

Over 500 Years Lifetime Dual-layer Blu-ray Disc Recordable based on Te-O-Pd Recording Material

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ABSTRACT: 50GB BD-R media with Te-O-Pd recording material was estimated to have a life expectancy of over 500 years according to acceleration test under stressed conditions. This stable recording material will reduce the possibility to lose important data even in sever storage environment.

1. Introduction

Recent growth of digital cameras, DVD-recorders and DVD-multi drives are pushing away the conventional photo-film and video cassette tapes from the main stream of archival storage media. Consumer stores their photo or movie data into the convenient recordable or rewritable CD/DVD discs and hard drives. This movement encouraged optical discs and hard drive manufacturers to invest their resources to develop inexpensive media with high performance. However, to replace the photo-films, it is indispensable for such electrical storage media to have a life time of more than human's one, i.e. about 100 years. At that time, even if corresponding players are out of the market, we can manage to salvage them at any cost. For official documents, a lifetime of 100 years should be required under controlled storage condition. But considering accidental trouble of the condition and importance of the documents, durability against harder condition is desired. Moreover, for the consumer use, the storage conditions are various so we will need more severe test to confirm that our media have enough endurance.

Inorganic recording material based on Te-O-Pd ternary-system has an excellent environmental stability [1]. Figure 1 shows a recording mechanism of Te-O-Pd materials. An as-deposited Te-O-Pd film is formed in amorphous-like state in TeO₂ matrix, in which Pd-Te and Te fine particles are dispersed. By laser irradiation, Pd-Te and Te are crystallized as recorded state. The free energy of crystalline state is lower than that of amorphous state so that once information data are recorded as crystalline marks, these are very stable and barely return to amorphous state. In addition, TeO₂ matrix is oxides of metal and not intrinsically eroded. While, this material also has optical and thermal characteristics suitable for high density recording and high speed recording of over 500Mbps [2,3,4,5]. Due to these features, the recording material is expected to satisfy market requirements as a personal and public storage media. In this paper we demonstrate the basic recording characteristics of our write once discs based on the Blu-ray Disc format of 50GB-capacity. To demonstrate the durability of the media, we perform acceleration test under high-temperature and high-humidity environment and estimated the lifetime.

2. Experiments

Figure 2 shows a cross-sectional view of the developed dual-layer medium. L0 and L1 layers are formed between a polycarbonate (PC) substrate of 1.1 mm thickness and a resin cover layer of 75 μ m, and separated by a space layer. Both layers were consisted of four films with different thickness: a reflective film, a protective film, a recording film and a protective film in this order on the substrate. Ag-alloy was introduced for reflective films to realize good recording characteristics due to its high thermal conductivity. The thicknesses of the recording film and the reflective film of L1 were thin (~10nm) enough to realize high

transmittance. Protective films introduced on both sides of recording films enable High-to-Low recording. The experimental disks were evaluated on the base of the BD format. The recording speeds were 4.92m/s at 1X (=36Mbps) and 9.84m/s at 2X (=72Mbps).

In order to evaluate the durability of media, we measured symbol error rate (SER) rather than jitter because it is more easily affected by the defects caused from erosion, etc. And SER is more directly connected with the playability so it is suitable to judge the possibility of trouble in the practical use. First, we measured dependences of initial SER on write-power. Next, to confirm the stability of recorded data, dependences of SER on the read cycles with high frequency modulation were measured. Finally we adopted acceleration test to confirm the archival stability of this disc based on Eyring model [6]. Procedure is as follows; [Step1] Write test data to the media samples (n=3) for each of 5 environmental stress conditions which are (a)90°C/80%, (b)85°C/80%, (c)80°C/80%, (d)90°C/50% and (e)90°C/20%. [Step2] Each sample disc was exposed under each condition until SER exceeds $4.2E-4$ i.e. the criterion on the BD specification. Determine the failure time. [Step3] Plot failure times vs. reciprocals of absolute temperature for each condition.

