

Trends in HDDs for Consumer Electronics Usage and their Supporting Technologies

Atsushi Saito
Hiroshi Nishida

OVERVIEW: In recent years, HDDs have not only spread in the field of IT but also in the field of CE, namely, information devices. Hand-in-hand with a rapid increase in recording density has been the appearance of manufactured products with various “form factors” (i.e. size and format), and practical HDD applications ranging from stationary devices (like HDD recorders) to mobile devices are growing. At Hitachi, based on its advanced, high-recording-density technologies, a “removable HDD”—which can be loaded with contents and carried with ease—has been developed and is being offered in a product line-up. This removable HDD, called iVDR, can handle diversified-content applications (e.g. stationary, in-car, and mobile devices) and the infrastructure for supporting iVDR applications is currently being developed. The HDD has started to break free of the field of simple external memory devices, thereby entering a pioneering phase of development of new applications in which the HDD will play a major role.*

INTRODUCTION

THE HDD (hard disk drive) has become popular mostly as an information-recording device in the IT field. From the year 2000 onward, the capacity of HDDs has been constantly increased as their cost has

been lowered, allowing HDDs to handle contents ranging from still images (i.e. photos) and music up to video images. Accordingly, HDDs are being increasingly mounted in a multitude of CE (consumer electronics) appliances (see Fig. 1). As a recording

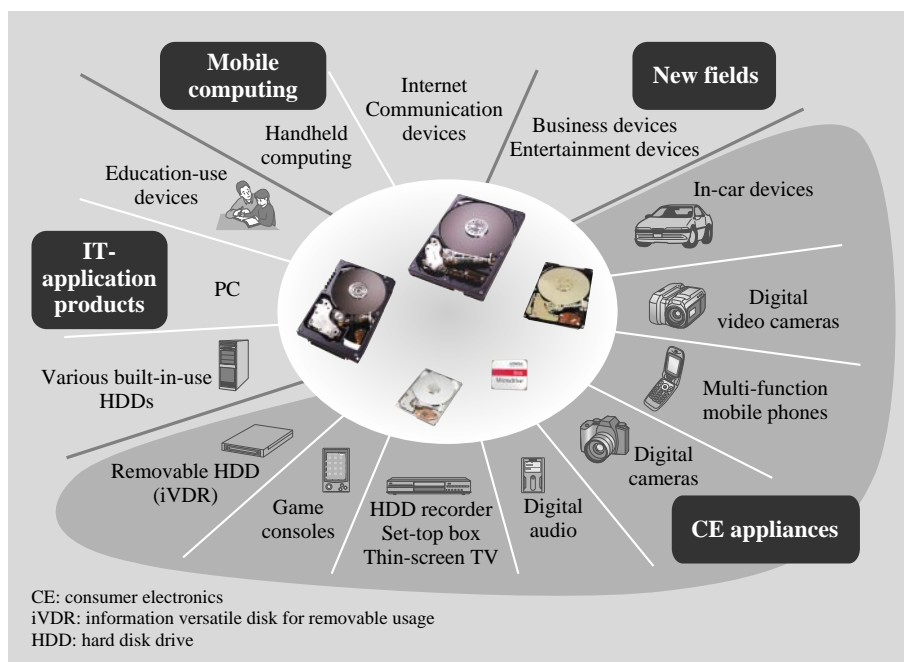


Fig. 1—Expanse of Devices with HDDs.

Although the HDD has become popular mostly in the IT field, in recent years, its incorporation into CE appliances has been advancing rapidly. In close correlation with the rapid improvement in recording density, yet more miniaturization of HDDs has been continuing, and a huge variety of applications of HDD—not only in fixed devices but mobile devices as well—are handled by HDDs.

* iVDR is a trademark of iVDR Hard Disk Drive Consortium.

media for such appliances, HDDs are finding a wide range of applications. Presently, the HDD has grown into an integral component of digital home appliances.

In the current article, the characteristics of the HDD, and its market trends over the years, are first described. After that, as a technology for handling various applications and for widening the application fields of HDDs, the “removable HDD (iVDR: information versatile disk for removal usage)” — whose standardization is currently being implemented — is described in terms of its significance, supporting technologies, and latest topics.

BREAKTHROUGHS IN HDD TECHNOLOGY

An HDD has a construction in which a disk composed of a magnetic recording layer revolves at high speed, and a recording/reading head “floats” above the disk (about several nanometers). Recording of digital information (in the form of the bits “1” or “0”) is performed by applying an electric current to a coil mounted on the recording/reading head to generate a magnetic field, which then creates small magnetic domains on the recording layer. How small these domains can be stably formed — and how accurately they can read — is the key to improving magnetic recording density. To improve the sensitivity of the reading head, the “GMR (giant magnetoresistance) effect” is applied. In addition, servo-control technology for locating the head accurately above the target position on the disk as well as signal-processing technology for reading information at high signal-to-noise ratio of the signal being read are essential for increasing recording density.

