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Industry View
Cautious

Primer

Taiwan DRAM/IDM

Memory Module Industry

MSCI Country: Taiwan

Asia Strategist's Recommended Weight	11.2%
MSCI Asia/Pac All Country Ex Jp Weight	11.3%

Conclusion: Over the cycle, well-managed memory module makers, such as Transcend, have outperformed pure memory fab operators, such as Powerchip and Nanya. Since 1999, Transcend has achieved average ROIC/ROE of 20%/23% versus negative figures for the Taiwan DRAM industry. Scale matters in the memory module industry. Amid DRAM/NAND shortages, larger module makers have better access to limited chip supply. Amid oversupply, larger module companies have better pricing power and can react quicker to clear inventory.

Where in the supply chain? The memory module industry is the downstream of DRAM/NAND flash production that sells memories to PC makers and distributors. In a memory module, DRAM chips are put (typically eight chips per module) on PCB boards, then slotted in PCs. NAND chips are used in MP3s, memory cards for handsets and digital cameras, and USB drives as removable data storage.

Outperforming memory makers: Amid memory over-supply, memory module makers tend to outperform memory makers, as the former have significantly lower fixed costs (2% of revenue). Module makers keep positive margins on a cost-plus business model, pricing memories by adding assembly and brand value.

DRAM module short-term opportunity: DRAM module prices could rebound on a cut in DRAM production. **Long-term risks:** 1) shrinking of the white box market is negative for DRAM module makers; 2) fewer after market sales opportunities, given high memory content per box purchased at already low DRAM prices; 3) Windows 7 is less memory hungry than Vista, a negative trend for DRAM content per box.

NAND flash module short-term risk: Lack of growth driver in 2009; the share of solid-state drives (SSDs) in the NAND flash market will be low in 2009 (we estimate 8% of demand mix) as SSDs have a 6x price-to-performance premium to hard-disk drives (HDDs). **Long-term opportunity:** NAND flash ASP is declining. Three-bits-per-cell technology should help reduce cost and narrow the price/performance gap, supporting SSD proliferation.

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Contents

What's a DRAM Module?

Dynamic random access memory (DRAM) modules are used in PCs, workstations, and servers to hold temporary instructions and data needed to complete tasks. DRAM modules comprise a series of DRAM chips mounted on a printed circuit board (PCB) with gold contacts.

DRAM modules can be categorized by a combination of:

1. Form factors: single in-line memory modules (SIMMs), dual in-line memory modules (DIMMs), and Rambus in-line memory modules (RIMMs).

2. Memory technologies: EDO, SDRAM, DDR SDRAM, DDR II SDRAM, and RAMBUS. Most module form factors can support various memory technologies.

Exhibit 1
A DRAM Module

Source: Micron

In the DRAM industry, chip memory size is expressed in megabits (mb), and module capacity size is expressed in megabytes (MB). As an example, eight DRAM bits equal 1 DRAM byte. Eight 512mb DRAM chips make one 512MB DRAM module. For error correction code (ECC), one extra chip is added to the DRAM module for data correction purposes; this is popular in high-end servers and workstations.

Chip configuration: Each memory chip has a matrix of tiny cells. Each cell stores one bit of information. Key parameters of the cell organization include capacity (size), depth, and width. There are various kinds of configurations for the same size of DRAM chips. As examples, for 1 gigabit chips (capacity size), the expression of 128mb x 8 bit indicates the data depth of the chip is 128mn (million locations) and the data width of the chip is 8 bits.

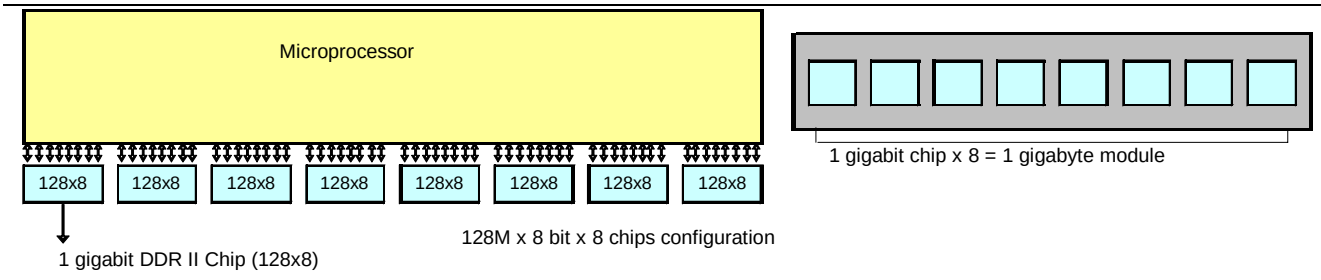
Memory module configuration: For a mainstream PC that has a 64-bit memory data bus, the DRAM module normally has eight separate x8 bit DRAM chips, each chip with eight lines for connection to the 64 data lines (it can also have four chips with x16 configurations or 16 chips with x4 configurations). The x8 configuration is the most popular today for desktop PC and notebook applications. Memory modules can also accommodate memory chips on dual sides (that is, putting sixteen x 8 chips on two sides for the 64 bit data bus).

Exhibit 2
DRAM Module and Chip Configurations (64 bit bus)

DRAM Module Capacity	DRAM Chip Density	DRAM Chip Configuration	Number of Chips/Module
512 MB	256mb	64 Meg x 4	16
	512mb	64 Meg x 8	8
	1gb	64 Meg x 16	4
1GB	512mb	128 Meg x 4	16
	1gb	128 Meg x 8	8
2GB	1gb	256 Meg x 4	16
	2gb	256 Meg x 8	8

Source: Morgan Stanley Research, Micron, Transcend

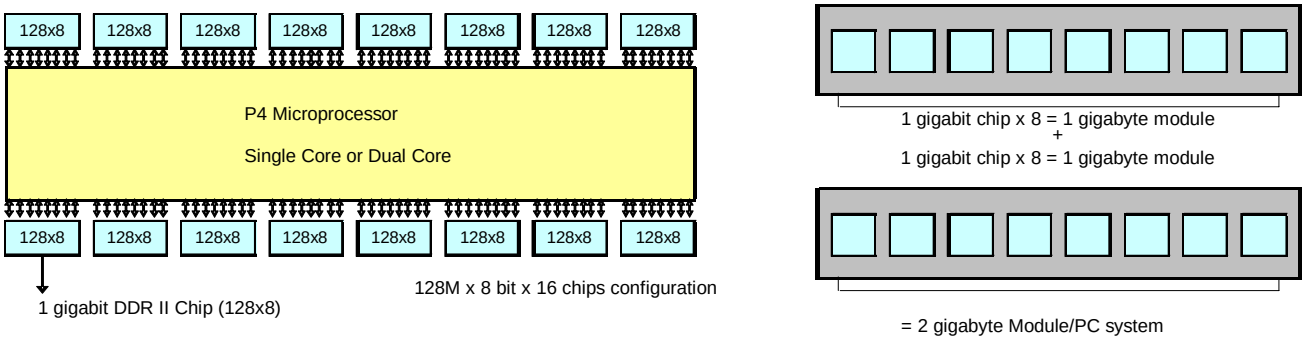
Exhibit 3
1GB PC System Using One 1GB DRAM Module (Made by Eight 1 gigabit 128M x 8 bit Chips)



