Long-Term Storage Features of Optical Disks According to Recording Conditions

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ABSTRACT
Optical disks are widely used in libraries and archives as digital data media due to their long-term storage stability. Though archive-grade optical disks are already available on the market, there is relative less focus on the reliable recording conditions. Commercial DVD-R media were recorded at various recording speeds with the maximum speed of 16X, and tested at acceleration aging conditions. Through the evaluation of long-term storage features by the data stability test, a higher recording speed over 12x resulted in better long-term storage stability.

Keywords
Long-term data storage, Optical disks, Archival application, Recording condition, Data stability

1. INTRODUCTION
Optical disks have considerable potential to provide reliable long-term data storage since it has little influence from the environmental electromagnetic fields and physical shocks. In addition, the contactless reading process of optical data storage promises undamaged multiple information playbacks [1]. For these reasons, optical disk is considered a long-term storage system for library and archival applications. Though there are few reports related to the influence of recording conditions on storage reliability, many users have confirmed the advantages of optical data storage. Thus, we studied the effect of recording speed on data stability by evaluating the quality of recorded data through acceleration conditions.

2. EXPERIMENTAL PROCEDURE
A different kind of commercial DVD writer and DVD-R media (1-16x) were prepared for the recording experiment. Current optical disk drives provide a range of recording speeds from 1x 8x, to 16x. The recording speed is controlled by two different modes such as a constant linear velocity (CLV) and constant angular velocity (CAV). The CLV mode provides a constant linear speed through all recording tracks by controlling the speed of spindle motor. On the other hand, the CAV mode fixes the motor speed with the same angular velocity, then the linear speed in the recording tracks increases from the inner tracks to outer tracks. The CAV mode provides shorter recording time than the CLV mode since the rotation speed of spindle motor at the CAV mode is kept as the highest value. In this study, four different recording conditions were selected as shown in Fig. 1.

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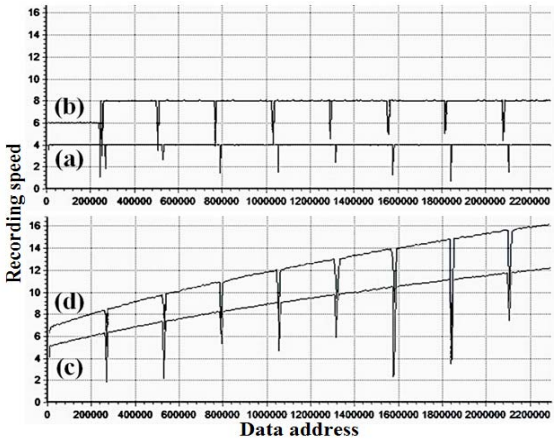

Figure 1. Various recording conditions at (1)4x: CLV, (2)8x: zone-CLV, (3)12x: low speed CAV, (4)16x: high speed CAV.

After being recorded at different recording conditions, the DVD-R media were stored for 1000 hours (250 hours/cycle, 4 cycles) at acceleration conditions to estimate the archival lifetime of optical media followed by the ISO/ICE 10995 [2]. In this study, the most severe condition of 85ºC/85%RH was selected to understand the effect of recording speed. The data stability of test disks was measured by measuring the parity inner code error sum 8 value (PI8) after every acceleration test cycle. The PI8 value means the total number of parity inner errors in any 8 consecutive error correction code (ECC) blocks. The value of 280 for PI8 is considered as a limit of stability without the error correction [2]. The PI8 value was measured in all tracks using an optical disk analyzing software with a special emphasis on the maximum PI8 which is considered as the most important value for stable playback. The experimental procedure is shown in Fig. 2.

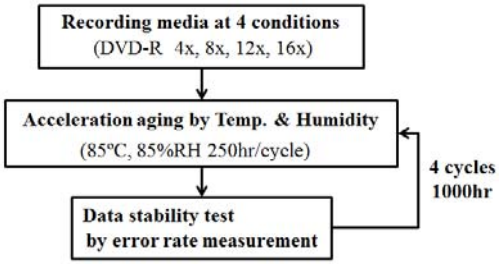

Figure 2. Experimental procedure for the stability test.

3. RESULTS & DISSCUSSIONS

3.1 Initial state after recording

The playback stability results of DVD-R media after being just recorded are shown in Fig. 3. The PI8 evaluation results show a stable value less than 100 with all media as well as at whole tracks. The distribution of PI 8 value is roughly uniform through the track positions. Thus, the data stability with a range of recording speeds shows an almost same value at the initial recording state.

