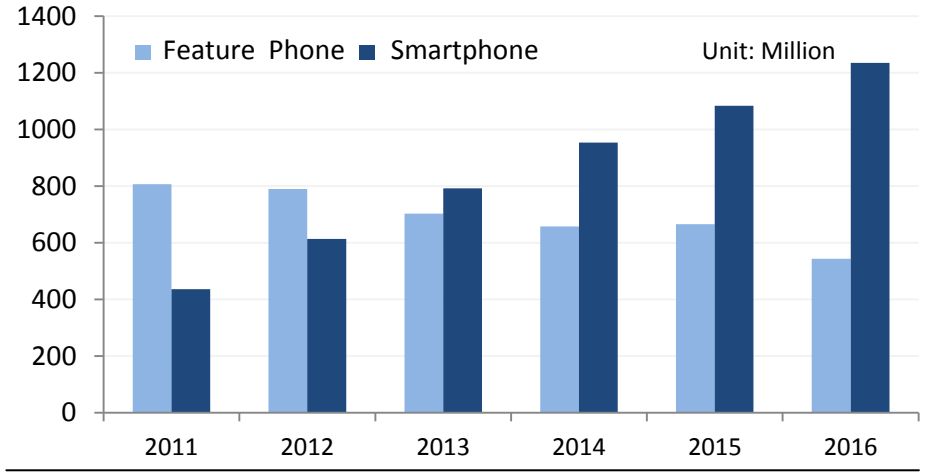
Flash memory card have been widely used in mobile phone and camera application markets. Especially Micro SD card became the mobile phone's standard configuration. It occupied the mainstream Flash market application status. During the time that eMMC and SSD hadn't begun mass quantity shipments, Flash memory product have become one of the major profit products of many companies. But with the recession of feature phone and part of the main force application products do not support external memory card application, which affected the productivity output of original manufacturers; plus cost reduction factor it caused market demand recession and price decline. Some companies appeared profit falling and even losses. In the future, with the feature phone recession, Smartphone popularity and built-in 4GB or above eMMC storage in Smartphone, there will be no necessity for external storage, which may result in further reduction of the total demands on Flash memory card.

4.2.2 Emerging-market will become the motive force of future development

With the continuous improvements on Flash memory technology, the density demands from customers are unceasingly increasing. With the advantages of low-cost, portable and customer recognition degree, Flash memory card will continuously take over the major market of subsidiary storage devices. It will also keep providing powerful support to products like Smartphone, Tablet PC, GPS, driving recorder, digital book and MP3/MP4. Especially the driving recorder is becoming the important application market in China. It requires high storage density, thus, there is still room for the growth of Flash memory card in the future. But it will stride forward higher density, higher speed and wider markets. Some of the low density products also can turn to replace CD and DVD such none environment friendly and fragile storage field. Of course, it is also depends on how supportive the original manufacturers are.

Exhibit 21:

Flash chips shipping forecast for Smartphone & Feature phone



Source:IHS iSuppli Note: Flash includes NOR Flash and NAND

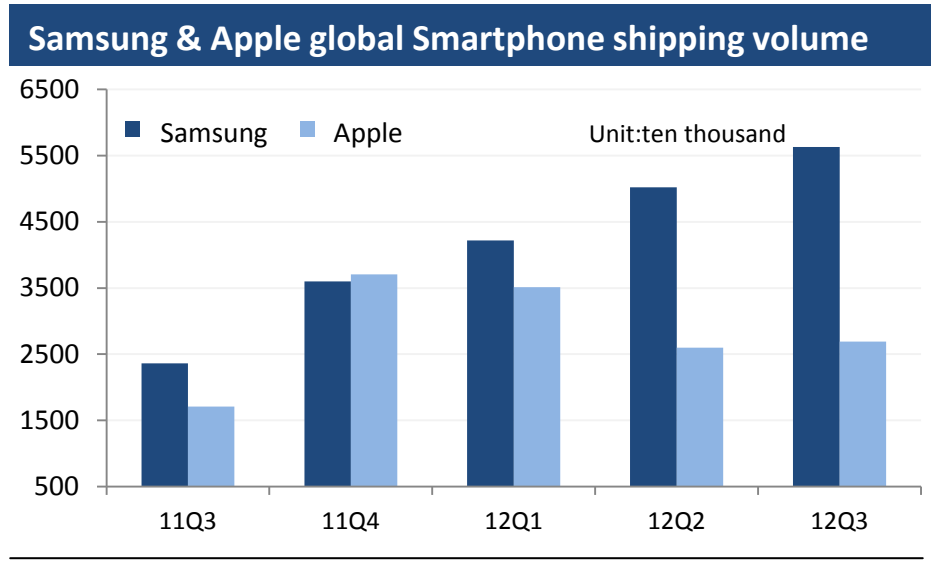
5. Terminal application demands appeared one raise and another fail in 2012