Source: Morgan Stanley Research, DRAMeXchange

Exhibit 4

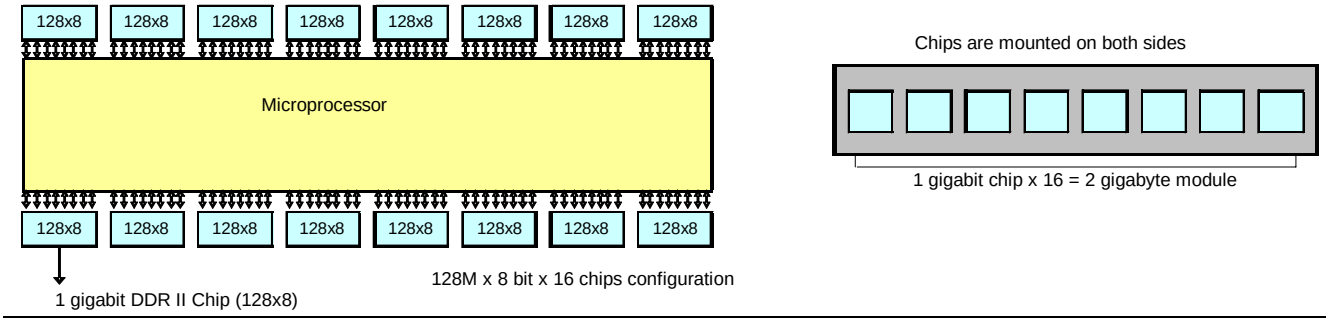
2GB PC System Using Two 1GB DRAM Modules (Made by Eight 1 gigabit 128M x 8 bit Chips)



Source: Morgan Stanley Research, DRAMeXchange

Exhibit 5

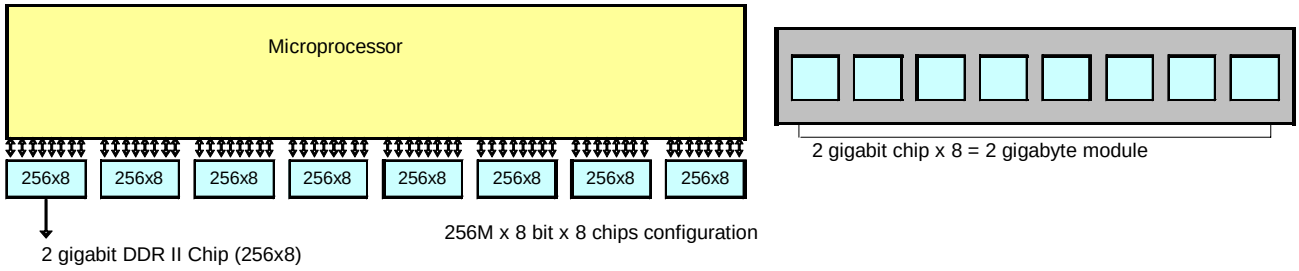
2GB PC System Using One 2GB DRAM Module (Made by Sixteen 1 gigabit 128M x 8 bit Chips)



Source: Morgan Stanley Research, DRAMeXchange

Exhibit 6

2GB PC System Using One 2GB DRAM Module (Made by Eight 2 gigabit 256M x 8 bit chips)

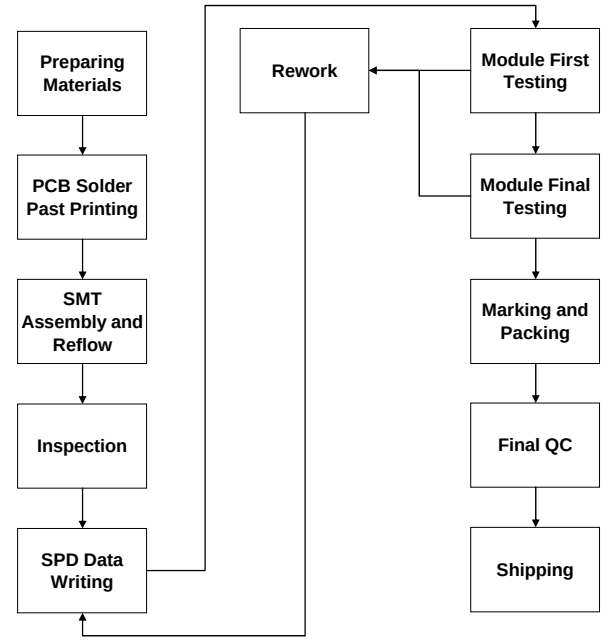


Source: Morgan Stanley Research, DRAMeXchange

DRAM Module Production Flow

The three major components that make up a DRAM module are as follows: the memory chip, PCB, and other on-board elements such as resistors and capacitors. In DRAM module production flow, PCBs are first printed with solder paste, and automated surface mount technology (SMT) systems are used for surface mount and through-hole assembly of the components onto the PCB. The modules are then heated through reflow and cooled to form permanent attachments. Modules that pass inspection are packaged and shipped for sale.

Exhibit 7
DRAM Module Production Flow



Source: Morgan Stanley Research

Exhibit 8
DRAM Module Process Nomenclature

Process	Description
PCB Solder Paste Printing	Solder paste is used for the connection between chip leads and PCB pads. Screen printing or stencil printing are used to apply solder paste to PCB pads.
SMT Assembly	Chips and components are placed on PCB via high-speed pick-and-place equipment. Equipment with multi pick-and-place heads are used to achieve the high speed requirement.
Inspection	Automated visual inspection equipment is used to detect missing chips/component after the SMT process and solder joint quality.
Reflow	Reflow is used for the soldering chips and components with the PCB. DRAM modules pass through an infra-red heating machine with a series of temperature profiles for preheating, soldering, and cooling stages. Heaters may be placed above or below the conveyor to improve the homogeneity of the temperature.
SPD Data Writing	Serial presence detect (SPD) is a standardized way to automatically access information about memory modules. SPD data contains timing parameters, manufacturer, serial number, and other useful information about the memory module.
Module Testing	Testing of the memory modules to ensure they meet specifications. This includes guardband testing, SPD data verification, power cycling testing, power management testing, at-speed testing, and stress-testing.
Rework	Remove chip/components from PCB and perform SMT process when the module does not meet the standards required.
Marking and Packing	Tested modules are labeled and packed for shipment.

Source: Morgan Stanley Research, Kingston, PennWell

DRAM Module Industry Structure

DRAMs are in module form when installed in PCs. About 70% of DRAM chip sales are in DRAM module form for main markets, such as for PCs, the remaining 30% (including specialty memories) are in discrete or wafer forms for distributors and other electronics makers. The DRAM module market can be divided into 1) primary tier one (OEM market); 2) channel/DIY and white box market; and 3) the after market.

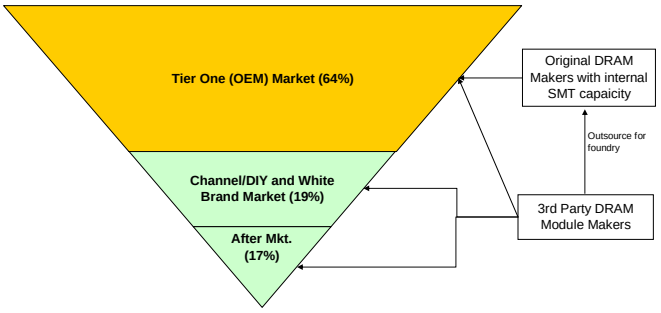
Primary (Tier-one OEM) Market
This accounted for 64% of the DRAM module market in 2008, we estimate. It is the tier-one market for top PC makers, such as Dell, HPQ, Lenovo, Acer, and Asustek. In this market, most memory modules are in the primary form from DRAM vendors (Samsung, Hynix, Micron, Elpida, etc); some are from third-party DRAM module makers (Kingston, Transcend, etc) that also purchase DRAMs directly from original DRAM makers.

Channel/DIY and White Box Markets
These account for around 19% of the DRAM module market. DRAM module makers including Kingston, Transcend, A-Data, Smart Modular, etc dominate these markets.

After Markets
These accounts for around 17% of the DRAM module market. This is also the core business for DRAM module makers including Kingston, Transcend, A-Data, Smart Modular, etc.

