Stacked Volumetric Optical Discs (SVOD)

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ABSTRACT

Data capacity of a developing optical disk (multi-layer, holographic, etc.) is increasing toward to a few 100 GB, however that of HDD and computer tape (LTO) is already beyond 1TB. From the data storage view point, data capacity of optical disk should be increased rapidly. Therefore, we had proposed the stacked volumetric optical discs (SVOD) with sub tera Byte. By using a special cartridge in which is included 100 thin optical discs of 25GB data capacity, the optical disk cartridge capacity becomes 2.5TB. We had developed thin film production nano-imprint line, multi stack cartridge, small sized thin disk auto changer, and the prototype model controlled by optical disk library system. Especially, the most important result is that a commercialized standard BD drive without any change is used for the thin disk R/W. Using only overlapping a special stabilizer to the thin disk, W/R performance for whole data area (r=24mm to 58mm) of the thin disk is almost same as that of a commercialized BD-R thick disk. The system size is very small, so you can put it beside your PC on your desk. Only using normal USB connection between the SVOD and your PC, you can use it like an external HDD.

Keywords SVOD, nano-imprint, thin disk, sheet disk, thin disk auto changer, multi stack cartridge, TB

INTRODUCTION

Multi-layer disk and Holographic memory researches are going well for future optical disk. However, the data capacity is discussing in the range of few 100GB. HDD and computer tape data capacity is already over 1 TB. Now, a favorite archive media is still required for a data center, broadcast, medical, network companies. Therefore, we had proposed the stacked volumetric optical discs (SVOD [1-5]) with sub tera Byte. We prepared 100 thin optical disks and a cartridge, and they are put in the cartridge with separate sheet for each thin disk with pull out tag. Also we developed the special auto disk changer. It pulls out an arbitrary thin disk from the cartridge with the tag and mounts it to a BD drive with a special stabilizer disk. The all disks in the cartridge are well controlled by commercialized standard software of optical disk library. When the thin disk data capacity is 25GB, the cartridge capacity becomes 2.5TB. Thus, it is possible to provide a few Tera Byte optical disk system, using a commercialized optical drive and library software without any special change. This is one quick way to set up Tera Byte optical storage system.

EXPERIMENTAL METHODS & RESULTS

In order to realize a Tera Byte optical disk system quickly, we had developed SVOD with 100 thin disks made by a nano-imprint technology as shown in Fig.1. To avoid several kinds of contaminations on the thin disk surface, a nano-imprinted fabrication system was prepared. The performance test was done using a standard commercialized BD drive as shown in Fig.2. That is, our main purpose was a quick development of Tera Byte optical storage system. However, thin disk could not rotate stably on the normal drive, we developed a special aerodynamic stabilizer as shown in Fig.3. The structure and air dynamic flow during 9000 rpm is shown in Fig.4. It shows a stable rotation. Because there are 8 holes inner area of the stabilizer and stable air flow can be realized between the thin disk and the stabilizer. When we use no inner hole stabilizer, a measurement result of axial acceleration is shown in Fig.5. The thumping vibration of the axial acceleration can be observed and it is over the specification. However, by using 8 hole stabilizer as shown in Fig.6, the axial acceleration was drastically decreased and it is in the specification.

Thus, we succeeded to obtain stable thin disk rotation tangential and radial tilt margins are measured.

Both results of the thin disk are almost same as those of 1.2mmt commercialized disk. In Fig.7 the tangential tilt margin of the thin disk is shown. Concerning radial tilt margin, it is shown in Fig.8. the wide margin can be confirmed, And it is also same as that of 1.2mmt standard disk.

Fig.9 shows the Arrhenius plot of lifetime of the thin disk for durability test. The lifetime is estimated over 100 years. The result is also same as that of 1.2mmt product one. From these performance test result, there is no difference between thin disk and thick normal 1.2mmt disk. Readout durability test was performed. The result is shown in Fig.10. After 1million readout cycle, the jitter increase is very small. This result is almost same as that of 1.2mmt standard disk. How about a cramping test for the thin film? We made the cramping test machine and checked it. The result shows the thin disk hole shape change could not be observed after 1 million cramping test. Therefore, there is only little change of eccentricity of the thin disk.

