Present Status and Future Prospect for Magnetic Recording Media

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1. Introduction

With increased areal density, hard disk drives (HDDs) have evolved towards smaller sizes and larger capacities. This evolution toward smaller sizes and larger capacities goes beyond the boundaries of traditional PCs, and has resulting in markets being established for such outstanding products as music players, video/movie players, cell phones, and other devices that are equipped with HDDs.

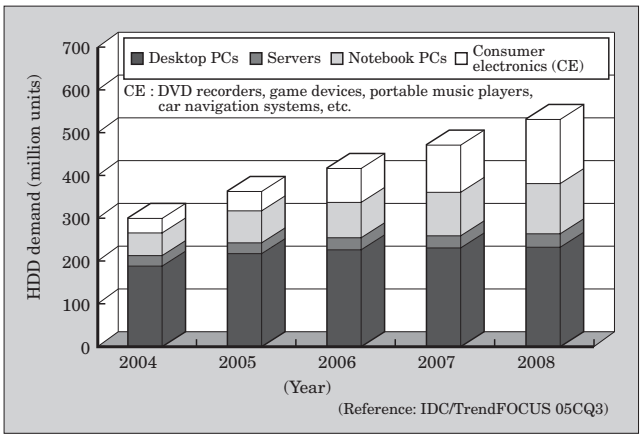
This paper describes the market trends and technical trends of HDDs, for which future growth is anticipated, and also discusses the technical development status and future prospects for Fuji Electric's magnetic recording media.

2. HDD Market Trends

Figure 1 shows the forecasted demand for HDDs. The number of HDD units installed in traditional applications of desktop personal computers (PCs) and servers has remained at a slightly increasing rate, but the increase in number of units installed in notebook PCs and consumer electronics (CE) devices has been remarkable. In particular, the CE market segment is expected to continue growing by more than 33 % annually. Figure 2 shows forecasted demand for HDDs to be installed in CE devices. HDD-DVD recorders are equipped with 3.5-inch HDDs having recording capacities in the range of 160 gigabytes (GB) to 1 terabyte (TB). Car navigation systems and MP3 players are equipped with 2.5-inch and smaller HDDs. This lineup includes a diverse assortment of HDD sizes of 2.5, 1.89, 1.0, and 0.85 inches, and these are effective in extending HDD applications to mobile devices and cell phones. In 2005, HDD-equipped cell phones were introduced to the market.

It is thought that CE demand will increase with time due to such factors as the 2008 Beijing Olympics, and simultaneously, the HDD market is also expected to exhibit growth.

Fig.1 HDD market forecast



3. Technical Trends of Magnetic Recording Media

Figure 3 shows the internal mechanical structure of an HDD. An HDD consists of such components as the magnetic recording media, a magnetic head, a head actuator, and a spindle motor.

Figure 4 shows the changes over time in areal density. Areal density has increased as a result of improved head performance, media performance and drive tracking and accuracy, as well as higher densities. In particular, areal density has improved as a result of enhanced GMR (giant magnetoresistive) head performance and better media performance through the use of an AFC (anti-ferromagnetic coupling) structure. However, adjacent bit interference, adjacent track interference and thermal stability are significant