The market demands of Smartphone and Tablet PC is flourishing. The Smartphone brand with the fastest growth should be Samsung. With the expanding Smartphone scale, it affected the development of other mobile phone brands in the industry. The sales data of iPhone from Q1-Q3 in 2012 shows the downward trend of sales volume. Brands with sales volume eroded still have HTC and Nokia. While there are some domestic low-cost Tablet PC solution continuously bringing out from Allwinner and Rock-chip. Low-cost Tablet PC rised sharply, which result in certain loss of iPad's market share. iPad market share in 2012 dropped from 65% of Q1 to 50.4% of Q3.

The development of Smart phone and Tablet PC is very influential, however, with the continuously technology improvements, the application functions of Smart phone and Tablet PC have impacted the development of other electronic products, such as functional machine, Note Book, camera, digital book, PC and so forth. We can see the demands of feature phone dropped obviously. There is also dropping trend appeared in the camera market. According to the CIPA data, from January to September in 2012, the worldwide cumulative shipping quantity of digital cameras from Japan manufacturers compare with the corresponding period in 2011 declined 12.7% and dropped to 75,924,000pcs. The global cumulative shipping volume of digital book also appears huge decline, and it seems to be continued. IHS iSuppli once predicted that the worldwide PC shipping volume in 2012 would be 348.7 million units. It dropped 1.2% comparing with the worldwide shipping volume of 352.8 million in 2011.

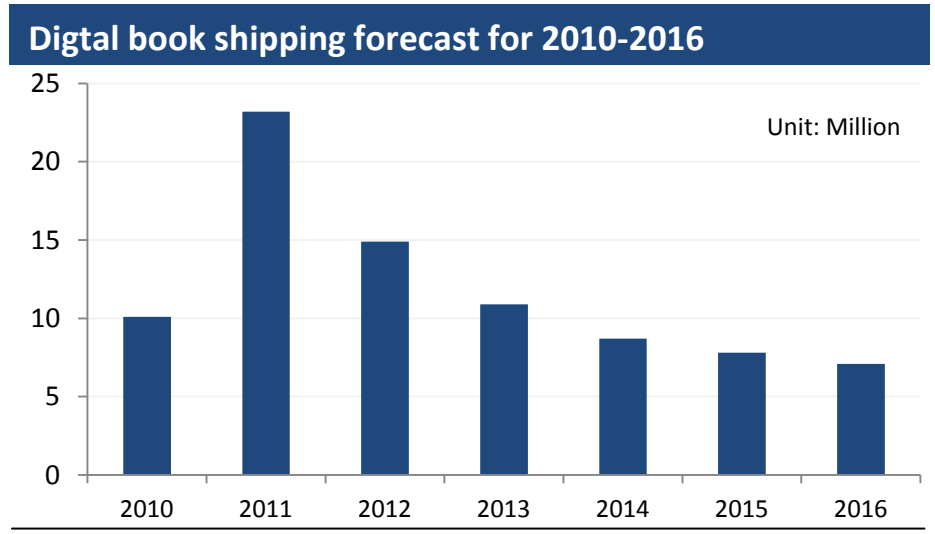
In the first half year of 2012, the productivity of NAND Flash has been continuously increasing. Under the slow economic development environment, except the demands of Smartphone, Tablet PC and PC are sustained growth; the demands of other electronic products have been declining or with limited growth. The demands of consumer electronics may be called one raise and another fail. On one hand, the NAND Flash application market got new opportunity, on the other hand, it encountered difficulties.