Fig.11 shows recording power margin of BD type SVOD. In all data area, wide power margin can be observed. Several evaluated results (Jitter, modulation and asymmetry) of the thin disk are arranged in the table I. Thus, nano-imprinted thin disk can be used under the condition of blue laser and high NA of 0.85. In all data area of the thin disk, full high vision TV can be recorded and playback completely.

Next we prepared the cartridge as shown in Fig. 12. 48 thin disks are stocked in the cartridge with an envelope for each disk. 1 disk data capacity is 25 GB. In this case, the data capacity of the cartridge becomes 1.2TB. 48 disks are covered with thin envelope. These structures are very important to keep clean surface of the thin plastic disk. After 10,000 cycle set unset test, there is no change of PI error distribution in all data area. And cartridge drop off test was confirmed. Thus, this cartridge system is durable.

Using this cartridge, auto thin disk mini changer was fabricated as shown in Fig.13. The changer can be connected to the PC with USB. In the PC, optical disk library software is installed and user can operate the SVOD mini changer like an external HDD. For example, it is very easy to copy from 1TB HDD to SVOD mini changer. It is only one drag operation from HDD icon to SVOD icon on the PC screen.

CONCLUSIONS

An auto nano-imprinted thin disk maker was constructed. Using this machine, 0.1mmt thin disk for blue laser high NA was fabricated and the W/R performance in all data area of 24mm-58.5mm was confirmed as same as that of 1.2mmt commercialized BD disk. To make a 1.2TB optical storage system, the cartridge included 48 disks was designed and the cartridge durability test was also confirmed. Moreover, thin disk auto mini changer was demonstrated using the cartridge with 48 disks. Using USB connection between the SVOD library and PC, durable disk set and unset operations were confirmed. Thus, the SVOD is very durable and long life storage. When 5 SVOD mini libraries are connected each other, a RAID 5 optical disk system can be operated. When a cartridge changer is prepared, 1 Peta Byte SVOD Rack Unit System can be realized. In near future, we hope to use the SVOD as a century archive system and that this is useful to reduce IT energy problem.

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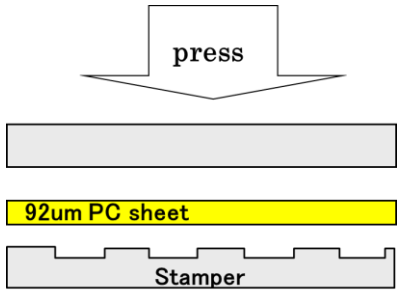

Fig.1 Schematic figure of nano-imprint

Fig.2 Thin film disk is put on the motor of commercialized standard BD drive.

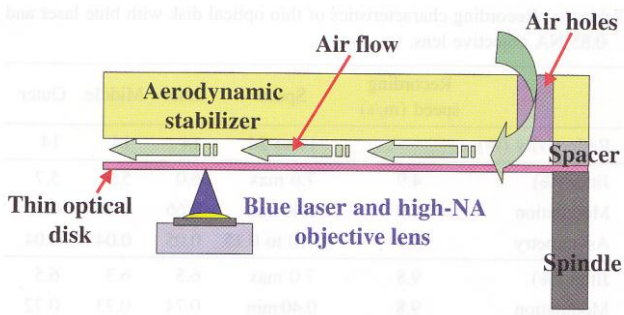

Fig.3 Aerodynamic stabilizer is mounted on the disk.

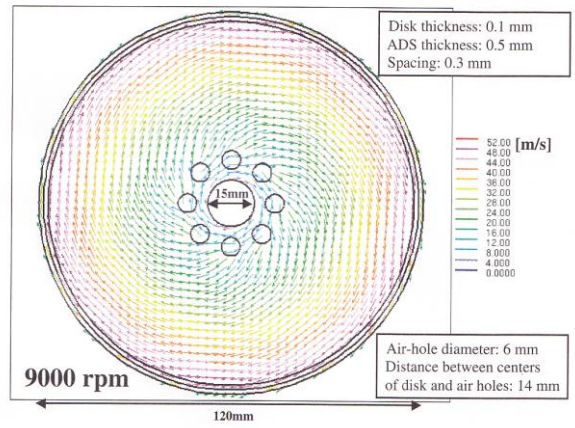

Fig.4 Aerodynamic stabilizer with inner holes.