Third-party DRAM module makers purchase DRAM chips either directly from DRAM makers or from the spot market. They assemble DRAM chips into modules and sell them to PC OEMs or end-users via their own distribution channels.

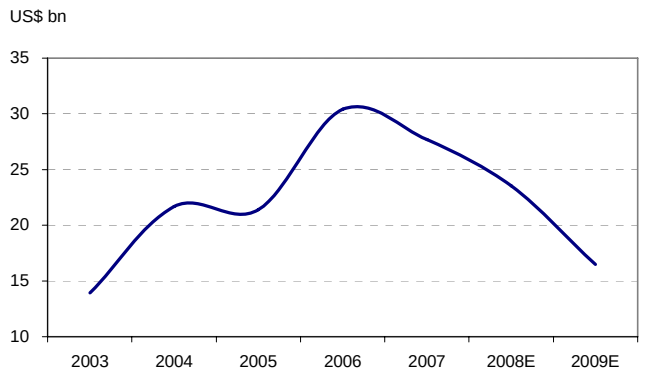
Exhibit 9
DRAM Module Industry Structure, 2008



Source: Morgan Stanley Research, isuppli

The overall DRAM module market peaked in 2006 as ASP rose amid under-supply. The market size declined 9% YoY in 2007 and 15% YoY in 2008, we estimate. We estimate a 30% YoY decline in 2009 to US$17bn mainly because of lower ASP and no shipments growth.

Exhibit 10
DRAM Module Market: 30% YoY Decline in 2009E



E = Morgan Stanley Research estimates Source: isupplu, Morgan Stanley Research

How the DRAM Module Market Works

Traditional Business Model
Tier one DRAM makers (Samsung, Hynix, Elpida, Micron, etc) have internal SMT capacity for DRAM module assembly and testing. Third-party DRAM module makers (Kingston, Transcend, Adata, Smart Modular, etc) purchase packaged DRAM chips directly from DRAM makers and assemble DRAM modules using their own SMT capacity and then resell to PC makers and distributors mainly for the after market and channel/white box markets.

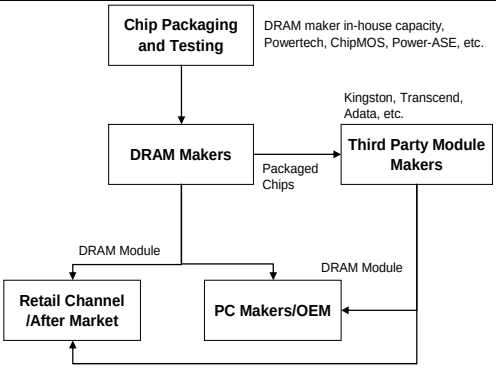
OEM Business Model
Tier-one DRAM makers outsource DRAM module assembly and testing to third-party DRAM module makers. Tier-one DRAM makers then sell the DRAM modules to PC makers and distributors themselves in tier-one OEM primary markets.

eTT (Effectively Tested) and UTT (Un-Tested) Based Memory Module Business Model
In DRAM wafer fabs, each DRAM wafer is usually probed for defects and undergoes a reliability test to determine wafer yield before final packaging and testing. The UTT business model relies on probing and skips final testing. eTT chips are probed but not fully tested.

DRAM module makers purchase eTT and UTT DRAMs and perform module level testing that simulates the individual chip final testing process. They can sell eTT- and UTT-based DRAM modules at lower prices.

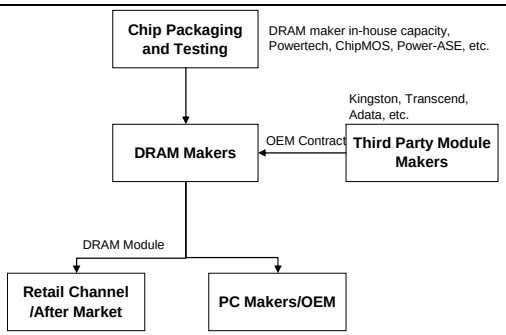
Wafer Consign Business Model in Memory Downturn
In the memory down-cycle, third-party module makers can buy DRAM wafers directly from DRAM makers, and then consign them to IC packaging and testing houses to reduce cost.

Exhibit 11
Traditional DRAM Module Business Model



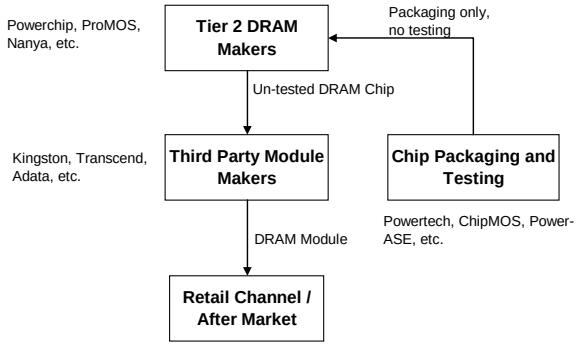
Source: Morgan Stanley Research

Exhibit 12
DRAM Module OEM Business Model



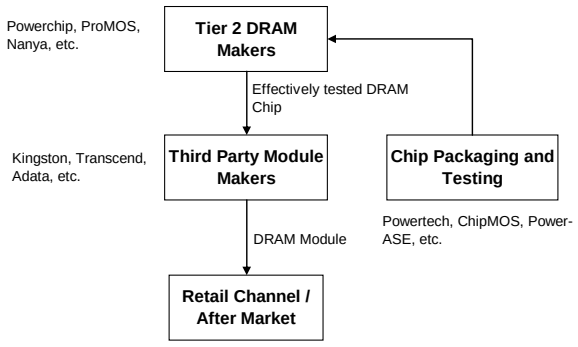
Source: Morgan Stanley Research

Exhibit 13
UTT DRAM Business Model



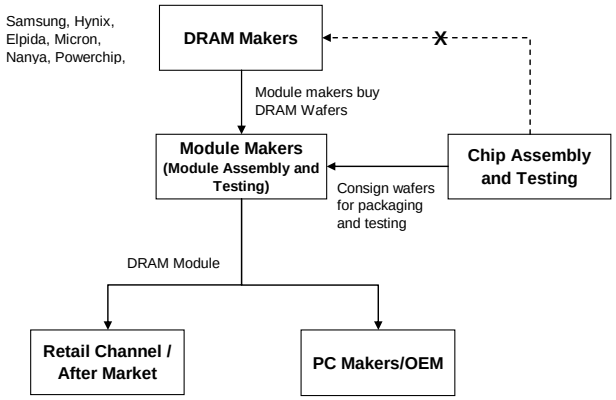
Source: Morgan Stanley Research

Exhibit 14
eTT DRAM Business Model



Source: Morgan Stanley Research

Exhibit 15
Wafer Consign Business Model



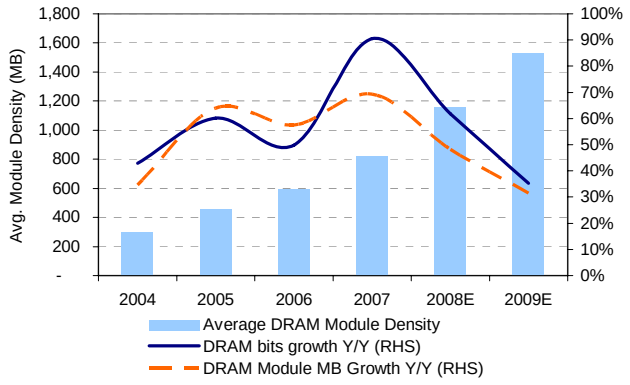
Source: Morgan Stanley Research

DRAM Module Industry Trends

DRAM Module Movements Compared with DRAM Chips
In 2003-08, DRAM module megabyte growth was at around a 54% CAGR, compared with DRAM bit growth of 60% a year, as the PC market increased at a 13% CAGR (DRAM bits growth was higher because of other market proliferation). In the same period, the DRAM module ASP declined at around a 3% CAGR as module density increased at around a 35% CAGR, compared with the DRAM bit ASP decline at a 32% CAGR (DRAM module ASP decline was significantly lower because of higher density per module). We forecast DRAM module megabyte growth of 31% YoY in 2009 and average module density of 1.5 GB, versus 48% YoY in 2008 and average module density of 1.2 GB.

