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## WHITE PAPER

# Opportunities for Solid State Storage in Thin, Portable Connected Devices

Sponsored by: SanDisk

Jeff Janukowicz Bob O'Donnell

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## IN THIS WHITE PAPER

In this white paper, IDC discusses the growing use of thin connected devices in the portable computing market and the impact that this growth is having on storage within these devices. This white paper also explores the evolving need for solid state storage and discusses both current and future design requirements for thin and light, performance-oriented portable devices.

## SITUATION OVERVIEW

The market for mobile connected devices has exploded over the past few years, with the introduction of low-cost notebooks, mininotebooks (aka "netbooks"), media tablets like the Apple iPad, smartphones, ebooks, smart media players like Microsoft's Zune, and other devices giving both consumers and business professionals a wealth of options from which to choose. In 2010, these categories combined to reach worldwide unit shipments of over 500 million devices. Even better, IDC expects the number to double to over 1 billion by 2014.

The reasons for this phenomenal growth are many, but they can be summarized in a few key points. First, consumers and business buyers are attracted to these devices by their thin, lightweight designs and their impressive functional capabilities. Today's slim connected devices offer more computing and entertainment power than desktop PC towers of a just a years back — and do so at increasingly affordable prices. Second, people are buying and using multiple devices. The notion of a single do-everything "Swiss army knife" of mobile technology may be intellectually appealing to some, but practically speaking, most people find that they want to use a few different devices for different types of applications, and they're willing to pay for multiple devices. Finally, connectivity between these devices and out to the Internet is improving rapidly, making it easier to share data across these devices. As a result, the cloud, coupled with improving wireless broadband ubiquity and higher connection speeds, alters the need for local storage requirements in these devices. In some use cases, lower-capacity solutions will be acceptable and provide an opportunity for other storage mechanisms, such as solid state drives (SSDs).

Initially, consumer and business buyers were content to have mobile devices that provided a few hours of battery life, reasonable performance, and basic connectivity. The intense competition within and across these device categories has altered that landscape, however, and is now driving the creation of extremely powerful and extremely thin devices. This, in turn, is placing more emphasis on the types of

Global Headquarters: 5 Speen Street Framingham, MA 01701 USA P.508.872.8200 F.508.935.4015 www.idc.com

components being used to create these devices, with more focus being placed on lower-power and thinner parts, which can be used to create slim designs with longer battery life. However, this can't be done at the expense of performance, as research has shown that individuals are unwilling to make large sacrifices in speed just to get a thinner device. The trick is to manage and balance the expectations across all of these vectors: performance, power consumption, and z-height. To that end, we've started to see widespread use of lower-power ARM-based CPUs, as well as NAND flash, as the core technologies being leveraged across these devices.

## NAND Flash Technology and the Consumer

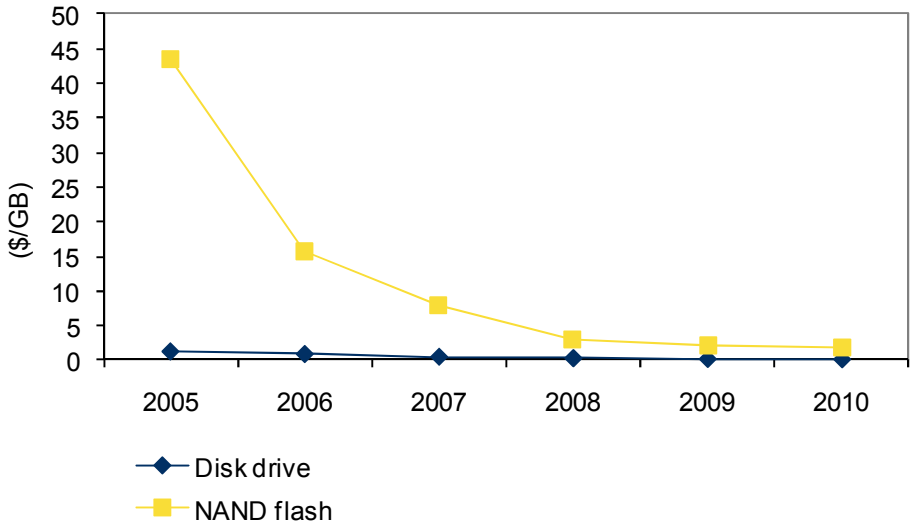
NAND flash is a nonvolatile memory that can continue to store information in the absence of a power source, making it an ideal storage media. As a technology, NAND flash has advanced significantly over the past decade. Thanks to a multitude of advancements in semiconductor technology, NAND has enabled many of the consumer devices in our world today. From mobile phones to MP3 players and SSDs in the PC market, NAND has become the de facto storage media in many portable devices because of the intrinsic characteristics of the technology. NAND flash provides system designers with storage that meets the following requirements:

- **Required density.** NAND provides large amounts of storage capacity, typically measured in gigabytes (GB) of capacity that is sufficient for many user applications and devices.
- **Low power consumption.** NAND requires little power to operate, which makes it ideal for battery-operated devices.
- **Flexible form factor.** The small size and the low weight of the NAND die and packages enable devices to be thin and light.
- **Enhanced reliability.** With no moving parts, NAND provides a reliable storage device with a high tolerance for shock and vibration.
- **Cost effective.** The industry's ability to shrink process geometries (i.e., make the memory cell smaller) and store multiple bits per cell (as in MLC NAND) provides scalable storage with economical benefits. Figure 1 highlights the recent price erosion of NAND flash versus a traditional hard disk drive (HDD) and how it is now an economical choice in many designs.

**FIGURE 1**

Mobile 2.5in. HDD Versus NAND Flash Price Erosion




Source: IDC, 2011

While NAND media does possess many benefits, it is important to ensure that the storage media provides the utmost reliability and performance at the device level. As a result, SSD OEMs must provide more advanced features for use in the computing market. Today, the use of cutting-edge controller technology provides SSDs with increased levels of performance and higher reliability thanks to sophisticated digital signal processing (DSP) algorithms, wear leveling, and high levels of error detection and correction codes (EDC/ECC). These advanced techniques, compared with raw NAND, make SSDs an excellent choice for storage in demanding applications.

Interfacing between the host device and storage medium is another important differentiator when it comes to the performance of the storage subsystem. In modern PCs, the ATA interface is used to connect the host bus to mass storage devices such as HDDs and SSDs. Leveraging a high-performance standard interface enables easy system integration with mobile devices as well as high-productivity capabilities, given the interface's performance characteristics.

Today, solid state storage vendors are beginning to bring the pieces together to provide OEM devices with the necessary performance to develop the next generation of tablets and ultrathin mobile devices based on the standard SATA interface. For example, Apple's MacBook Air, Sony's VAIO, the Dell Adamo series, Lenovo's ThinkPad, and the Samsung 9 Series.

## FUTURE OUTLOOK

Looking forward, we see that the demands being placed on mobile devices are only going to increase. People's expectations are that they will have the ability to access information and entertainment, anytime, anywhere. And not just any information or entertainment — increasingly, they expect full-fidelity work documents and applications and HD video. In addition, the diversity of devices and the number of devices per person are going to increase. As mentioned earlier, most individuals find that instead of moving to only one or two devices that do everything, they're purchasing and using multiple different devices, with each device having a certain advantage or preference over other devices for different applications (or in different physical locations or situations). For example, notebooks and mininotebooks are more focused on content creation, while media tablets, ebooks, and connected portable media players are focused on content consumption. Virtually all these devices support Web browsing and email, but even there, they do so to different degrees — it's much easier to get through lots of emails on a keyboard-equipped notebook or mininotebook than on a touch-only tablet device, for example. In addition, while most of these devices were introduced with a consumer focus, they have quickly evolved to become important business tools as well. For example, most of the Fortune 500 is experimenting with Apple's iPad as a new member of its client repertoire.

The data, content, and applications being accessed across these devices often come from the Internet, but definitely not exclusively. The growing importance of mobile "apps" drives home the fact that locally stored and run applications and at least some subset of the data they use need to be stored on the devices. Certainly cloud-based computing models are gaining favor, but IDC believes that this hybrid local/cloud storage model will be the primary means by which all of these devices operate for many years to come.

This diversity of devices is also leading to a diversity of ecosystem players that are helping to create all these devices. For example, we've seen both major PC OEMs and smartphone vendors move into the red-hot media tablet space. Similarly, we've seen typically PC-focused, x86 architecture semiconductor vendors such as Intel and AMD providing solutions for smaller mobile devices, while Qualcomm, Texas Instruments, and other smartphone-focused vendors that leverage ARM architectures are moving upstream into larger computing devices. Microsoft's recent announcement regarding support for ARM architectures in future versions of its Windows operating system is bound to further increase this crossover. Similarly, Google's originally mobile phone–focused Android OS has successfully moved over to tablet devices, again exemplifying this blending of multiple partner ecosystems into a larger whole.

## Current and Future Storage Needs

The HDD is a more than 50-year-old technology that has been the primary storage device in many applications thanks to its ability to provide enough user capacity at acceptable price points. However, requirements are changing and a wider array of devices and use cases are in the market. What is the form factor of the device? What types of applications will be run on the device? What is the operating system? These are some of the critical factors to consider when determining local storage requirements in performance-oriented, thin portable devices.