3. Results and Discussions

Figure 3 shows the dependence of SER values on the peak power with 5-tracks recording at 1X and 2X speed. The optimum writing powers were less than 12.0mW at 1X and less than 14mW at 2X to achieve enough SER values and its means this disc has enough performance as a BD-recordable media at initial stage.

Figure 4 demonstrates a read stability characteristics of our test discs, showing that dependence of SER values on the read cycles for 1X-speed and 2X-speed with high frequency modulation. The SER values were quite stable till 1 million times reading for both layers. In addition, although specifications are 0.6mW for 1X and 0.7mW for 2X, reading with 1mW at 2X-speed causes no deterioration in SER up to 100 million passes. These results mean that Te-O-Pd material is relatively secure against the false setting by commercial drives and that it is very suitable for higher speed reading where we need more reading power to obtain enough signal-to-noise ratio.

Figure 5 shows the results for L0 layer and L1 layer. If we draw a straight line which passes on the point of condition (d) and whose slope was determined by the points of condition (a), (b) and (c), the cross points of this line and 30°C grid depicts the life expectancy for 30°C/50%. However, because SER didn't reach its threshold under the conditions (d) and (e) even if more than 1400Hr has passed, we needed to estimate failure time at these conditions by measurements with more stress such as write-power error. With the additional stress, failure times of 90°C/50% and 90°C/20% were found to be four and twelve times as long as that of 90°C/80%, respectively. Thus, we plotted the estimated failure times with those magnification factors for non-stress conditions (d) and (e). As shown in Figure 5, a life expectancy of more than 1000 years in the office environment (30°C/50%) is estimated. However, as mentioned above, estimation of stability under severer conditions was required. In this meaning, 50 years even in Amazon jungle (40°C/80%) and 300 years in Sahara desert (45°C/20%) can be expected. Finally, over 500 years in the heavy climate of Osaka (35°C/60%) and ideally 2000 years in this Montreal (25°C/50%) are anticipated. Although humidity seems to affect life time to some extent, these results proved that Te-O-Pd material is enough durability as storage media.

4. Conclusions

Inorganic recording material with Te-O-Pd composition possesses a good archival stability because i) information is recorded as crystalline mark whose free-energy is lower than that of surrounding amorphous area and ii) oxides of metal is not intrinsically eroded. According to the high-temperature and high-humidity acceleration test, it is estimated that the dual-layer Blu-ray disc recordable media with Te-O-Pd based material has a lifetime of more than 500 years. This durability will reduce the possibility to lose important data in the sever storage environment by mistake and it relieves consumers' anxiety.

5. References

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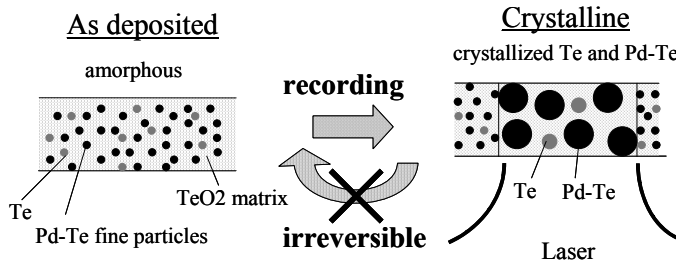


Fig. 1: Recording mechanism of Te-O-Pd films

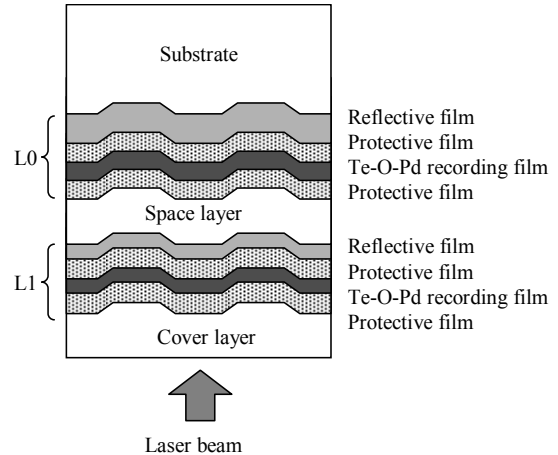


Fig. 2: Cross-sectional view of the dual-layer medium.