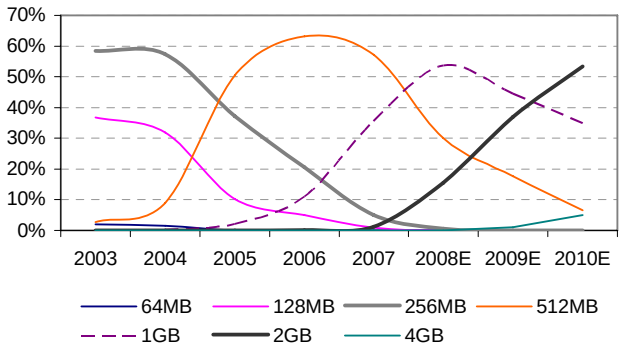
2GB DRAM Module to Become Mainstream by 2010
Accordingly to iSuppli, DRAM content per box increased to 2.1GB per system in 2Q08. A typical configuration for 2GB DRAM in a PC today is to install two 1GB DRAM modules (with eight 1gb chips). As a result of increasing DRAM per box and a DRAM ASP decline, we expect 2GB DRAM modules (with 16 1gb chips or eight 2 gb chips) to become more popular in 2H09 and become mainstream modules by 2010.

Exhibit 16
DRAM Module Density versus DRAM Bits Growth
Module megabyte growth to slow to 31% in 2009E



E = Morgan Stanley Research estimates. Source: isuppli, Morgan Stanley Research

Exhibit 17
DRAM Module Density Migration for PCs
2GB take-off in 2009E



E = Morgan Stanley Research estimates. Source: Morgan Stanley Research, isuppli

Market Share: Scale Matters, the Big Getting Bigger

Kingston leads the market; it had around a 28% market share in 2007. The DRAM module market began to consolidate in 2004. Second-tier DRAM module makers, such as TwinMOS and Kingmax, exited the market during the downturn. The top five DRAM module makers' market share rose to 56% in 2007 from 38% in 2006. We think this trend will continue because of the following factors: 1) amid shortages, larger module makers have better access to limited chip supply; and 2) amid oversupply, larger module makers have better pricing power and can react quicker to clear inventory. We expect Transcend to continue to gain market share through brand value

Exhibit 18

DRAM Module Ranking: 2007

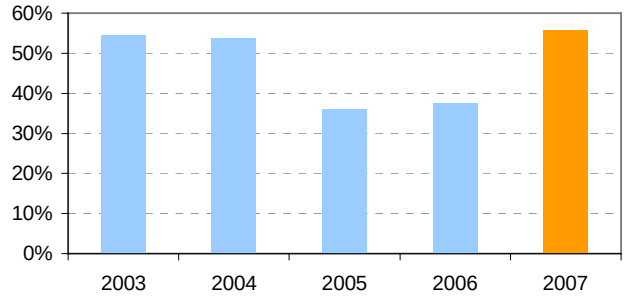
Ranking	Company Name	Revenue (US$ mn)	Market Share
1	Kingston	2,235	27.5%
2	Smart Modular	645	7.9%
3	A-Data	621	7.6%
4	Ramaxel	561	6.9%
5	Transcend	478	5.9%
6	Apacer	474	5.8%
7	MA Labs	468	5.8%
8	Crucial	398	4.9%
9	Corsair	380	4.7%
10	PQI	258	3.2%
11	Kingmax	225	2.8%
12	Buffalo	219	2.7%
	Others	1,171	14.4%
	Total	8,133	100.0%

Source: Morgan Stanley Research, isuppli

Exhibit 19

Market Share for DRAM Module Makers

Combined share for top five rose to 56% in 2007



Source: Morgan Stanley Research, isuppli

Risk: How Much DRAM is Enough in PCs?

Operating system changes drive not only PC unit growth but also content per box increases. Besides CPU speed and standalone graphics cards, memory size is one of the most important factors for new operating system performance. Software and operating system developers continue to expand the functions of their products, which means greater memory requirements. The basic requirement for operating systems such as Windows Vista is 1GB, but optimal performance requires at least 2GB of memory.

For the next-generation Microsoft operating system, Windows 7, the minimum memory requirement is similar to that for Windows Vista, as Microsoft has enhanced its memory management, a potential long term-negative to the trend of memory-per-box increases.

Exhibit 20

Windows Operating System Memory Requirement

	Minimum	Optimal	Limitation
Windows 98	64-128 MB	128-256 MB	512 MB
Windows 2000 Professional	128-256 MB	512MB - 1GB	4 GB
Windows XP Professional	128-256 MB	512MB - 1GB	4 GB
Windows Vista 32 bit	1-3 GB	2-4 GB	4 GB

Source: Microsoft, Kingston, Morgan Stanley Research

Exhibit 21

Windows Vista Memory Requirement – Starting from 1GB per Box

Requirements	Entry	Mainstream	Performance	High-end
Desktop	1GB – 3GB (Home Basic, 32 bit)	2GB – 4GB (Home Basic, 32 bit)	2GB – 8GB (Home, 64 bit)	4GB – 128GB (Ultimate, 64 bit)
Notebook	1GB – 3GB (Home Basic, 32 bit)	2GB – 4GB (Home Basic, 32 bit)	2GB – 8GB (Home, 64 bit)	4GB – 128GB (Ultimate, 64 bit)
At Home	– Email	– Download and manage music	– Download and manage photos,	– Movie/photo/music editing
	– Picture share	– Manage and share photos	music, movies and TV	– Digital home
	– Web surfing	– Interactive web surfing	– Photo enhancement	– Gaming
	– Basic office products	– Personal finance	– Web hosting	– Web hosting
	– Personal finance	– Basic creative software	– Games	– Personal finance
		– Basic office products	– Personal finance	– Full suite of office products advanced features
			– Full suite of office products	
At Work	– Email	– Email	– Email	– Software programming
	– Web surfing	– Web surfing	– Web surfing and development	– Design engineering
	– Basic office products	– Full suite of office products	– Graphic design	– Advanced web and database development
	– Corporate software (CRM, accounting, manufacturing)	(Word, Excel, PowerPoint, Project, etc)	– Full suite of office products advanced features	– Production level editing
		– Corporate software (CRM, accounting, manufacturing)	(Word, Excel, PowerPoint, Project, etc)	– Sound engineering
			– Corporate software (CRM, accounting, manufacturing)	– CAD based engineering programs

Source: Kingston, Microsoft, Morgan Stanley Research

Exhibit 22

Windows 2000/XP Professional Memory Requirement – 512MB-1GB per Box for Optimal Performance

Baseline: 128MB - 256MB		
Optimal: 512MB - 1GB		
Administrative and service	**Light** - Word processing, email, data-entry	128MB - 256MB
	Medium - Fax/communications, database administration, spreadsheets; >2 applications open at a time	128MB - 256MB
	Heavy - Complex documents, accounting, business graphics, presentation software, network connectivity	256MB - 512MB
Executives and analysts	**Light** - Proposals, reports, spreadsheets, business graphics, databases, scheduling, presentations	128MB- 256MB
	Medium - Complex presentations, sales/market analysis, project management, internet access	256MB - 512MB
	Heavy - Statistical applications, large databases, research/technical analysis, complex presentations, video conferencing	512MB - 1GB
Engineers and designers	**Light** - Page layout, 2 - 4 color line drawings, simple image manipulation, simple graphics	256MB - 512MB
	Medium - 2D CAD, rendering, multimedia presentations, simple photo-editing, Web development	512MB - 1GB
	Heavy - Animation, complex photo-editing, real-time video, 3D CAD, solid modeling, finite element analysis	1GB - 2GB

