Terabyte and Gigabits/s Archival Storage Using Flexible Optical Disks

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1. Introduction

Nonlinear storage such as hard disk drives, optical disk drives, and semiconductor memory are spreading in place of video-tape recorders (VTRs)—which have been used for program production by TV stations for over 50 years. In the meanwhile, VTR tape is still the main and unique storage medium for archival application, namely, preserving programs for a long time. For example, a huge amount of VTR tapes (i.e., more than 700,000) have piled up at NHK over the years (Fig. 1). However, new kinds of preservation media are expected to replace VTR tapes for archival application because several types of VTRs are going out of production and nonlinear-storage technologies are being demanded for archival application.

Optical disks have a lifetime more than 50 years. Moreover, as the CD players have already proved, reading devices will be supplied over a long time owing to the long product life of an optical disk. In addition to these merits regarding archival application, optical disks are an inexpensive form of archival media. However, compared to tape media such as linear-tape-open (LTO) systems which are widely used as backup and archival application, optical storage is seriously lacking in terms of performance, namely, capacity and recording speed.

A flexible optical disk (FOD) fabricated on a very thin (0.1 mm thick) polycarbonate substrate seems to be a recording medium to break the performance barrier concerning current optical disks by using conventional technologies [1, 2]. Optical storage based on FODs for archival application is currently being developed at NHK STRL.

2. Concept of archival storage using FODs

Some large-capacity storage systems using FODs have been reported [3, 4]. These systems, however, have two problems: low recording speed and excessive size for broadcast applications. To solve these

problems and achieve tape-media-equivalent performance, we have devised a new concept of storage based on FODs, namely, “flexible-optical-disk archival storage” (FOD-AS) as shown in Fig. 2. Plural FODs stored in the palm-sized cartridge are simultaneously written or read by plural drives in the system the size of a current broadcast-use VTR [5, 6]. This storage system achieves superior performance compared to LTO systems and the potential for performance improvement in the future. Figure 3 shows the example of the roadmap for FOD-AS. As for the future, the introduction of advanced technologies such as multi-layer recording and high-speed disk rotation promises larger capacity and higher data transfer rate. FOD-AS is expected to be widely used beyond broadcast-use archival application.

3. Prototype of FOD-AS

The specifications of the FOD-AS prototype are listed in Table 1. The three key technical components for creating a FOD-AS, namely, FOD cartridge, compact FOD drive, and carriage mechanism for FODs, are described as follows.

(i) Palm-sized cartridge

Figure 4 shows the prototype of the FOD cartridge with a height of about 6 cm, which is composed of ten trays, each containing ten FODs with a 25-GB-capacity recording layer. The cartridge can therefore store one hundred FODs, giving total capacity of 2.5 TB. In other words, one tray has a capacity of 250 GB, which is equivalent to that of the cassette for a broadcast-use VTR (HD-D5).

(ii) Compact FOD drive

Figure 5 shows the prototype of the compact FOD drive and its configuration. A stabilizing mechanism is indispensable for stable rotation of the FODs because of their flexibility [2]. The new configuration makes the FOD drive almost the same size as current optical disk drives because the tray for housing the FODs also functions as a stabilizing mechanism. Each FOD is loaded into the drive with its recording layer upward. Each one can rotate without any contact by forming an air film of a few hundred micrometers between the tray and the FOD. An optical head is positioned above each FOD and writes data to each one. HDTV video (MPEG2 at 100 Mbps) recording confirmed the stable operation of the prototype FOD drive (Fig. 6).

(iii) Carriage mechanism for FODs and FOD-AS

Figure 7 shows an FOD-AS prototype, which can be installed in a 19-inch wide rack like a current broadcast-use VTR. The FOD-AS is composed of a cartridge, ten FOD drives (a pair of drives in five tiers), and the carriage mechanism for transporting the FODs. One tray is pulled out from a cartridge, and each of the ten FODs stored in the cartridge is distributed to one of ten FOD drives by rotating and lowering arms which have an air-adsorption mechanism to absorb air onto the inner unrecorded area of the FODs. The distributed FODs are collected in reverse order of distribution. The carriage mechanism for transporting the FODs worked stably and quickly when DVD drives were used in place of FOD drives.

FOD-AS is expected to achieve a data-transfer rate of more than 1 Gbps using parallel recording.

4. Conclusion

An archival storage system using flexible optical disks—called “flexible-optical-disk archival storage” (FOD-AS)—that provides terabyte capacity at gigabits/s data-transfer rate was proposed. FOD-AS is expected to be put to practical use for archival storage at broadcast stations in the near future because of its merits of random accessibility, long-life data-storage capability, and long intervals between data-migration operations for archival storage. Thanks to its high performance, FOD-AS is also applicable to other archival applications such as a data-center storage.