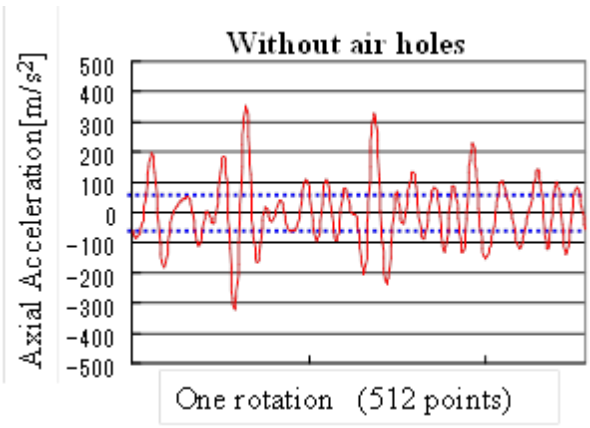

Fig.5 Axial acceleration without inner holes. Dashed line is the specification, and the experimental result is over the spec..

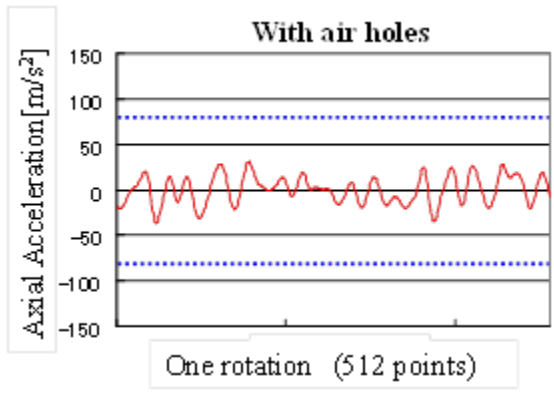

Fig.6 Axial acceleration with inner holes. The experimental result is in the spec.. Air flow keeps flat disk rotation.

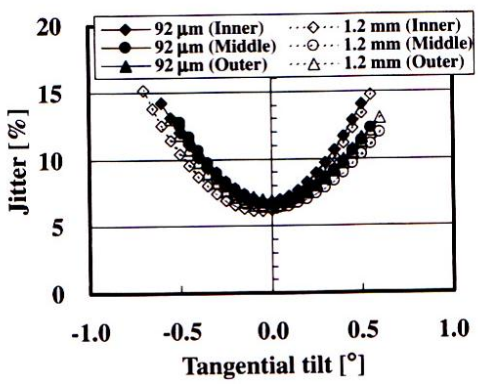

Fig.7 Tangential tilt margin curves of 92um SVOD and 1.2mmt product disk. These are overlapped. Thus, thin disk can be used as a standard disk.

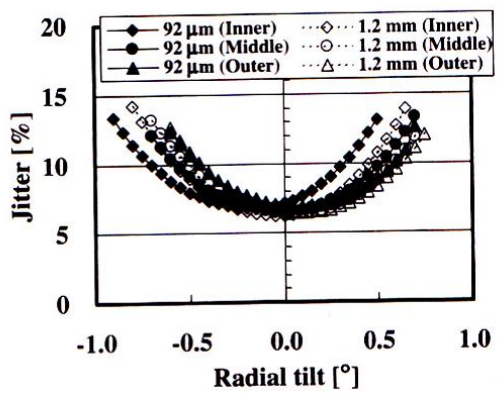

Fig.8 Radial margin curves of thin disk. These are overlapped. This shows that thin disk can be used as a standard disk.

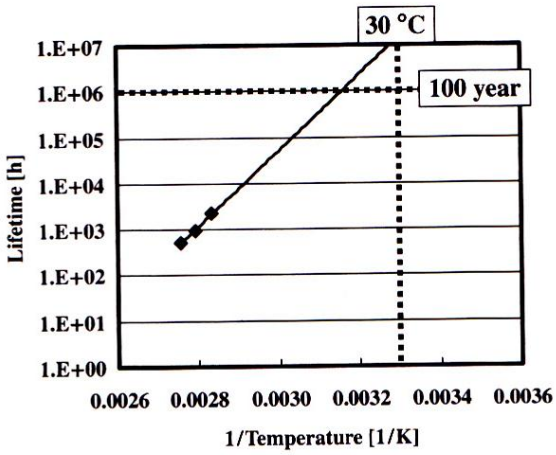

Fig.9 Arrhenius plot of thin disk for durability test. The result is almost same as 1.2mmt disk.