Source: Kingston, Microsoft, Morgan Stanley Research

Exhibit 23

Windows 98 Memory Requirement – 128MB-256MB per Box for Optimal Performance

Baseline: 64MB - 128MB		
Optimal: 128MB - 256MB		
Students	**Light** - Word processing, basic financial management, email and other light internet use.	64MB - 128MB
	Medium - Home office applications, games, internet surfing, downloading images, spreadsheets, presentations	128MB - 256MB
	Heavy - Multimedia use such as video, graphics, music, voice recognition, design, complex images	256MB - 384MB
Home users	**Light** - Word processing, basic financial management, email and other light internet use	64MB - 128MB
	Medium - Home office applications, games, internet surfing, downloading images, spreadsheets, presentations	128MB - 256MB
	Heavy - Multimedia use such as video, graphics, music, voice recognition, design, complex images	256MB - 384MB

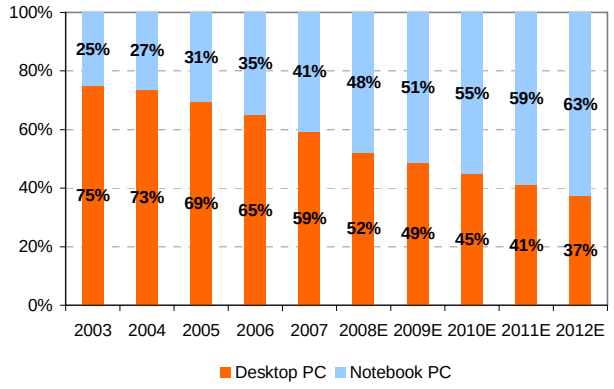
Source: Kingston, Microsoft, Morgan Stanley Research

Risk: Shrinking DRAM White Box and After Markets

We estimate the DRAM white box and after markets accounted for 36% of the DRAM market in 2008, down from 43% in 2006. We expect this declining trend to continue because of the following factors: 1) the white box market is shrinking because of branded market share gains; 2) there is limited notebook PC DRAM replacement, as it is more difficult for individual users to open a notebook than to open a desktop PC to add memory after sale; and 3) the high pre-installed content per box, given low DRAM prices, will affect after market sales. We forecast the white box and after markets will shrink to 26% of the DRAM market by 2012.

Exhibit 24

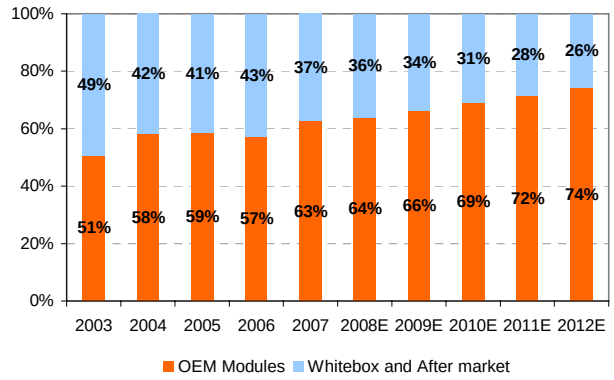
Increasing Notebook PC Penetration – A Negative Trend for Memory Module Growth



E = Morgan Stanley Research estimates. Source: Morgan Stanley Research

Exhibit 25

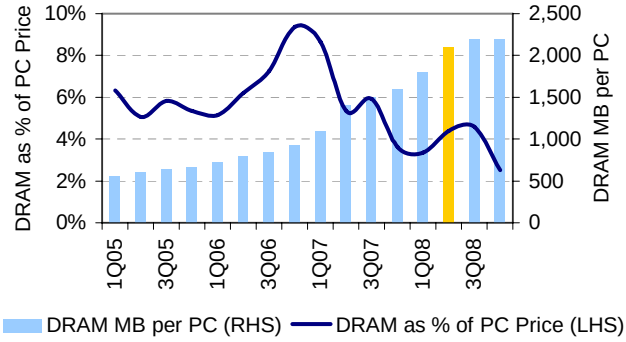
White Box and After Markets Shrinking – A Negative Trend for Memory Module Growth



E = Morgan Stanley Research estimates. Source: Morgan Stanley Research

Exhibit 26

DRAM Content/Box – High Pre-installed PCs Negative for After Market Sales of Memory Modules



Source: Samsung, Morgan Stanley Research

NAND Flash Card Market

Flash memory cards are used as data storage devices for digital cameras, mobile phones, and other handheld devices. PC card (PCMCIA) was the first commercial memory card format to come out in the 1990s, but now is used only in industrial applications and for communication connections.

In 1998, Sony launched its proprietary memory card format named Memory Stick. Besides the original Memory Stick, this family includes Memory Stick Pro, Memory Stick Duo, Memory Stick Micro (M2), and Memory Stick Pro-HG.

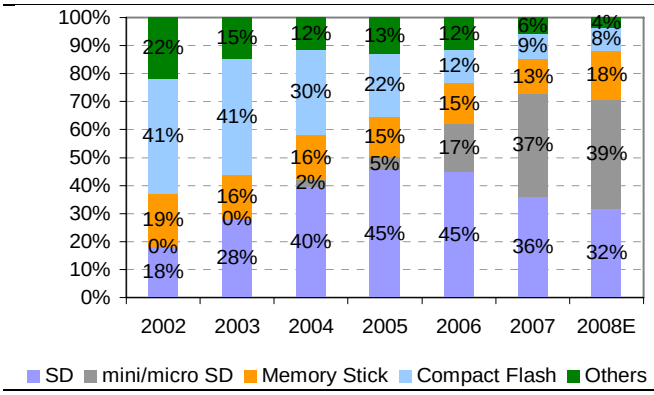
Other smaller memory card formats came out in the 1990s, including Compact Flash (developed by SanDisk), Smart Media (developed by Toshiba). In the early 2000s, new, even smaller formats appeared, including Secured Digital (SD), Multimedia Card (MMC), and xD. Today, the mainstream is the SD family (SD and mini/micro SD), developed by Matsushita, SanDisk, Toshiba, etc, with a 71% market share.

In the NAND flash card market, many module makers have been becoming more like channel resellers by buying assembled memory cards from Samsung and selling under its own brand to channels. Module makers still keep their own production lines to assemble MP3s, USB drives, and SSDs.

NAND memory card gigabyte shipments increased at a 125% CAGR in 2005-08, compared with NAND flash bit growth of 160% a year. The average NAND flash card density increased around 100% a year. We expect this trend to continue as NAND flash production costs continue to trend lower.