Here, we take a look back on the trends in improvement of recording density of HDDs. In 1956, IBM developed the world’s first HDD, called the RAMAC*. It had a surface recording density of about 2 kbit/sq.in. Since 1990, with the development of the “MR (magnetoresistance) effect” head, the “GMR effect” head (for further increasing the magnetic-recording effect), and AFC (anti-ferro magnetically coupled) media, the rate of increase of recording density has almost reached 100%. In recent years, development of perpendicular recording as well as research on magnetic and optical combined recording have advanced. In comparison with the surface recording density of the world’s first HDD, the present

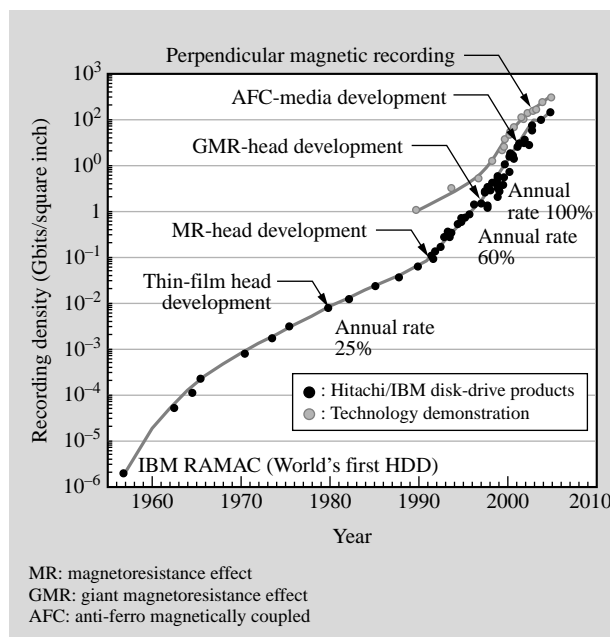


Fig. 2—History of Increasing Recording Density. Since the world’s first HDD appeared in 1956, its recording density has been steadily increasing.

recording density has been improved by about 65 million times. Accompanying this dramatic leap in recording density, the miniaturization of the size of HDDs has continued up till the present. Accordingly, HDDs with various sizes smaller than 3.5 inches have appeared, and these compact HDDs are finding a multitude of applications (see Fig. 2)⁽¹⁾.

HDDS IN CONSUMER DEVICES

Market Trends

As a result of the increase in recording density in the manner described above, and boosted by cost reduction resulting from mass production, the proportion of CE devices equipped with HDDs has been increasing in recent years, and HDDs have moved into applications beyond the IT field of servers, PCs, etc. In the second half of the 2000s, HDD-equipped devices in the CE field are forecast to capture a bigger proportion of the total shipped units than that of HDD-equipped devices in the IT field. Looking at 2005, the mounting of 3.5-inch HDDs for PVRs (personal video recorders) will dominate overall, but the ratio of 1.8-inch and 1.0-inch HDDs mounted in mobile devices will reach about half the total amount. Bringing into play their characteristics (namely, large capacity, high-speed access, and high-speed data transfer), it is considered that HDDs are likely to continue to take

* RAMAC is a registered trademark of International Business Machines Corp. in the U.S.

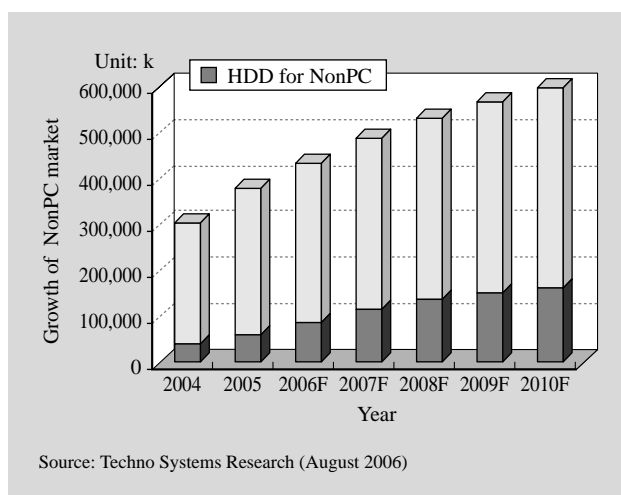


Fig. 3—HDD Market Trends in IT and CE Fields.
HDDs—which have up until now been mostly centered on applications in the IT field—are expected to rapidly spread to the CE field.

on an important role as the large-capacity recording media necessary for video-image data as well as still images and sound (see Fig. 3).

Diversification of CE Devices and HDD-handling Technology

Up till now, the specifications of HDDs have mainly been determined according to PC applications; however, in line with the expansion of HDDs to CE applications, moves to rethink HDD specifications according to such CE applications have started.