Exhibit 22:



Source: IDC research institution

Exhibit 23：



Source:IHS iSuppli

NAND Flash market outlook in 2013

The NAND Flash nanometer process technology was fully turned into 2xnm era in 2012. It is anticipated to be into the 1xnm era in 2013 and gradually improving the proportion of 1xnm technology production. In 2013, the output of each Flash Wafer would be increased again. At the meantime, the apparent availability will be increased as well. The NAND Flash original manufacturer will not have new productivity to be increased. Besides, the demands of Smartphone and Tablet PC in 2013 will consume most of the NAND Flash productivity. Consuming PC HDD hard disk storage have been gradually switched to SSD storage, plus cloud storage and network storage springing up, and with the driving of emerging-markets development of TV intelligent and Multi-screen interaction, all these will support NAND Flash market development.

1. NAND Flash productivity consumed by Smartphone and Tablet PC

In 2013, the market application of mobile products such as Smartphone and Tablet PC will be further expanded. It will become one of the major driving forces of the NAND Flash market development.

Smartphones from Samsung, Nokia, HTC, Lenovo gradually spread to low-cost market in 2012. Samsung will continue to maintain Smartphone rapid growth momentum in 2013. Other branded manufacturers all tend to improve the shipping quantity in 2013. Plus the Smartphone shipping driving of domestic brands such as Huawei and ZTE, according to IDC prediction, the worldwide Smartphone shipping volume will exceed 800 million and approach to 900 million. With the development of Quad-core Smartphone, eMMC will gradually become the mainstream embedded storage of Smartphone; however, the NAND MCP only be used in low-end Smartphone, the market share will be less than 40%. The built-in capacity of Smartphone is likely to grow up from 4GB/8GB to 16GB or above.

Under the promotion of domestic dual-core chip from Allwinner and Rock-chip, Tablet PC shipping volume grown up rapidly in 2012. Android Tablet PC shipping quantity will be further expanded in 2013. Plus iPad shipping volume, the estimated worldwide Tablet PC shipping quantity of 2013 would be around 172.4 million umits.Tablet PC embedded eMMC storage density will be increased from 8GB/16GB to 32GB or above. The development of Smartphone and Tablet PC is currently the biggest support to NAND Flash productivity consumption.

2. SSD application on consumer electronics, network server and cloud storage

The rising cloud computing is going to drive the development of cloud storage and network server storage. Simply speaking, cloud computing enables various application systems obtain needed resources (hardware, platform and software), storage space base on demands and easy extending methods via network. That's how the huge storage scale is generated. For instance, Google cloud computing have over 1 million servers. Other 'Cloud' such as Amazon, IBM, Microsoft and Yahoo all have several hundred thousands of servers. Normally, an enterprise private cloud has hundreds of servers. Huge storage demands lead us growth space of SSD. It will be the biggest customer of NAND Flash applications when SSD join this field in the near future.

3. NAND Flash consumption by Emerging-markets

Apart from the big NAND Flash consumption by Smart phone and Tablet PC, the growth of some Emerging-markets such as Smart TV and Multi-screen interactive also boosts the NAND Flash demands.

Android OS have becoming more and more popularized on Smart TV. You can download, use, and uninstall Apps from internet via the operation interface. You can also enter the internet browsers to download movie, TV play, video and recording programs and so forth. You can even connect via Wifi tether function to interconnect with other home digital devices such as mobile phone, PC, digital camera, printer and so forth. The operation is simply like using a mobile phone. It's just not easy to carry. Currently, there are some high-end Smart TVs with 4GB and 8GB built-in memory, this will increase the demands and consumption of NAND Flash as well.

Multi-screen interaction bases on DLNA protocol or IGRS protocol, achieves audio/video and picture transmission, sharing, displaying simultaneously and control between different OS and different smart devices (e.g. mobile phone, Tablet PC, TV…etc), so as to stimulating the development of usage of intelligent products (e.g. Smart TV).