Exhibit 27

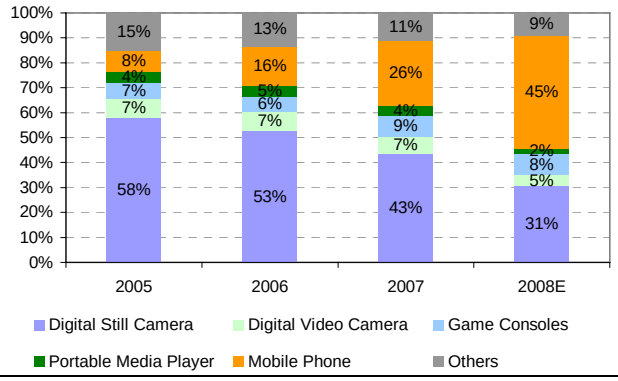
Flash Memory Card – Mini/Micro SD Takes the Lead



E = Morgan Stanley Research estimates. Source: Morgan Stanley Research, Gartner

Exhibit 28

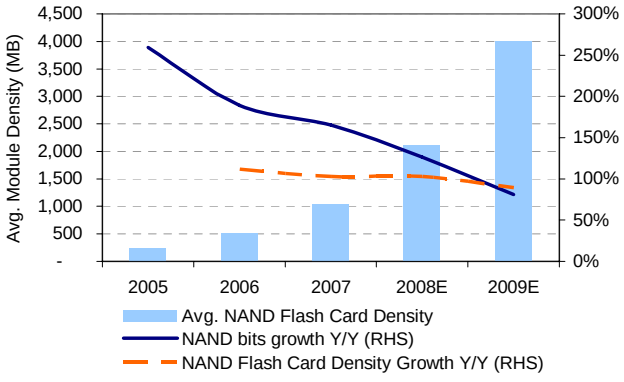
Flash Memory Card Application Mix



E = Morgan Stanley Research estimates. Source: Morgan Stanley Research, Gartner

Exhibit 29

NAND Memory Card Density versus NAND Flash Bit Growth



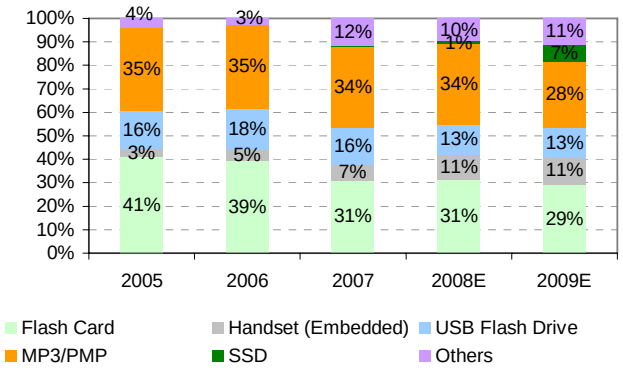
E = Morgan Stanley Research estimates. Source: isuppli, Morgan Stanley Research

NAND Flash Market Share

NAND flash is mostly used for flash cards, MP3 players, and USB drives. For USB drives, Kingston, Transcend, and SanDisk are the top three globally by market share. For NAND flash cards, SanDisk leads the market with a 28% share. SanDisk leads the NAND flash storage market, given its brand value and wide flash card product portfolio. For MP3s, Apple leads the global market with a 26% market share.

Exhibit 30

NAND Flash Consumption Mix



E = Morgan Stanley Research estimates. Source: isuppli, Morgan Stanley Research

Exhibit 31

3Q08 Global USB Drive Market Share

Ranking	Company Name	Market Share
1	Kingston	14.7%
2	Transcend	13.5%
3	SanDisk	12.6%
4	Sony	5.4%
5	Verbatim	3.3%
6	Lexar	2.5%
7	Buffalo	2.3%
8	PNY	2.1%
9	Imation	1.7%
10	Memorex	0.6%
	Others	41.4%
	Total	100.0%

Source: Transcend, Morgan Stanley Research, Santa Clara Consulting Group

Exhibit 32

2007 NAND Flash Card Market Share

Ranking	Company Name	2006 Market Share	2007 Market Share
1	SanDisk	25.0%	28.2%
2	Toshiba	18.4%	19.5%
3	Kingston	2.2%	6.7%
4	Samsung	9.5%	6.6%
5	Sony	9.0%	6.4%
6	Transcend	2.6%	4.2%
7	Panasonic	6.7%	3.8%
8	Lexar	3.8%	3.7%
9	A-Data	2.5%	3.2%
	Others	20.4%	17.7%
	Total	100.0%	100.0%

Source: Gartner, Morgan Stanley Research

Exhibit 33

2007 MP3 Market Share

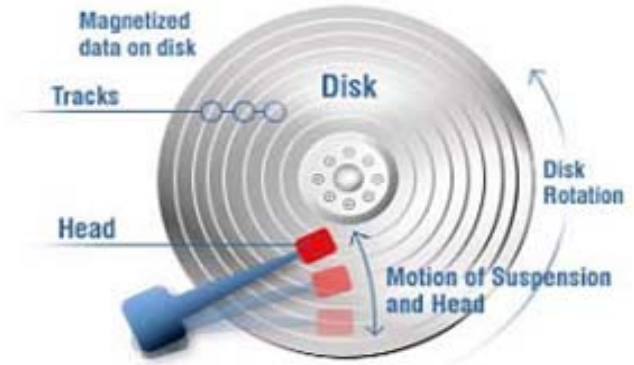
Ranking	Company Name	Worldwide	United States
1	Apple	26.3%	47.8%
2	SanDisk	3.0%	7.7%
3	Samsung	1.6%	2.3%
4	Creative	1.5%	0.0%
5	Sony	1.1%	2.0%
6	Microsoft Zune	0.0%	2.0%
	Others	66.5%	38.2%
	Total	100.0%	100.0%

Source: IDC, Morgan Stanley Research

Solid State Drive – the Next Killer Application

SSDs are non-volatile flash storage devices that contain no moving parts. SSDs have been widely used in industrial applications and low-cost PCs, given their high performance, light weight, and low power consumption. Unlike in traditional HDDs, there are no moving parts in SSDs, minimizing the risk of mechanical failure. SSDs have faster seek and start-up times than HDDs do, as SSDs do not need to spin up until the rotation speed is achieved.

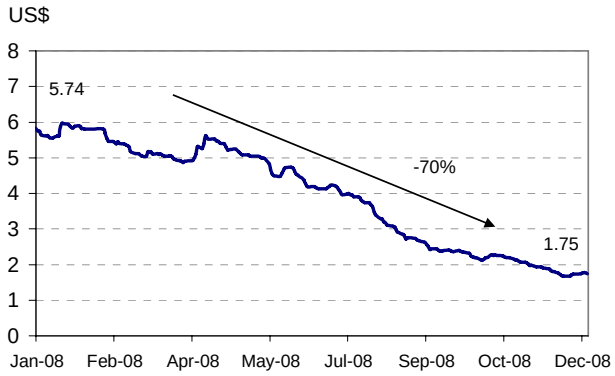
Exhibit 34
HDD: Moving Parts Slow Disk Performance



Source: Texas Memory, Morgan Stanley Research

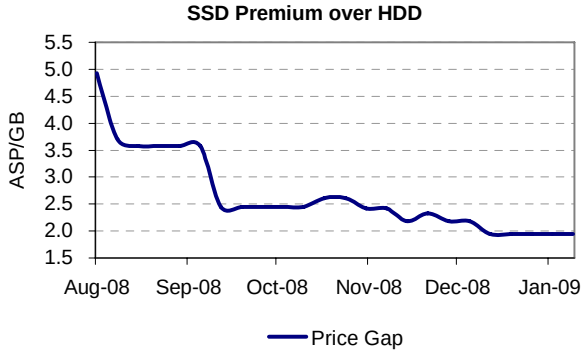
Many NAND flash makers expect the high density of SSD (at least above 16GB) to consume a considerable amount of NAND flash. However, pricing is still the main concern, especially in an economic down-cycle. For 16gb MLC NAND flash, although ASP dropped 70% in 2008, the price gap between SSD and HDD is still large. Price per GB for SSD is about US$2.4, against about US$0.4 for HDD.
Three-bits-per-cell technology and technology migration to 30nm should narrow the price/performance gap between SSDs and HDDs.