References

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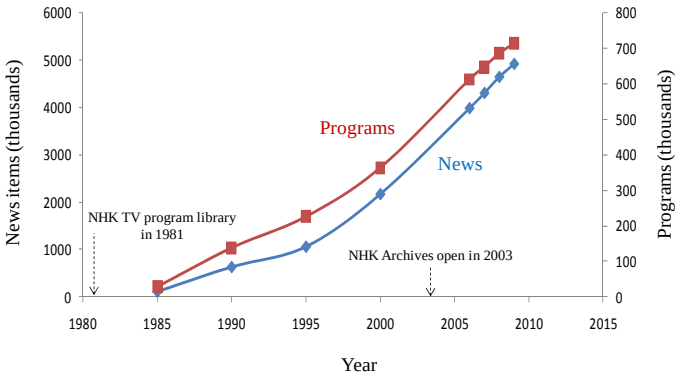

Fig. 1. Transition of news and program contents preserved at NHK

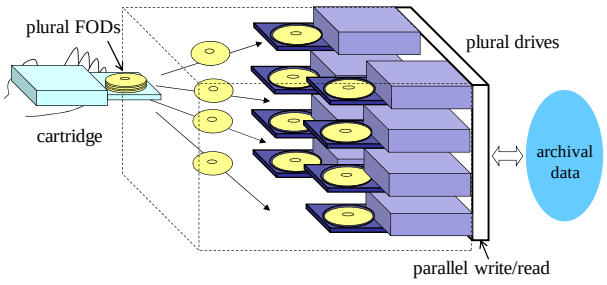

Fig. 2. Concept for flexible-optical-disk archival storage (FOD-AS)

Table 1. FOD-AS specifications

Drive	wavelength/NA	405 nm/0.85
	number of drives	10
Media	capacity	25 GB
	type	write-once
	diameter/thickness	120 mm/0.1–0.2 mm
Cartridge	total capacity	2.5 TB
	number of FODs	100
	dimensions (H × W × D)	58.5 × 136 × 147.5 mm
Dimensions	500(H) × 420(W) × 700(D) mm	

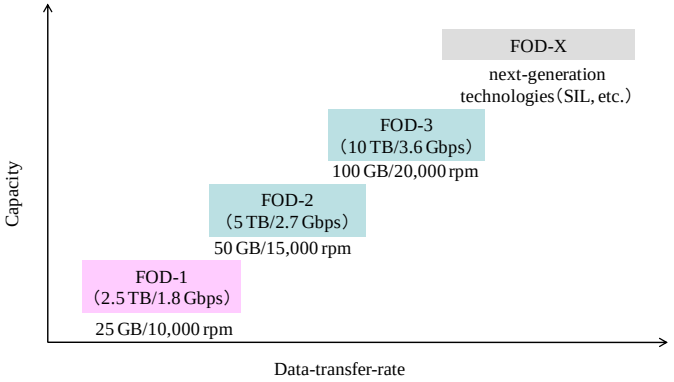

Fig. 3. Example of FOD-AS roadmap in the case of 100 disks/cartridge and 10 drives/unit

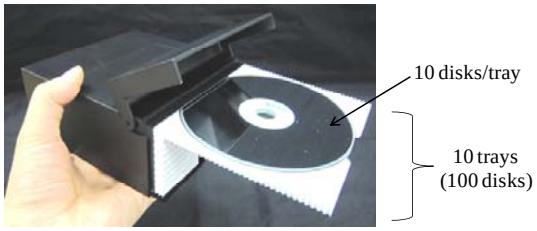

Fig. 4. FOD cartridge (2.5-TB capacity)

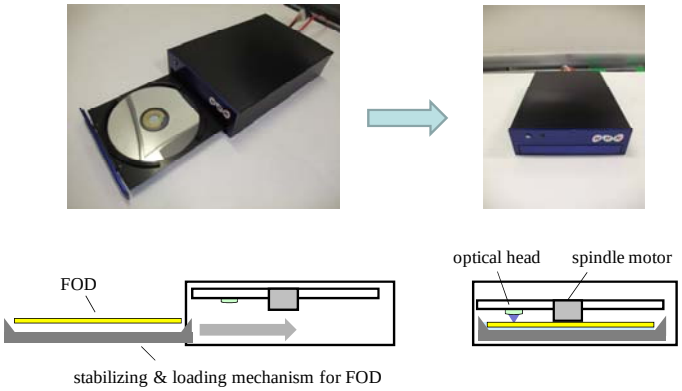

Fig. 5. Compact FOD drive

Fig. 6. Playback HDTV video

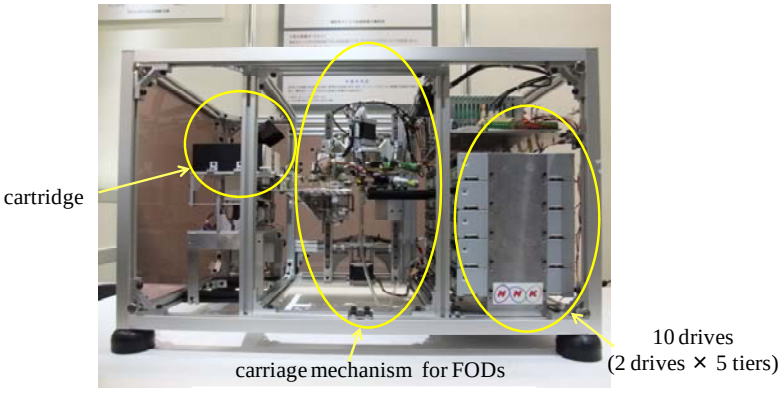

Fig. 7. FOD-AS prototype