As the market matures and evolves, device OEMs must identify some important requirements to determine what type of storage best fits the device:

- **Device purpose.** Is the device designed primarily for content creation or consumption? Productivity- and business-focused devices require higher levels of performance from storage.

- **Storage capacity.** How much capacity is needed to support the applications, operating systems, and user data? Cost is also a function of capacity and the budget for storage within the device's bill of materials.

- **Device form factor.** What is the overall size of the device, and what is its screen size? In many thin portable designs, the z-height is just as important as the x-y dimensions. To achieve a thin design, OEMs must consider a lower z-height storage solution to fit with the device. Therefore, an HDD with a 9.5mm or even a 7mm z-height may not be a good fit in these cases. However, an SSD module or one with a BGA form factor with a height as low as 1.85mm can be a perfect fit. This also enables fanless designs and greater airflow, contributing to cooler device operation.

When evaluating storage solutions for ultrathin mobile devices such as tablets, some OEMs are leveraging embedded MMC (eMMC)–based products to transition smoothly from the mobile handset market to these new converged devices. However, other OEMs are starting to utilize SATA designs that were traditionally in the computing space, such as in x86, Windows 7–based productivity tablets.

As a result of the popularity and growth of these converged devices, the requirements for storage are changing (see Table 1). Storage requirements are shrinking in terms of the form factors to fit in these portable devices, performance expectations are growing, and power consumption requirements are becoming more demanding — all to satisfy new use cases and provide the desired superior user experience to end users.

**TABLE 1**

Storage and Connectivity Features by Portable Device Category

| Portable Device Form Factor | Handheld | Media Tablet | Laptop |
|---|---|---|---|
| Intended use | Communication or audio playback; nominal video content consumption due to screen size | Content consumption with some content creation | Compute with multiple/broad use cases; high productivity, content creation management, and consumption |
| Examples | Smartphones, portable media players | Tablets, pads | Notebook PCs, ultrathin PCs, mininotebooks (or netbooks) |
| Mobility expectations | Very small and extremely portable | Small and excellent portability | Acceptable size and good portability |
| Connectivity expectations | Persistent connection is imperative | Persistent connection is preferred; full value of device is realized when connected | Intermittent connection is assumed; local storage capacity can substitute for lack of persistent, high-bandwidth connectivity |
| Reliance on cloud | Medium–high | High | Low–medium |
| Customer storage expectations | Minimal, or good enough to hold several photos or video clips | Moderate — prefers enough to hold numerous applications and to avoid the need to delete content in order to add new content | Capacious storage; more storage capacity with each new-generation PC at a lower PC price |
| OEM storage expectations | Small, light, robust, low-power device at a steadily lower unit ASP and lower $$/GB | Small, light, robust, low-power device; will accept a relatively higher $$/GB | High-capacity device at a steadily lower $$/GB |
| Storage technology | NAND | Primarily NAND | Primarily HDD, expanding use of NAND |

Source: IDC, 2011

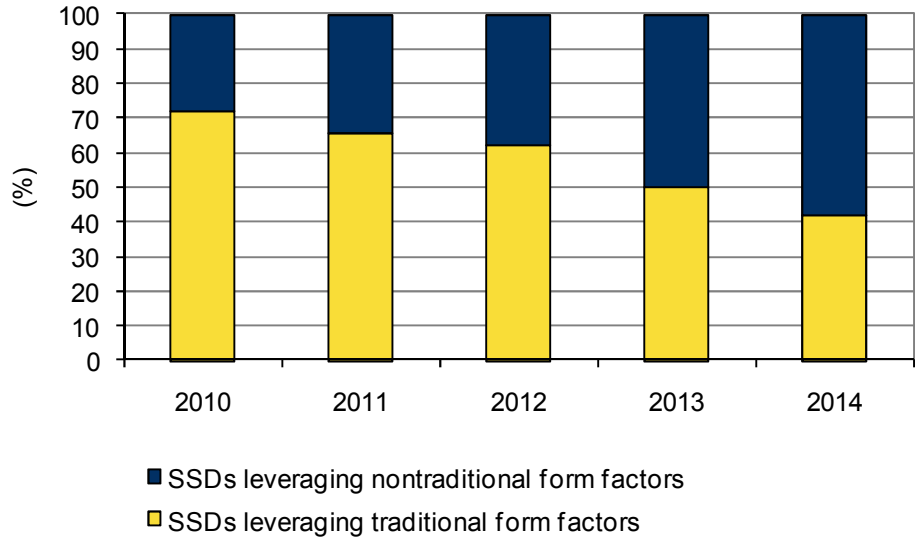
## Outlook for SSDs

Thanks to the many advances of solid state technology, the use of SSDs is expanding. In fact, IDC expects the use of SSDs to grow at a 67% compound annual growth rate from 2009 to 2014. SSDs are in use in many PC platforms, leveraging traditional form factors as a means to boost system performance, provide increased reliability, and lower overall power consumption.