Exhibit 35
16Gb MLC NAND Flash ASP Dropped 70% in 2008



Source: Morgan Stanley Research, DRAMeXchange

Exhibit 36
SSD: ~US$2.0/GB (6x) Premium over HDD



Source: Morgan Stanley Research, Arclink

Advantages of SSD

- Faster start-up, as no spin-up required
- Faster boot and application launch on low seeking time
- Lower weight and power consumption
- High mechanical reliability, as there are no moving parts
- Wider range of operating temperatures; most HDDs have an operating range of 5-55 degrees Celsius, while SSDs can operate at 70 degrees.

Disadvantages of SSD

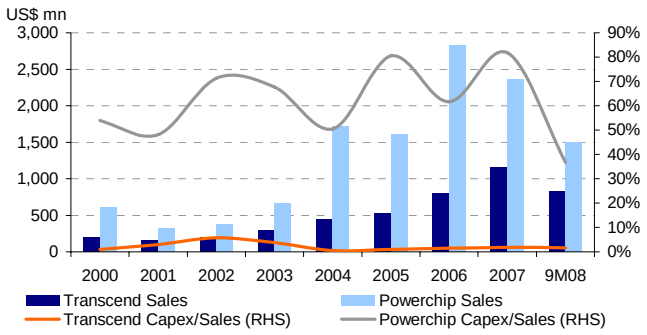
- Higher cost – price per GB for SSD is about US$2.4, still much higher than US$0.4 for HDD
- Limited write cycles – a typical SSD will wear out after 1K to 10K cycles for multi-level cell; need special file system or firmware to mitigate this problem.
- Slower random write speed compared with HDD for small writes, as erase blocks on SSD are quite large (0.5-1.0 MB).

Module Capital Investment is Lower Than For Memory Makers

Unlike memory makers that require large fab investments, module makers' main investments are for working capital for inventory and accounts receivable. Scale matters in the memory module industry. Amid DRAM/NAND shortages, larger module makers have better access to limited chip supply. Amid oversupply, larger module companies have better pricing power and can react quicker to clear inventory. Channel strength becomes key for scale. Capex requirements for SMT lines are not excessive; we estimate 500K units/mth of capacity will cost NT$20mn (US$600K). Module makers can have positive free cash flow over the cycle.

Exhibit 37

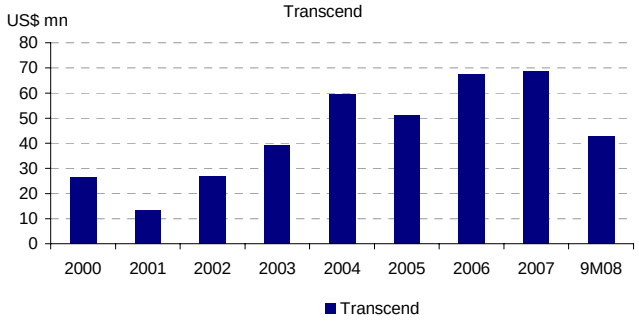
Module Maker's Capex is 1/100 of That for DRAM Makers



Source: Morgan Stanley Research, Taiwan Economic Journal (TEJ)

Exhibit 38

Positive Free Cash Flow for Module Makers



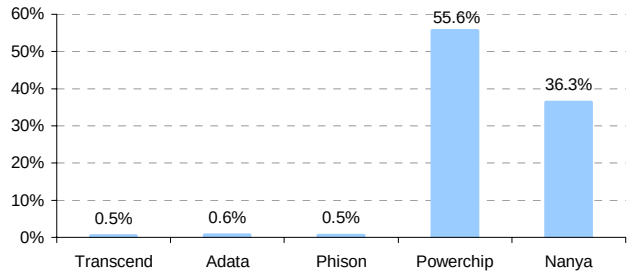
Source: Morgan Stanley Research, TEJ

Module Makers Outperform DRAM/NAND Makers over Memory Cycle

Memory module makers outperform memory makers over the cycle, as the former have lower fixed costs (2% of revenue). Module makers keep positive margins on a cost-plus business model, pricing DRAM/NAND modules by adding assembly and brand value. We stimate DRAM chips account for 85% of DRAM module COGS and that NAND chips account for 80% of flash card COGS.

Exhibit 39

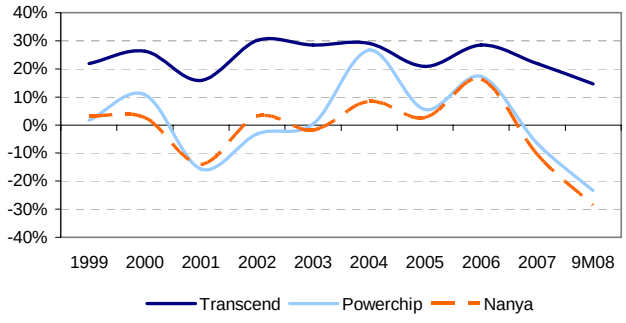
Module Makers Have Much Lower Fixed Cost than DRAM Makers Do: 1-3Q08



Source: Morgan Stanley Research, TEJ

Exhibit 40

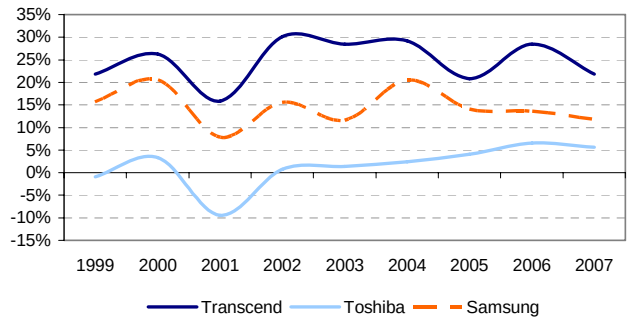
ROIC: Module Makers Outperform DRAM Makers



Source: Morgan Stanley Research, TEJ

Exhibit 41

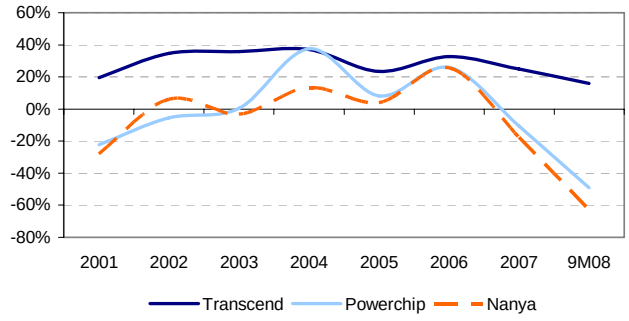
ROIC: Module Makers Outperform Flash Makers



Source: Morgan Stanley Research, TEJ

Exhibit 42

ROE: Higher for Module Makers



Source: Morgan Stanley Research, TEJ

Exhibit 43

Du Pont Analysis – Module Makers Have Better ROE Than DRAM Makers Do

2003	EBIT margin	Asset Turnover	Interest burden	Financial leverage	Tax retention rate	Core ROE
Transcend	17%	1.45	0.1%	1.56	76%	29%
Adata	7%	4.84	0.3%	2.30	72%	53%
Nanya	0%	0.34	1.4%	1.72	171%	-4%
Powerchip	1%	0.29	0.9%	2.07	-194%	3%
Toshiba	2%	1.37	0.5%	5.41	30%	4%
Samsung	10%	0.96	0.3%	2.29	83%	17%
Sandisk	24%	0.54	0.3%	1.34	70%	12%

2004	EBIT margin	Asset Turnover	Interest burden	Financial leverage	Tax retention rate	Core ROE
Transcend	13%	1.93	0.1%	1.34	86%	30%
Adata	6%	4.54	0.1%	2.13	76%	41%
Nanya	20%	0.43	1.0%	1.68	89%	12%
Powerchip	40%	0.47	0.5%	1.62	95%	28%
Toshiba	3%	1.38	0.5%	5.18	49%	8%
Samsung	14%	1.20	0.2%	1.98	82%	28%
Sandisk	24%	0.77	0.3%	1.19	63%	13%
Smart Modular	3%	3.10	0.4%	3.76	114%	35%