Fig.2 Market forecast of HDDs for CE

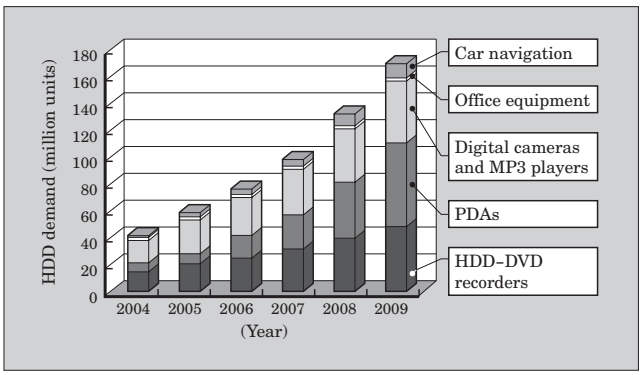


Fig.3 HDD mechanical structure

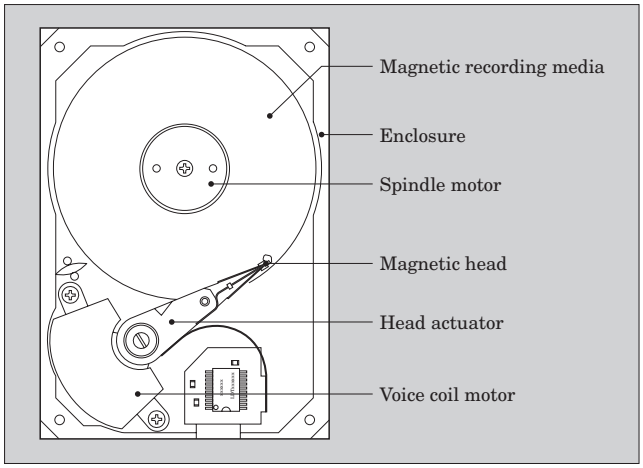
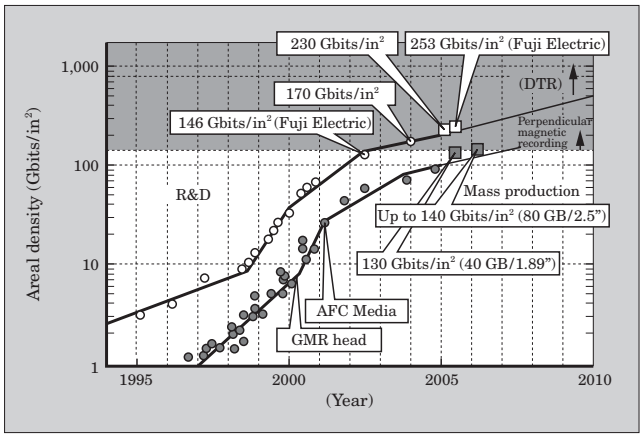


Fig.4 Changes over time in HDD areal density



factors affecting longitudinal magnetic recording media which is more than 150 Gbits/in^2, and further increases in the higher recording density would be difficult to implement.

On the other hand, because perpendicular magnetic recording media has, in principle, a high areal density and is magnetically stable, its performance surpasses that of longitudinal magnetic recording media. Perpendicular magnetic recording technology will drive further increases in the areal density.

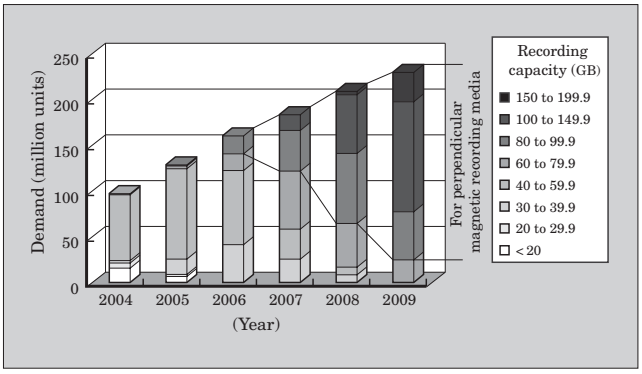
In 2006, incorporating perpendicular magnetic recording media, HDDs entered an era of even larger capacity.

4. Development Status of Magnetic Recording Media

4.1 Substrate technology for magnetic recording media

The characteristic feature of magnetic recording in an HDD is that a magnetic head which performs recording and reproduction flies with extremely low clearance above magnetic recording media that is rotating at high-speed. The distance at which the magnetic head flies above the media, i.e., the flying height, is a factor that has a large impact on recording and

Fig.5 2.5-inch magnetic recording media forecast by capacity



reproduction performance, and a flying height on the order of nanometers with low variance is required.

Magnetic recording media substrate technology is required to provide substrates of good quality in order to achieve “a nanometer-order flying height with low variance” for the magnetic head flying above the magnetic recording media. In particular, improvements to the surface precision, i.e., flatness, presents a technical challenge.

Fuji Electric is producing a substrate for 3.5-inch 80 GB magnetic recording media, which is presently the mainstream product, and has also completed development of a substrate that realizes surface precision suitable for the magnetic head flying requirements of 160 GB magnetic recording media. At the same time, this substrate increases the areal density and reduces substrate surface defects which are a noticeable problem, and also contributes to a reduction in signal dropouts during recording and reproduction.

4.2 Longitudinal magnetic recording technology

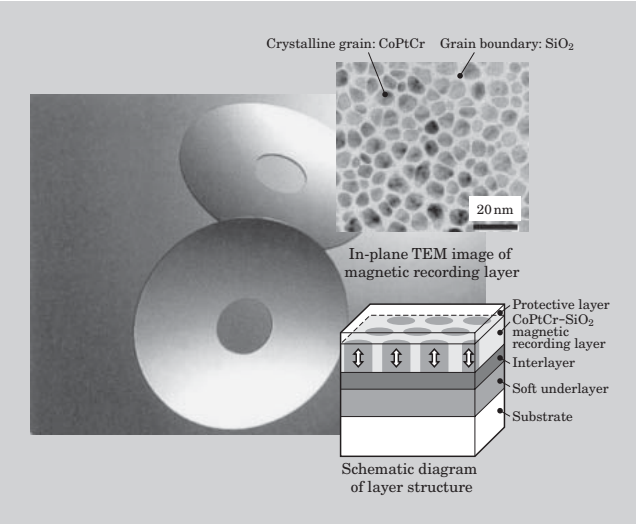
The present main product of 3.5-inch 80 GB magnetic recording media uses an AFC magnetic structure in combination with a GMR head to achieve high quality.