Originally, most SSDs were designed leveraging traditional HDD form factors, such as 2.5in. designs, in an effort to provide an easy upgrade path for end users and to provide OEMs the flexibility in their choice for storage devices. Yet, this approach does not take advantage of one of the key attributes of solid state storage — it is form factor agnostic. What this means is that SSD vendors and system OEMs are free to design and develop unique form factors that are best suited for end-consumer use. As a result, OEMs are increasingly expected to leverage nontraditional, flexible form factors to meet the form factor requirements of the devices (see Figure 2).

**FIGURE 2**

Form Factors of Portable Consumer Devices




Source: IDC, 2011

## SanDisk's iSSD

The SanDisk iSSD allows manufacturers to design thinner and sleeker computing devices while incorporating all the benefits of NAND flash into the devices and eliminating the size and weight constraints associated with the traditional HDD. With no moving parts, the SanDisk iSSD is reliable and power efficient. As a result, it provides extended battery life and eliminates the risks that are often associated with the mechanical components of the HDD.

The SanDisk iSSD provides all the benefits of an SSD in an efficient and small size. It delivers greater system responsiveness (i.e., performance) in the tiny BGA form factor that provides flexibility for system OEMs that seek to create the next generation of tablets and ultrathin mobile devices based on the standard SATA interface.

As a result, storage solutions and embedded designs, such as SanDisk's iSSD, that meet the stringent size requirements of small and light devices while offering greater performance will enable OEMs to deliver an enhanced user experience in their next-generation designs and blend the best of both the embedded and the SSD worlds into one storage solution. Table 2 highlights SanDisk's iSSD product.

**TABLE 2**

SanDisk's iSSD

| Metric | iSSD |
|---|---|
| Technology | MLC NAND |
| Form factor | BGA, embedded NAND |
| Dimensions (W) x (D) x (H) | 16mm x 20mm x 1.85mm |
| Weight (g) | 0.83 |
| Acoustics (bels) | None |
| Size (GB) | 4GB–64GB |
| Performance (Max)* | 160MBps read; 110MBps write |
| Power (W) | 0.18 |
| Interface | SATA — support in PC ecosystem |
| Target market | Ultrathin computing and high-productivity tablet |

* These performance numbers refer to 32GB and above. Based on internal testing; performance may vary.

Source: IDC, 2011

## CHALLENGES

Some think that a mature market like the PC segment is static and unchanged, yet nothing could be further from reality. The explosion of mobile connected devices from low-cost notebooks and ultrathin PCs to mininotebooks (aka "netbooks") and media tablets is giving both consumers and business professionals a wealth of options from which to choose. Likewise, OEMs must be diligent with their product road maps to identify solutions for the marketplace. Many of the segments are emerging, and salient points about use models are being defined by users today.

For storage providers, this creates a challenge. For starters, cost is always an issue. In traditional PCs, the cost comparison between HDDs and SSDs will continue to be an important deciding factor as SSDs are more expensive on a dollar-per-gigabyte basis. In these other mobile devices, the cost of storage (NAND) must fit within the devices' bill of materials. Some designs have low price points, and OEMs must be able to provide enough capacity to meet end-user demand.

Yet, as new form factors emerge, usage models change, and devices mature, the market for storage will be more complex than simply cost per capacity (i.e., $/GB). Storage providers must think about not only cost but also form factors, power consumption, and reliability when developing a solution. In the case of an embedded design, like SanDisk iSSD, OEMs also need to evaluate the advantages of an embedded design versus a module approach that can provide easier upgrades (or removal) when needed.

## CONCLUSION

The market for smart, mobile connected products is growing at a blistering pace, and as it grows, it continues to diversify. Each consumer and each business worker has his or her own unique set of needs and preferences, and device vendors are working

hard to create a wide variety of devices to fit those needs and at the same time balance the desire for performance, reliability, battery life, and thinness.

This new class of thin, performance-oriented devices will place increasing challenges on storage subsystems and hardware OEMs' need to create solutions that help address the height, performance, power consumption, and noise requirements of end users, yet maintain a reasonable price. Embedded designs, such as SanDisk's iSSD, that meet the stringent size requirements of small and light devices while offering greater performance will enable OEMs to deliver an enhanced user experience in their next-generation designs and blend the best of both the embedded and the SSD worlds into one storage solution.