2005	EBIT margin	Asset Turnover	Interest burden	Financial leverage	Tax retention rate	Core ROE
Transcend	10%	2.11	0.1%	1.21	83%	22%
Adata	5%	4.79	0.1%	1.91	85%	38%
Nanya	1%	0.50	0.8%	1.75	71%	0%
Powerchip	11%	0.34	0.4%	1.83	114%	7%
Toshiba	4%	1.41	0.5%	4.48	49%	10%
Samsung	9%	1.09	0.3%	1.86	85%	16%
Sandisk	25%	0.74	0.0%	1.24	63%	14%
Smart Modular	7%	1.90	2.5%	8.23	75%	66%

2006	EBIT margin	Asset Turnover	Interest burden	Financial leverage	Tax retention rate	Core ROE
Transcend	10%	2.06	0.1%	1.53	89%	27%
Adata	4%	3.12	0.2%	2.77	81%	28%
Nanya	19%	0.55	0.5%	1.75	85%	15%
Powerchip	30%	0.41	0.4%	1.77	94%	20%
Toshiba	4%	1.24	0.6%	5.16	51%	10%
Samsung	11%	1.05	0.4%	1.79	83%	16%
Sandisk	17%	0.47	0.2%	1.44	46%	5%
Smart Modular	6%	1.69	2.7%	2.85	97%	23%

2007	EBIT margin	Asset Turnover	Interest burden	Financial leverage	Tax retention rate	Core ROE
Transcend	7%	2.11	0.3%	1.34	80%	17%
Adata	1%	3.03	1.0%	2.44	27%	1%
Nanya	-17%	0.40	0.6%	2.10	100%	-15%
Powerchip	-14%	0.35	0.8%	2.17	82%	-10%
Toshiba	3%	1.36	0.7%	5.53	56%	11%
Samsung	9%	1.06	0.3%	1.80	82%	14%
Sandisk	8%	0.55	0.2%	1.44	56%	3%
Smart Modular	9%	1.86	2.3%	2.06	86%	24%

Source: Company data, Morgan Stanley Research

Business Model Comparisons

Kingston
Kingston is the largest DRAM maker globally. It had around a 30% market share in 2003-07. In the memory down-cycle, Kingston has been buying DRAM in wafer form (low prices) and consigning it to Powertech for testing and assembly. This helps mitigate the accounts receivable risk from ProMOS/Powerchip at Powertech and support Powertech's utilization. We estimate this would increase Kingston's sales cycle 7-10 days.

Transcend
Transcend focuses on brand value; about 85% of its sales are from DRAM module and NAND flash module related products (memory cards, USB drives, etc). Transcend sources DRAM chips from Samsung, Powerchip, Nanya, and others and assembles them with internal SMT capacity. It buys flash memory cards mostly from Samsung (as the second-largest customer) and sells with its brand. Transcend expanded its product line to higher-margin strategic products in 2005, including MP3s, digital photo frames, SSDs, and mobile hard drives.

A-DATA
A-DATA focuses more on DRAM OEM production for Dell, HP, and other second-tier brands. It has licenses from Disney to produce memory-related products with Disney's logo and brand name. A-DATA was the third-largest DRAM module maker globally in 2007 and ranked seventh for NAND flash storage devices.

SanDisk
SanDisk focuses on flash memory. It has its own fab with Toshiba and receives intellectual property royalties for licensing. SanDisk leads the NAND flash storage (USB drive and memory card) market, given its ownership of a NAND flash fab, brand value, and a wide flash card product portfolio. It has filed litigation with 25 flash card, USB flash drive, and NAND controller vendors on patent infringements. SanDisk has a full flash card suite including the SD family, MMCs, Memory Stick, etc.

Memory Makers
Nanya has cultivated the Elixar memory module brand and Micron the Crucial and Spectek brands to off-load their DRAM products, in addition to regular contract markets with major PC OEM makers (Dell, HPQ). Powerchip has the Mira brand for white box channels.

Exhibit 44
Memory Modular Maker Sales Mix, 2007

	DRAM Module	NAND Flash Product	Others	Total
Kingston	67%	33%	0%	100%
Transcend	37%	58%	5%	100%
ADATA	56%	42%	2%	100%
SanDisk	0%	100%	0%	100%
PQI	37%	62%	2%	100%
Apacer	50%	50%	0%	100%
Phison	0%	100%	0%	100%
Smart Modular	85%	15%	0%	100%

Source: Company data, Morgan Stanley Research

Memory Glossary

bit	Smallest unit of data storage
byte	Commonly used for storage capacity of memory modules; 8 bits equal one byte.
CF Card	Compact flash card were developed by SanDisk in 1994 and used in various portable electronic devices. Compact flash cards have been replaced by smaller cards recently, but are still a preferred format for digital single-lens reflex cameras because of their superior capacity and reliability.
DDR II SDRAM	Double data rate two SDRAM
DDR SDRAM	Double data rate SDRAM
DIMM	Dual in-line memory modules
DRAM	Dynamic random access memory
DRAM Module	DRAM module comprise a series of DRAM chips mounted on a printed circuit board (PCB) with gold contacts. DRAM modules are used in PCs, workstations, and servers to hold temporary instructions and data needed to complete tasks.
EDO DRAM	Extended data out DRAM
eTT DRAM	Effective tested DRAM
HDD	Hard disk drive; a data storage device that uses a rotating magnetic disk to store digital data.
Memory Stick	A removable flash memory card format launched by Sony. The Memory Stick family includes Memory Stick PRO, Memory Stick Duo, Memory Stick Micro, Memory Stick PRO-HG, Memory Stick PRO Duo, and Memory Stick PRO-HG Duo.
MLC	Multi-level cell, NAND-based flash memory technology. More than one bit stored in each cell.
MMC	MultiMedia Card was developed by Siemens and SanDisk in 1997.
MP3	Portable music player that can store, organize, and play audio files.
NAND Flash	Flash is a non-volatile memory that can store data when power is off. Flash memories include two types, NOR-type and NAND-type. NAND flash has faster erase and write times than NOR flash does and offers greater storage density.
NAND Module	NAND chips are put on PCB boards and used in MP3, memory cards, handsets, USB drives, etc for data storage.
PC Card	Peripheral interface designed for notebook computers to connect other devices (network cards, modems, etc).
PCB	Printed circuit board
RIMM	Rambus in-line memory modules
SD card	Secure digital card is a removable flash memory card format developed by Matsushita, Sandisk, and Toshiba. The SD card family includes miniSD, MicroSD, and SDHC (Secure digital high capacity).
SDRAM	Synchronous dynamic random access memory
SIMM	Single in-line memory modules
SLC	Single-level cell, NAND-based flash memory technology; one bit stored in each cell.
SMT	Surface mount technology
SSD	Solid state drive; a data storage device that uses solid-state memory such as NAND flash to store digital data.
USB Flash Drive	Data storage device consists of NAND flash memory and are integrated with a USB (universal serial bus) interface.
UTT DRAM	Un-tested DRAM
xD card	xD cards were developed by Olympus and Fujifilm in 2002 mainly for digital cameras.

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Industry Coverage:Taiwan DRAM

Company (Ticker)	Rating (as of)	Price (02/19/2009)
Frank A.Y. Wang		
Inotera Memories, Inc. (3474.TW)	O (06/26/2006)	NT$12
Nanya Technology Corp. (2408.TW)	U (07/17/2008)	NT$6.35
Powerchip (5346.TWO)	U (07/17/2008)	NT$3.57
Winbond Electronics (2344.TW	E (11/24/2005)	NT$3.31
Jerry Su		
Transcend Information (2451.TW)	E (02/19/2009)	NT$63.50

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