Longitudinal magnetic recording media that uses the AFC structure is being developed to achieve even higher areal densities and to support the TMR (tunneling magnetoresistive) head, which is the next-generation head. Also, magnetic material technology and underlayer structure technology are being advanced, and the orientation ratio is controlled to realize magnetic recording media technology suitable for 160 GB capacity per 3.5-inch disk and 60 GB capacity per 2.5-inch disk.

4.3 Perpendicular magnetic recording technology

There is an increasing need for small-size yet large-capacity HDDs capable of supporting the next generation of applications. This need will be met by perpendicular magnetic recording technology, which promises dramatic improvements in areal density. Small-size HDDs are driving the practical application of perpendicular magnetic recording technology. Figure 5 shows the projected growth in recording capacity per disk in

Fig.6 In-plane TEM image and cross-sectional schematic diagram of perpendicular magnetic recording media



2.5-inch HDDs. Beginning with the 2.5-inch 80 GB generation of HDDs, perpendicular magnetic recording is predicted to become the dominant recording technology, and by the year 2008, more than half of 2.5-inch HDDs are expected to use perpendicular magnetic recording.

In response to market needs, Fuji Electric began mass-producing 2.5-inch 80 GB perpendicular magnetic recording media. This media is formed from a magnetic recording layer of granular structure and a soft underlayer beneath the magnetic recording layer, and mass-production was made possible by the development of a magnetic recording layer that supports high areal density and the use of a thinner soft underlayer of 50 nm. Additionally, the substrate surface finishing was optimized with regard to magnetic domain noise in the soft underlayer and the flying performance of the magnetic head, and newly developed carbon overcoat technology improved the corrosion resistance. Figure 6 shows an in-plane TEM image and a cross-sectional schematic diagram of perpendicular magnetic recording media.

In the future, there will inevitably be increased need for small HDDs of less than 2.5 inches in size that use perpendicular magnetic recording technology to realize larger capacities, and manufacturing technology is being advanced to support smaller sizes and larger capacities.

4.4 HDI technology

The sum of the height at which the magnetic head flies above the magnetic recording media plus the thickness of a protective layer (which does not contribute to the magnetic recording) on the top of the magnetic recording media is known as the “spacing loss” and is a negative factor in magnetic recording. In order to reduce the spacing loss, the magnetic recording media must be made sufficiently flat so as to permit a low flying height of the magnetic head and the thickness of the protective layer must be reduced. Also, for the lubricant layer applied to the outermost surface, the transfer of lubricant to the head must be suppressed, and lower flying height of the magnetic head and improved flying stability are required.

To provide the required quality, density is increased and chemical stability improved in the protective layer, the fractionate condition is optimized in the lubricant layer, and HDI (head-disk interface) technology is established suitably for both longitudinal and perpendicular magnetic recording media.

4.5 Measurement technology

The common characteristic shared among all the above-described technologies is that the physical dimensions to be realized require the present measurement technology to be pushed to its limits. Measurement technology is being developed through diverse paths, including crystalline analysis, physical and chemical analysis of the outermost surface of the media, micro-defect analysis in order to reduce recording defects, dynamic electrical testing, and the like. By fully utilizing these technologies, not only can state-of-the-art performance of magnetic recording media be realized, but preparations are also underway to apply this measurement technology to the quality assurance process for mass-produced products so as to support the needs of a market requiring even higher levels of product quality.

4.6 Next generation recording media

Fuji Electric is advancing the development of DTM (discrete track media) as the next generation of recording media in which non-magnetic tracks are preformed in the magnetic recording media, noise factors are eliminated from adjacent tracks, and positioning information is supplied according to the formed tracks. Fuji Electric is also advancing technical development by focusing on forming ultra-fine recording units corresponding to the ordering of magnetic grains, patterned media technology that controls boundary noise, recording methods involving thermal assist, and so on.

5. Conclusion

In support of market needs for continuous improvement in the performance and quality of HDDs, the full-scale commercialization in 2006 of perpendicular magnetic recording-type HDDs, for which excellent performance has been claimed for many years, is a significant event. Fuji Electric is committed to pursuing larger capacities and a more complete product lineup based on the core technologies described in this paper.

References

(1) TrendFOCUS, Inc. Annual Reports. 1995 – 2005.
(2) IDC. Forecast documents. 2000 – 2005.

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