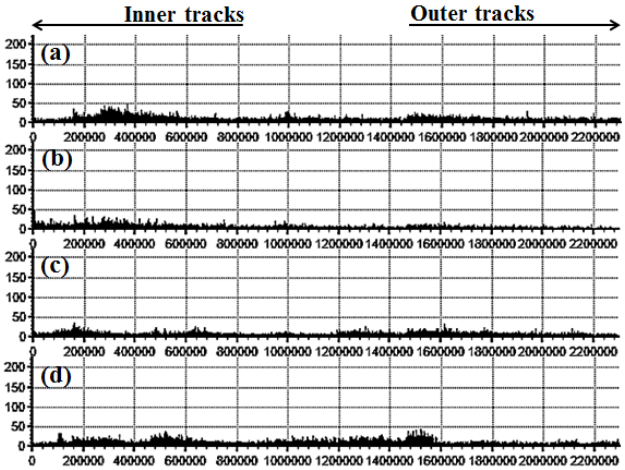

Figure 3. PI error sum 8 evaluation results at the initial state with different recording speeds of (a)4x, (b)8x, (c)12x, (d)16x.

3.2 Acceleration test results

The PI8 values were measured at a series of aging time with a 250-hour interval for the comparison of data stability as shown in Figure 4. Each PI8 value means the arithmetic average PI sum 8 from 10 media. From this graph, we can confirm that the media recorded at 16x speed shows more stable result than that of other recording speeds. It means that long-term storage features can be improved by increasing the recording speed to the maximum value since the recording conditions might be optimized for the higher speed, including a write strategy.

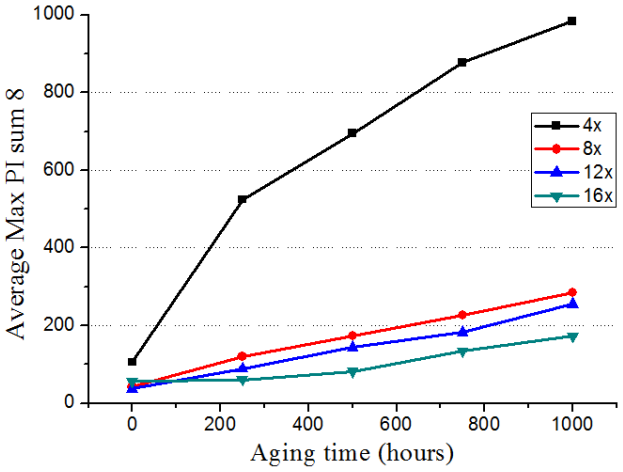

Figure 4. The average PI sum 8 value of DVD-R media as a function of recording speed after the acceleration aging test at the sever condition of 85ºC/85%RH.

3.3 Data stability test results

The PI8 values as a function of track positions were also observed as shown in Figure 5. The data stability of outer tracks increases at the higher recording speed such as Fig. 5(d). Since the higher speed (12x-16x) was realized at the outer track, more stability was observed at the outer tracks for the media recorded at the16x speed. As expected, the media recorded at lower speed showed less stability through whole tracks as shown in Fig. 5(a).

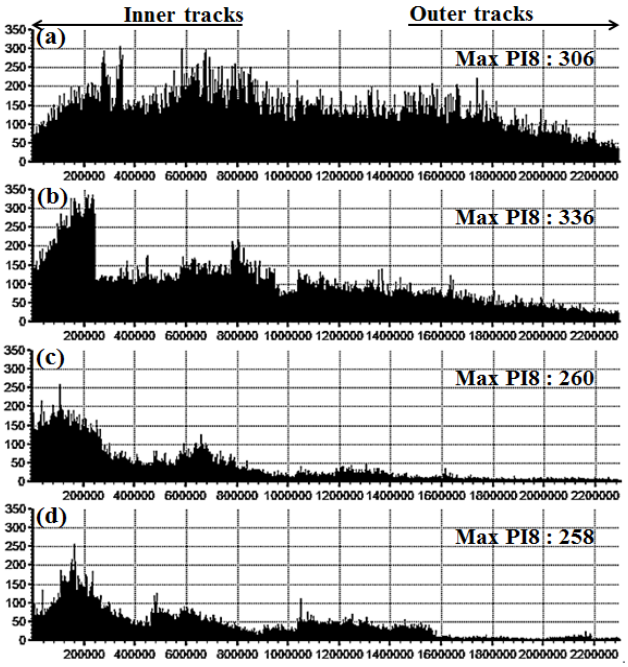

Figure 5. The PI8 evaluation results for the media recorded at (a)4x, (b)8x, (c)12x, (d)16x after acceleration aging test.

4. CONCLUSIONS

The data stability of optical disks was evaluated by the acceleration aging test according to various recording speeds. Though it is generally known that lower recording speed such as 4x provides a reliable data stability, we understood that the higher

recording speed (16x in this study) showed more stable long-term storage feature. In addition, the outer track recorded at higher speed (12x-16x) shows better data stability compared to the inner track recorded at a lower speed. Thus, if the recording parameters in the drive were optimized for a higher speed such as 16x, the higher recording speed might be recommended for long-term storage.

5. ACKNOWLEDGMENTS

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6. REFERENCES

[1] Chandru J., Basil M., and Michele Y. 2003. Longevity of CD Media: Research at the Library of Congress. http://www.loc.gov/preservation/resources/rt/studyofCDlongevity.pdf

[2] ISO/IEC 10995. 2008. Test method for the estimation of the archival lifetime of optical media. Geneva, Switzerland, 2008-04-15.