In the following, examples of a CE application of HDDs is given, and the characteristics and corresponding technologies are described (see Fig. 4).

(1) HDDs for mobile appliances

As a result of the miniaturization, weight reduction, improved anti-shock resistance, reduced power consumption, and lowering of acoustic noise, HDDs are continuing to be mounted in mobile (i.e. portable) appliances. Though these applications started with 2.5-inch HDDs, 1.8-inch and 1.0-inch types are becoming mainstream. And a 10-Gbyte HDD can now store approximately 2,000 songs (under the assumption of 5 min per song). The anti-shock resistance of the 1.0-inch HDD (shock incident duration of 1 ms) reaches 2,000 G when the device is in non-operational state, and this value is endurable when the device is dropped from more than 1 m. Moreover, in non-operational state or when falling is detected, the HDD carries a function that unloads the head from above the disk.

(2) HDDs for home appliances

DVD (digital versatile disk)-HDD recorders—aimed at recording TV pictures—are rapidly becoming popular as an application making use of the large capacity and high-speed access of HDDs. In the last few years, HDTV (high-definition television) broadcasting has become commonplace, so the need for further increasing recording capacity is growing. In this field, the 3.5-inch HDD is utilized, and in the case of an HDD with a capacity of 500 Gbytes, about 50 hours-worth of HDTV pictures can be recorded. Regarding HDDs mounted in such stationary devices, in addition to the special features of large recording

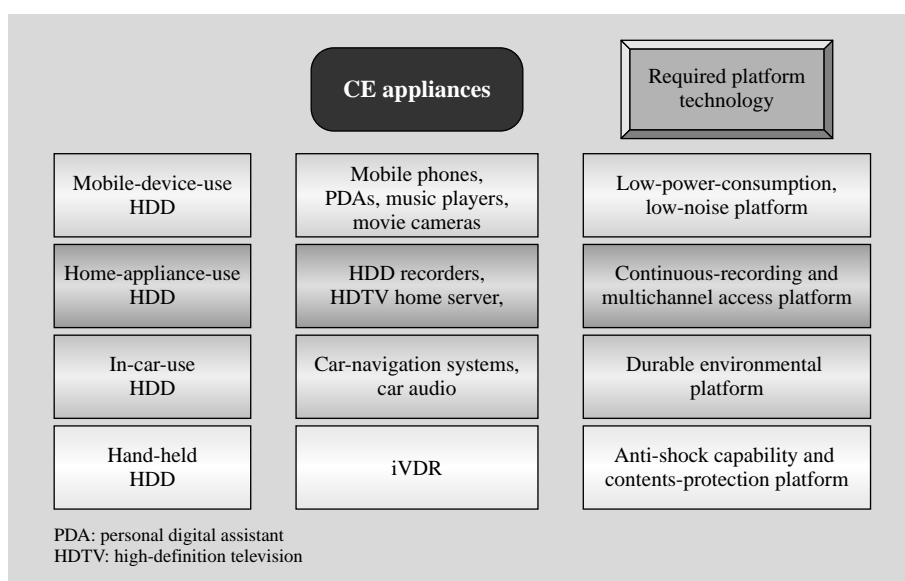


Fig. 4—Platform for Improving Freedom of HDD Usage.
The optimum platform for handling various usages can be found.

capacity and high-speed access, to achieve recording and playback without interruption, the capability to respond to AV (audio-visual) commands and to limit error-recovery time is implemented.

(3) HDDs for in-car appliances

In regards to HDD applications other than PCs, the first full-scale application of HDDs was in CE appliances, namely, car-navigation systems. In the case of these systems, the high-speed access of an HDD is highly valued, and the capability of searching for a target route instantaneously has been widely accepted by users. In the case of HDDs fitted in in-car equipment, the operational temperature range varies widely from -30 to 85°C . For ensuring good environmental-resistance performance, various innovations and advanced technologies have been implemented. For example, for recording at lower temperatures, in-car HDDs are given a magnetic property whereby the coercivity of the recording medium is not significantly raised at low temperature, and for handling sudden changes in environmental temperature, track density is optimized compared to PC-use HDDs.

(4) Removable HDDs (hand-held type)

The 3.5-inch HDD for home appliances is basically built in. In mobile appliances, although the 1.0-inch HDD can be removed and reinstalled, the 2.5-inch and 1.8-inch types are almost all basically installed. In the CE field, in contrast to the PC field, using a device for more than five years is not uncommon. To enjoy the benefits of the striking technological advances in HDDs (like large capacity and high performance), the “removable HDD”—which can be easily exchanged with the latest HDDs—offers functions (such as data transfer between various devices and easy-to-upgrade memory capacity) that are extremely convenient for users. As for the performance and features demanded by removable HDDs, on top of good anti-shock performance and low power consumption, contents protection has been put forward. As well as ensuring copyright protection concerning images and broadcasts, contents protection prevents leakage of important information.