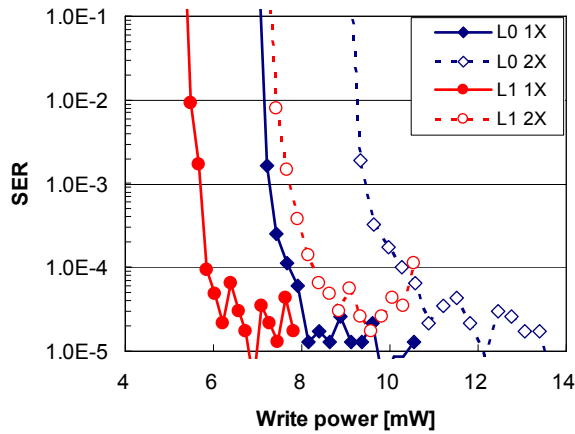


Fig. 3: Dependence of SER values on the peak power.

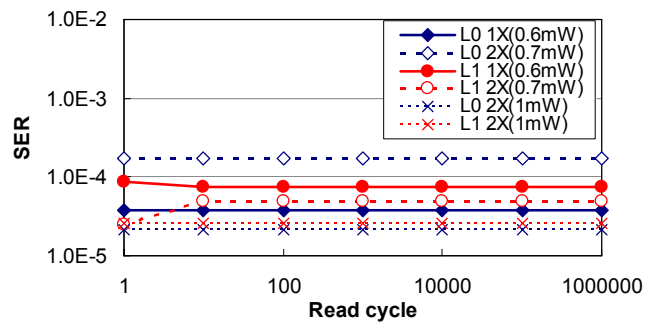


Fig. 4: Dependence of SER values on the read cycles.

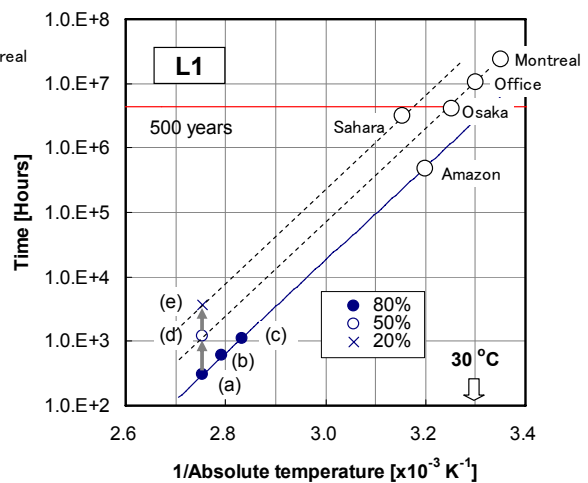
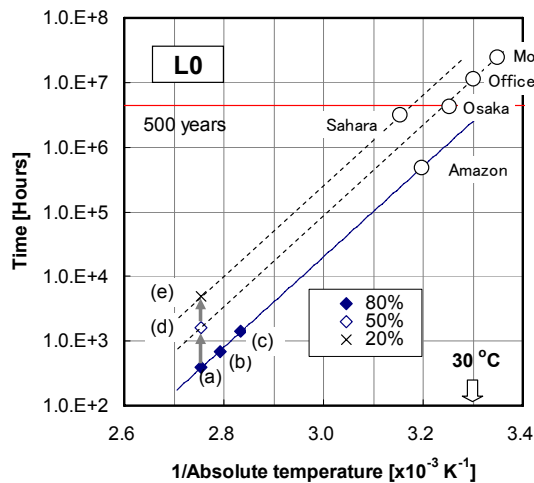


Fig. 5: Dependences of failure times on absolute temperature and relative humidity. Points (a), (b) and (c) are measured failure time. Points (d) and (e) are estimated failure times based on the measurement with more stress.