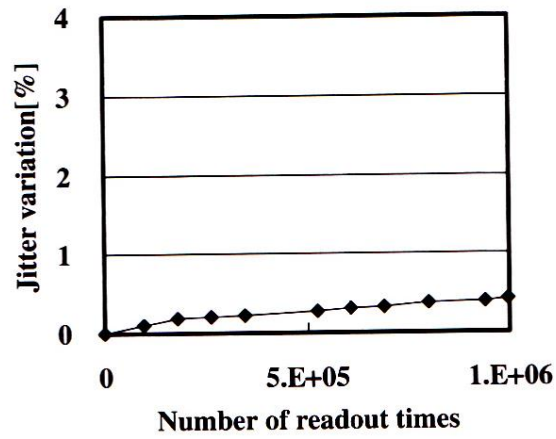

Fig.10 Readout power durability test of thin disk. This result is almost same as 1.2mmt disk.

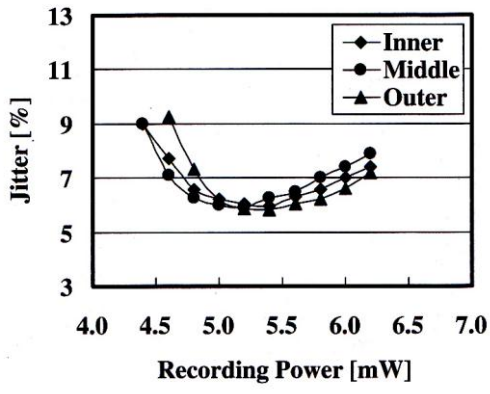

Fig.11 Recording power margin of thin BD type SVOD.

Table I. Recording characteristics of thin optical disk with blue laser and 0.85 NA objective lens.

	Recording speed (m/s)	Specs	Inner	Middle	Outer
Reflectivity (%)		11 to 24	14	14	14
Jitter (%)	4.9	7.0 max	6.0	5.9	5.7
Modulation	4.9	0.40 min	0.66	0.64	0.63
Asymmetry	4.9	−0.10 to 0.15	0.05	0.04	0.04
Jitter (%)	9.8	7.0 max	6.5	6.3	6.5
Modulation	9.8	0.40 min	0.74	0.73	0.72
Asymmetry	9.8	−0.10 to 0.15	0.10	0.08	0.08

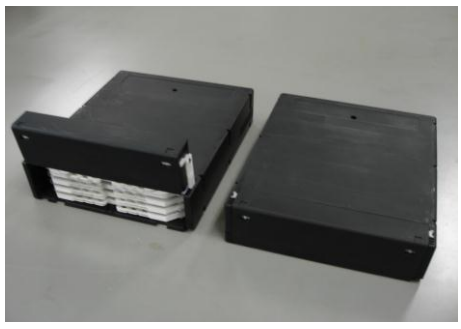

Fig.12 Cartridge of SVOD with 48 disks.

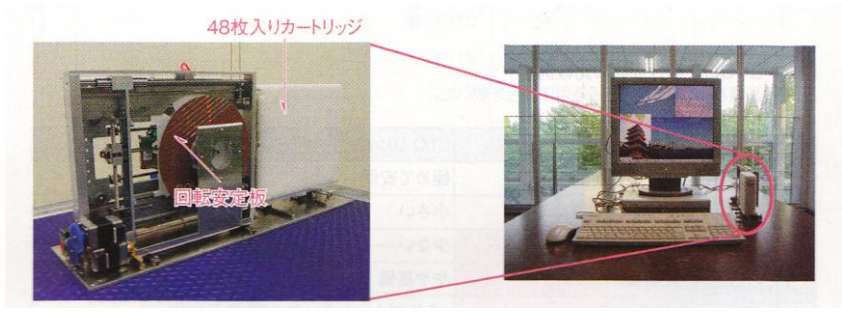

Fig.13 Proto type of SVOD mini auto disk changer
USB connection between SVOD changer and PC
Also optical library software is installed. User can operate SVOD very easily like an external HDD.