In the following section, the various technical approaches taken in removable HDDs are described.

REMOVABLE HDDS (iVDR)

To expand the application field of HDDs, the iVDR Hard Disk Drive Consortium—whose task is standardization of iVDRs—was established in March 2002. As of November 2005, with 61 overseas and



Fig. 5—iVDR Family.

The iVDR family is comprised of three standard types: 2.5-inch, 1.8-inch, and 1.0-inch (note that 1.0-inch is a temporary standard).

domestic companies (such as home-appliance, car, and parts manufacturers) participating, this consortium is laying down technical specifications for iVDRs and promoting their adoption. The 2.5-inch iVDR (iVDR) and 1.8-inch iVDR (iVDR-Mini) have already been standardized, and products conforming to these standards are being shipped. As for the 1.0-inch iVDR (iVDR-Micro), suitable applications are being searched for, and at present, a temporary specification is being used (see Fig. 5)⁽²⁾.

In the iVDR specification, it is stated that anti-shock performance during non-operational state must be more than 900 G. This performance requirement means that a fall on the carpet floor from just about 75 cm is sustainable. Moreover, the iVDR takes a dimensional form based on the specification, and lateral use between various devices with iVDR-compatible slots is possible.

At present, the iVDR Hard Disk Drive Consortium is composed of the four technical WGs (working groups) listed as follows:

- (1) Hardware WG for drawing up hardware and interface standards
- (2) Secure WG for drawing up contents-protection standards
- (3) File system and application WG for drawing up standard formats for file systems and applications
- (4) Service WG for formulating reference models and summaries of various requirements concerning iVDR services

As for iVDRs for providing security capability, a SAFIA (security architecture for intelligent attachment device), a method for contents protection making use of the HDD features, is used. Management and

operation of SAFIA technologies is proceeding at a licensing group set up by four companies (including Hitachi) in April 2005, and licenses for SAFIA technologies have been issued since November 2005⁽³⁾.

On top of the special features of HDDs, namely, large capacity and high-speed data transfer, a CPU (central processing unit) is built in. Consequently, various functions for improving usability can be provided. For example, by means of a function for discriminating target devices in response to attribute information incidental to the contents and a function for putting time limits on watching and listening to contents, flexible handling of diversified services is possible.

HDDs fitted with SAFIA contents protection recognize commands based on SAFIA specifications, and a control and operation "usage pass" (key including attribute information accompanying use of contents) can be safely and infallibly created. This "usage pass" is stored in a safe area that is inaccessible by normal commands, and encrypted contents are stored in a normal area.

At present, in the SAFIA licensing group, the realization of recording digital-broadcast pictures on iVDRs is being aimed at, and approaches to the relevant authorities for recording licenses are continuing. From now onwards, it is planned to promote adoption of SAFIA specifications in other application areas like music and map data.

At the iVDR Hard Disk Drive Consortium general meeting held in the autumn of 2005, standardization

that allows SAFIA technology to be mounted not just in iVDRs but also in built-in HDDs already mainstream in the CE field was approved. As regards built-in HDDs of stationary devices like PVRs, it is considered that incorporating SAFIA will lead to further expanded applications of iVDRs as a basic infrastructure of stationary devices.

CONCLUSIONS

In this article, regarding HDDs in the CE field, market trends, representative applications, and technologies supporting built-in HDDs were described.

Although HDDs have been cultivated in the computer world, from now onwards, their mounting in the field of digital home appliances will gain pace. At present, HDDs have advanced to take on a central role in the world of digital home appliances. From now onwards, to handle the diversification of HDD applications, development of new technologies and standardization for improving compatibility will continue, and improved HDDs that offer better ease of use will be proposed.

REFERENCES

- (1) A. Saito et al., "Consumer Market Developments and Technical Challenges Concerning HDDs," IDEMA Quarterly Seminar (July 2003) in Japanese.
- (2) iVDR Hard Disk Drive Consortium material, <http://www.ivdr.org>
- (3) SAFIA web site, <http://www.safia-lb.com>

ABOUT THE AUTHORS



Atsushi Saito

Joined Hitachi, Ltd. in 1982, and now works at the HDD Laboratory, Hitachi Global Storage Technologies Japan, Ltd. He is currently engaged in the study and development of new usage HDDs. Mr. Saito is a member of the iVDR Hard Disk Drive Consortium.



Hiroshi Nishida

Joined Hitachi, Ltd. in 1973, and now works at the Auto/iVDR Business Management, Hitachi Global Storage Technologies Japan, Ltd. He is currently engaged in the development of new usage HDDs. Mr. Nishida is a member of iVDR Hard Disk Drive Consortium.